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Appendix A

Economic Analysis

Economic Analysis	
Project Name:	Sutter Basin Pilot Feasibility Study—Flood Risk Management Project
Project Briefing:	The study area is located in Sutter and Butte Counties, California and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The study area covers approximately 300 square miles and includes the communities of Yuba City, Live Oak, Gridley, Biggs and Sutter with a total population of 80,000.
Study Authority:	The authority for USACE to study Flood Risk Management and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, is provided in the Flood Control Act of 1962 (Public Law 87-874).
Purpose and Scope:	The purpose of this document is to present the economic analysis conducted for the Sutter Basin Pilot Feasibility Study. This includes descriptions of the methodologies, assumptions, data and results of both the without and with project conditions. The document presents findings related to flood risk, potential flood damages, and flood risk management benefits. Additionally, this analysis coincides with the planning modernization paradigm of employing sound qualitative analysis guided by professional judgment rather than heavily based quantitative processes during the planning phase of study process. The economic analysis is in accordance with standards, procedures, and guidance of the U.S. Army Corps of Engineers. The Planning Guidance Notebook (ER 1105-2-100) serves as the primary source for evaluation methods. Also, guidance for risk-based analysis was obtained from EM 1110-2-1619 and ER 1105-2-101. Unless otherwise noted, benefits and costs values are expressed in October 2012 prices utilizing the FY12 discount rate of 3.75% and analyzed over a 50-year period of analysis. Economic Modeling was performed using the Corps FRM-PCX certified HEC-FDA (v1.2.5a) model.
Organization of Document:	This document is organized as follows: • Section 1 describes the study area and planning process conducted to date • Section 2 reviews the data used in the analysis and without-project conditions • Section 3 evaluates the final array of alternatives • Section 4 compares the final array of alternatives • Section 5 presents the Other Social Effects analysis • Section 6 discusses the Regional Economic Development impacts • Section 7 summarizes the economic analyses
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Date:	April 2013

1. STUDY BRIEFING

Planning Study. The Sutter Basin Pilot Feasibility Study was selected for inclusion in the National Pilot Program in February 2011. The pilot initiative provides an opportunity to test principles that have been outlined in the U.S. Army Corps of Engineers (USACE) *Recommendations for Transforming the Current Pre-Authorization Study Process* (January 2011), which was drafted by a workgroup of planning and policy experts from USACE and the Officer of the Assistant Secretary of the Army for Civil Works, ASA (CW), referred to as the 17+1 Team. This new process requires heavy involvement as well as input and decisions from the Vertical Team at multiple points throughout the study. The pilot study is divided into four phases, each with a key decision point and associated In-Progress Reviews (IPRs). Table 1 summarizes the four pilot study phases and associated decision points. Based on the pilot program principles, the Sutter Basin Pilot Feasibility Study strategy focuses on utilizing an appropriate level of detail based on the decisions being made at each stage of the study. This strategy includes qualitative analysis that will be increasingly detailed at each Decision Point or IPR and early screening of alternatives with little probability of implementation.

Table 1. Pilot Study Phases and Associated Decision Points

Pilot Study Phase	Decision Point	Date
Scoping	1 – Federal Interest Determination	Aug 2011
Analysis	2 – Tentatively Selected Plan and Draft Report	March 2013
Review	3 – Civil Works Review Board	Summer 2013*
Confirmation	4 – Chief's Report	Fall 2013*

*Dates are pending confirmation from vertical team.

Throughout the planning process, the Sutter Project Delivery Team (PDT) has recorded major milestones in the following documents:

- Appendix I, Measure Screening and Alternative Selection— This Progress Document details the broad array of management measures that were developed based on information from existing reports and studies, as well as public input and professional judgment. This document provides descriptions of the measures evaluated at the Critical Thinking Charette and indicate whether each one was retained or dropped and the reason(s) for screening.
- Appendix II, Draft Alternative Evaluation and Selection of Final Alternatives— This Progress Document is a compilation of a series of memorandums from the following disciplines: economics, civil design, real estate, cost engineering, hydrology, hydraulics, and geotechnical. These documents form the basis for selection of the final array of alternatives.

This documentation is in support of Appendix III, Evaluation and Comparison of the Final Array of Alternatives and Identification of the Tentatively Selected Plan. This document includes the description, evaluation and comparison of the final array of alternatives. For additional detail on the economic methodologies and step taken in the refinement of the draft array of alternatives, please see Progress Document #2, Economic Appendix.

Study Area. The 300 square mile study area is located in Butte and Sutter Counties California. A map showing the location of the study area relative to the watershed is provided as Plate #1. A map of the study area topography is provided in Plate #2, which shows elevation ranges from 110 feet to 30 feet. The study area is encircled by federal project levees along the Sutter Bypass, Feather River, Cherokee

Canal, Wadsworth Canal and the high ground of the Sutter Buttes. The federal levees are features of the Sacramento River Flood Control Project (SRFCP), authorized by Congress in 1917. The SRFCP incorporated features such as levees, weirs, and pumping facilities into a system of leveed river channels and flood bypass channels to provide Flood Risk Management benefits to the Sacramento Valley.

Population estimates from 2010 Census are tabulated by economic impact area in Table 2. A map of the estimated population density throughout the study area is provided in Plate #3.

Table 2. Population

Economic Impact Area	Population
Yuba City Urban	67,370
Biggs Urban	1,760
Gridley Urban	6,380
Live Oak Urban	8,360
Sutter County Rural	6,340
Butte County Rural	4,900
Total	**95,110**

The primary sources of flooding within the study area are the Butte Basin, Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal, and local interior drainage. Flood depths and frequency vary throughout the study area. Probability of flooding within the study area is primarily related to the stage of floodwaters within the river channels and the geotechnical probability of levee failure at flood stage. The Sacramento River Flood Control Project levees were often constructed of poor foundation materials such as river dredge spoils that does not meet current engineering standards. These legacy levees are relied upon today to provide FRM for numerous communities within the Sacramento Valley.

Historical Assessment. In 1955, flood waters from a levee breach encompassed a significant portion of the study area inundating 6,000 homes, drowning 38 people, injuring 3,200 individuals, and requiring 600 people to be rescued by helicopter (Plate #4). From 1950 to 2011, extensive flood fighting has occurred during 19 events, and levee failures adjacent to the Sutter Basin took place in 1986 and 1997. Flooding historically has occurred during the months of December through February with air temperatures of 38 to 55°F and water temperatures of 45 to 55°F; temperatures which significantly increase risk of death by exposure.

Recent geotechnical analysis and evaluation of historical performance during past floods indicate the project levees within the study area do not meet USACE levee design standards and are at risk of breach failure at stages less than overtopping. This was evidenced by historical boils and heavy seepage at stages less than authorized design flows. Underseepage failures are sudden and unpredictable, resulting in minimal warning time, and ineffectiveness of evacuation plans. Though, almost every location within the study area is afforded some flood risk reduction by these levees, the risk of unexpected levee failure coupled with the consequence of flooding presents a continued threat to public safety, property, and critical infrastructure.

2. REVIEW OF EXISTING CONDITIONS

Floodplain Area and Economic Inventory. An economic inventory was assembled following standard USACE methods. For the study area, a base geographic information system (GIS) inventory with parcel attribute data was provided by the local sponsor for both Sutter and Butte Counties. Field visits were conducted to collect and validate the base inventory data. Parcels with structures were categorized by land use and grouped into residential, commercial, industrial or public categories. The value of damageable structures was estimated based on depreciated replacement values. The total value of damageable property (structures and contents) within the Sutter Basin study area is estimated at $6.9 billion (Table 3). Table 4 displays the structural inventory by land use category.

Table 3. Value of Damageable Property
October 2012 Prices (Values in 1,000's)

Economic Impact Area	Structures and Contents				
	Commercial	Industrial	Public	Residential	Total
Biggs	6,600	2,400	0	74,600	**83,600**
Gridley	72,200	51,900	3,500	286,800	**414,300**
Live Oak	25,600	3,700	42,000	319,900	**391,200**
Yuba City	1,054,800	417,800	334,400	3,593,600	**5,400,700**
Rural Butte	3,900	45,700	0	200,300	**249,800**
Rural Sutter	9,000	39,600	18,500	275,000	**342,200**
Total	**1,172,200**	**561,000**	**398,500**	**4,750,100**	**6,881,900**

Table 4. Structural Inventory –Existing Conditions
Number of Structures within 0.2% (1/500yr) Annual Chance Floodplain

Economic Impact Area	Commercial	Industrial	Public	Residential	TOTAL
Biggs	18	1	0	586	**605**
Gridley	81	7	4	1,931	**2,023**
Live Oak	51	5	23	2,088	**2,167**
Yuba City	872	210	122	18,760	**19,964**
Rural Butte	10	16	0	1,242	**1,268**
Rural Sutter	10	29	8	1,162	**1,209**
Total	**1,042**	**268**	**157**	**25,769**	**27,236**

HEC-FDA Modeling Efforts. For the economic analysis, the existing levees were separated into thirteen levee reaches and a representative breach location was chosen for each reach. When the study area becomes inundated, the floodwaters flow from north to south and then pool in the southern portion of the study area to twenty feet or more. Therefore, a levee breach at the northern section of the Feather River would result in a larger inundation area than a breach at the southern portion, but does not necessarily mean that a northern breach has the highest risk (probability and consequence). Because the levees around the Sutter study area have distinct deficiencies, each has a different probability of failure in any

given flood event. The probability of flooding from each source is based on the hydrologic frequency, stage-discharge relationship and geotechnical performance. These parameters serve as inputs into the Corps FRM-PCX certified HEC-FDA model (v1.2.5a).

Without-Project Damages. The main analytical tool used to perform the economic analysis was the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software. This program stores the engineering probability data (hydrologic, hydraulic, and geotechnical) and the economic consequence data (structure/content inventory and depth-percent damage curves), and is used to model the flooding problem and potential alternative solutions in the study area. By relating the economic inventory data to the floodplain data, the HEC-FDA software computes economic stage-damage curves. Through integration of the main engineering relationships (exceedance probability-discharge curves, rating curves, and geotechnical levee fragility curves) and the main economic relationship (stage-damage curves), the HEC-FDA software computes project performance statistics and expected annual damages/benefits. The results of the economic modeling are then used as input into the net benefit and benefit-to-cost analyses and may also aid in plan formulation, all of which are performed external to the HEC-FDA software.

The HEC-FDA without project conditions model results (expected annual damages) for structures, contents, automobiles, and agriculture are shown, by economic impact area (EIA) in Table 5. The total study area without project damages are estimated to be $114 million.

Table 5. Expected Annual Damages—Without Project Condition
October 2012 Prices (Values in $1,000s), 3.75 Discount Rate

Economic Impact Area	Damage Category						
	Agriculture	Autos	Commercial	Industrial	Public	Residential	Total
Biggs	4	88	80	30	0	488	**689**
Gridley	5	176	998	296	48	973	**2,495**
Live Oak	9	240	322	52	464	1,435	**2,523**
Yuba City	246	4,175	15,477	6,342	4,207	26,031	**56,477**
Rural Butte	1,875	134	51	260	0	759	**3,079**
Rural Sutter	16,227	1,928	1,110	5,660	3,383	18,476	**46,783**
Total	**18,366**	**6,739**	**18,039**	**12,639**	**8,101**	**48,162**	**112,046**

Without Project Performance. In addition to damages estimates, HEC-FDA reports flood risk in terms of project performance. Three statistical measures are provided, in accordance with ER 1105-2-101, to describe performance risk in probabilistic terms. These include annual exceedance probability, long-term risk, and assurance by event.

- Annual exceedance probability measures the chance of having a damaging flood in any given year.
- Long-term risk provides the probability of having one or more damaging floods over a period of time.

- Assurance is the probability that a target stage will not be exceeded during the occurrence of a specified flood.

The worst project performance statistics may not necessarily be associated with the breach location producing the largest economic damages. For example, an impact area may be subject to flooding from two different rivers. River A might have a higher likelihood of flooding than River B but River B's associated floodplain (consequence) may be larger and cause more damages. If that is the case, then project performance (likelihood of flooding) is not the primary dictator in consequence. Nevertheless, if a proposed project alleviates River B's floodplain, the project performance is still limited by River A's performance. For the Yuba City economic impact area, performance is dictated by an index point along the Sutter Bypass. However, the associated floodplain does not impact Yuba City until the 0.2% ACE whereas a break along the Feather River poses imminent damages due to its associated consequence (floodplain) even though it statistically has a higher performance when compared to the Sutter Bypass. Project performance statistics for each area under without project conditions is displayed in Table 6.

Table 6. Project Performance by Economic Impact Area—Without Project Condition

Economic Impact Area	Breach Location	Annual Exceedance Probability		Long Term Risk			Assurance by Event			
		Median	Expected	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.20%
Biggs	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Gridley	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Live Oak	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Yuba City	F5.0R	0.04	0.04	33%	70%	86%	85%	67%	60%	22%
Rural Butte	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Rural Sutter	S4.0L	0.45	0.52	99%	100%	100%	33%	30%	22%	6%

Agricultural Damages. ER 1105-2-100, Appendix E, beginning on page E-113 includes specific guidance for studies where the primary damages occur to agricultural crops. Primary damages in this evaluation focus on the crop damage, loss of stored crops, and loss of farm equipment. These damages are directly related, and evaluated with special consideration for the expected time of seasonal flooding as well as the variability associated with crop prices and yields. The identified hydrologic/hydraulic variables, discharge associated with exceedence frequency and conveyance roughness and cross-section geometry, also apply to agricultural studies. Based on empirical analyses conducted for past Corps projects, subject matter expertise from the agricultural economist and professional judgment, the project delivery team expects agricultural damages to total 10-15% of total project damages; amounts which are not expected to drive plan selection. A simplified approach was developed for this study based on stage-damage curves for land use types within the study area and simplifying calculations by utilizing 1,000 ft by 1,000 ft hydraulic model grid elements. For detailed information regarding data collection, assumptions, and methodology see the Memorandum for File titled "Agricultural Damages for Final Alternative Comparison" dated 22 February 2013 (Enclosure 1).

3. ALTERNATIVE EVALUATION

Plan Formulation and Description of Alternatives. The plan formulation process develops and evaluates alternative plans to address the needs and desires of society as expressed in specific planning objectives. Accordingly, the tentatively selected plan best satisfies the objectives as well as the Federal interests, which are consistent with the Federal Water Resources Council's Principles and Guidance (P&G) and the Planning guidance Notebook (ER-1105-2-100). What follows is a brief timeline of the planning process leading up to the final array of alternatives. More detail can be found in Progress Document #1.

(1) Management Measures (Critical Thinking Charette): A broad array of management measures was developed based on information from existing reports and studies, as well as public input and professional judgment. Following the initial screening of measures, the team identified four themes (strategies) for plan formulation (1- Consequence Management Focused on Public Safety, 2-Urban FRM, 3-Maximize Existing System with FRM Focus, and 4-Ecosystem Restoration Focus). These themes were used to establish a preliminary array of conceptual alternatives by grouping measures according to the primary focus of each theme.

(2) Preliminary Array of Alternative: Each alternative was further developed and quantities, costs and economic benefits were estimated at a reconnaissance level. The use of these results was solely to screen out those preliminary alternatives that did not appear economically justified even in the most favorable conditions.

(3) Refinement of Draft Array of Alternatives (Value Engineering Study): The remaining alternatives were furthered refined. This resulted in combining and eliminating some of the alternatives as well as refining and optimizing those that were retained by adding or removing measures in order to ensure a robust array of draft alternatives. The draft array of alternatives were then evaluated in further detail, and screened to a final array of alternatives. See Economic documentation in support of Appendix II, Draft Alternative Evaluation and Selection of Final Alternatives, for more detail.

(4) Final Array of Alternatives: The final array of alternatives carried forward for final comparison include:

- Alternative SB-1: No Action
- Alternative SB-7: Fix-in-place the Feather River, Sunset Weir to Laurel Avenue
- Alternative SB-8: Fix-in-place the Feather River, Thermalito to Laurel Avenue

With-Project Modeling Results. Benefits were determined by incorporating increments of levee fixes into the HEC-FDA model that represent various with-project improvements. Flood risk management benefits (Table 8) equal the difference between the without project damages (Table 5) and the with-project residual damages (Table 7).

Table 7. Expected Annual Damages—Alternative Conditions
October 2012 Prices (Values in $1,000s), 3.75 Discount Rate

Alternative	Economic Impact Area						Total
	Biggs	Gridley	Live Oak	Yuba City	Rural Butte	Rural Sutter	
SB-1: No Action	689	2,495	2,523	56,477	3,079	46,783	112,046
SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue	689	2,495	2,523	8,289	3,079	31,071	48,146
SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue	263	348	396	8,281	1,467	30,721	41,476

Table 8. Annual Benefits—Alternative Conditions
October 2012 Prices (Values in $1,000s), 3.75 Discount Rate

Alternative	Economic Impact Area						Total
	Biggs	Gridley	Live Oak	Yuba City	Rural Butte	Rural Sutter	
SB-1: No Action	-	-	-	-	-	-	-
SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue	-	-	-	48,188	0	15,712	63,900
SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue	426	2,147	2,127	48,196	1,612	16,062	70,570

Probability Distribution of Damages Reduced. In accordance with ER 1105-2-101, flood damages reduced were determined as mean values and by probability exceeded. Table 9 shows the benefits for each alternative for a probability distribution and expected value. The damage reduced column represents the expected benefits for each alternative, while the probability damage reduced indicate the confidence of benefits exceeding the indicated amount. For example, Alternative SB-7 has expected benefits of $57 million at the 50% confidence interval, and 75% confidence that benefits will be equal to or greater than $37 million. The range in probability distribution of damages reduced is indicative of the uncertainty in the benefits estimates, which incorporates all the uncertainties in hydrology, hydraulics, geotechnical and economics in the HEC-FDA model. The uncertainty in damages reduced is a critical component when selecting an optimal plan during the plan formulation process. Professional judgment guides the determination of an alternative meeting a reasonable level of confidence regarding positive net benefits.

Table 9a. Probability Distribution of Damages Reduced—Study Area
October 2012 Prices (Values in $1,000s), 3.75 Discount Rate

Alternative	Annual Damages			Probability Damage Reduced		
	Without Project	With Project	Damage Reduced	75%	50%	25%
SB-1: No Action	112,046	112,046	0	0	0	0
SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue	112,046	48,146	63,900	35,742	52,323	87,895
SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue	112,046	41,476	70,570	38,445	58,915	97,166

Table 9b. Project Performance by Economic Impact Area—Alternative SB-7

Economic Impact Area	Breach Location	Annual Exceedance Probability		Long Term Risk			Assurance by Event			
		Median	Expected	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.20%
Biggs	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Gridley	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Live Oak	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Yuba City	F3.0R	0.002	0.003	3%	8%	13%	99%	99%	97%	48%
Rural Butte	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Rural Sutter	S4.0L	0.45	0.52	99%	99%	99%	33%	30%	22%	6%

Table 9b. Project Performance by Economic Impact Area—Alternative SB-8

Economic Impact Area	Breach Location	Annual Exceedance Probability		Long Term Risk			Assurance by Event			
		Median	Expected	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.20%
Biggs	F9.0R	0.002	0.002	2%	7%	11%	99%	99%	97%	64%
Gridley	F9.0R	0.002	0.002	2%	7%	11%	99%	99%	97%	64%
Live Oak	F9.0R	0.002	0.002	2%	7%	11%	99%	99%	97%	64%
Yuba City	F3.0R	0.002	0.003	3%	8%	13%	99%	99%	97%	48%
Rural Butte	F9.0R	0.002	0.002	2%	7%	11%	99%	99%	97%	64%
Rural Sutter	S4.0L	0.45	0.52	99%	99%	99%	33%	30%	22%	6%

4. ALTERNATIVE COMPARISON

Net Benefit Analysis. Economic feasibility and project efficiency are determined through a benefit-cost analysis. For a project to be feasible, benefits must exceed costs and the most efficient alternative is one that maximizes net benefits (annual benefits minus annual costs). The identification of such alternative is referred to the National Economic Development Plan (NED). Table 10 summarizes the net benefit analysis of the final array of alternatives using probability reduced damages at varying confidence intervals in terms of benefits and costs (25%, 50% and 75%), while Table 11 shows the net benefit analysis using the mean computed benefits and cost at an 80% confidence level[1] per standard USACE practice.

Table 10. Net Benefits[2] (Varying Confidence Intervals)—Final Array of Alternatives October 2012 Prices (Values in $Millions), 3.75 Discount Rate

Category	Alternative						
	SB-1: No Action	SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue			SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue		
		Low	Mid	High	Low	Mid	High
Total First Costs		392	410	430	676	708	742
Less Cultural Resources (-)		-3	-3	-3	-3	-3	-3
Interest During Construction (+)		25	33	42	61	81	102
Subtotal		***414***	***440***	***469***	***734***	***786***	***841***
Interest and Amortization		18	20	21	33	35	38
OMRR&R			0.28			0.45	
Annual Cost		18	20	21	33	36	38
Annual Benefits		36	52	88	38	59	97
Net Benefits		**23**	**39**	**58**	**11**	**30**	**51**
Benefit to Cost Ratio		**2.1**	**3.0**	**4.0**	**1.3**	**1.8**	**2.5**

[1] Standard practice in Corps Feasibility Studies.
[2] Net Benefits and Benefit to Cost Ratios are a result of Monte Carlo simulations using triangular distributions of annual benefit and annual costs confidence intervals as inputs.

Table 11. Net Benefits (Mean, Standard Corps Practice)—Final Array of Alternatives October 2012 Prices (Values in $Millions), 3.75 Discount Rate

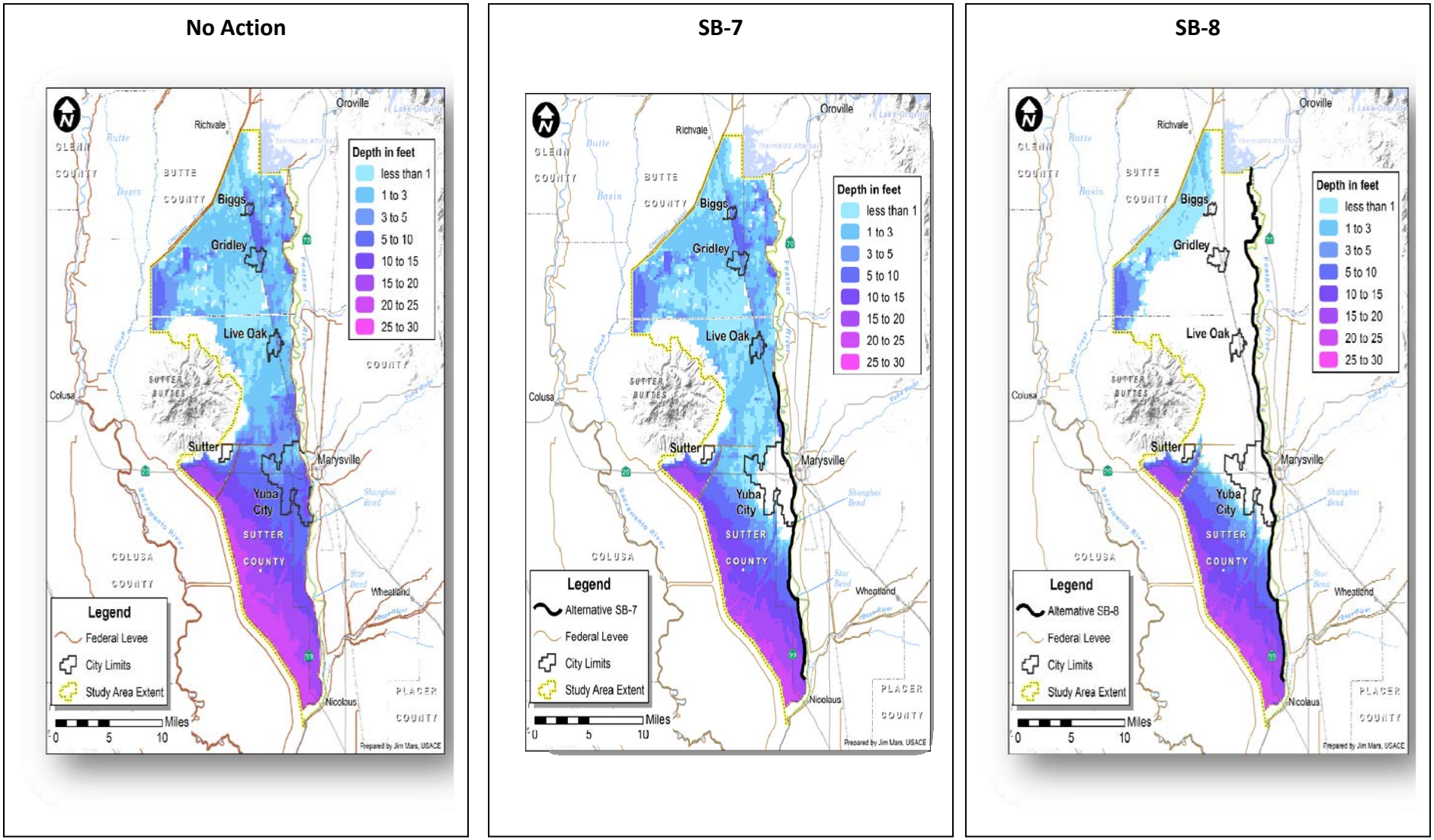
Category	Alternative		
	SB-1: No Action	SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue	SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue
Total First Costs		432	748
Less Cultural Resources (-)		-3	-3
Interest During Construction (+)		44	107
Subtotal		***473***	***853***
Interest and Amortization		21	38
OMRR&R		0.28	0.45
Annual Cost		21	38
Annual Benefits		64	71
Net Benefits		**43**	**33**
Benefit to Cost Ratio		**3.0**	**1.9**

Residual Floodplains: Residual 1% ACE floodplains[3] for the final array of alternatives are shown in figures below. SB-7 reduces adverse flooding effects but benefits are primarily centered on Yuba City. The alternative features do not address the significant flooding risk in the communities of Biggs, Gridley, and Live Oak. SB-8 reduces the residual risk for the northern communities.

Residual Population at Risk (PAR): PAR within the 1% ACE floodplain for the No Action Alternative is 94,600. SB-7 reduces the 1% floodplain PAR to 38,200, while SB-8 reduces PAR to approximately 6,600.

[3] 1% floodplains are based on the inundation from any levee having less than 95% assurance. The assurance estimate was based on geotechnical, hydraulic, and hydrologic uncertainty.

Figure 1: 1% ACE Residual Floodplains for the Final Array



5. OTHER SOCIAL EFFECTS

Purpose and Methodology. This portion of the economic analysis documents the results of the Other Social Effects (OSE) account analysis associated with the Sutter Basin Pilot Feasibility Study. The analysis is intended to provide a portrait of the social landscape of the study area and offer a glimpse as to the vulnerability of the populations that call Sutter Basin their home.

A concern for social effects associated with water resources development and management has long been part of federal water resources planning guidance, appearing as the Social Well-being Account in 1972 *Principles and Standards*, and later as the OSE account in the *Principles and Guidance* (P&G) adopted in 1983 and in the Corps' ER 1105-2-100. However, since the adoption of the P&G there has been a tendency to discount the role and importance of OSE factors in water resources planning. Now, new guidance is being promulgated and implemented—principally EC 1105-2-409 *Planning in Collaborative Environment*—is placing much greater emphasis on the importance of including a broad range of considerations in planning. In addition to NED factors, other considerations, including social factors addressed in the OSE account, are to be used to develop appropriate water resources solutions.

Essentially, the OSE account serves to answer the following question:

> *How are social connectedness, community social capital, and community resiliency likely to change in the absence of a solution to a water resource issue? How are vulnerable populations likely to be affected?*
>
> **Metrics:**
> - Social Connectedness will be measured using Gender, Race & Ethnicity, Age, Rural/Urban Communities, Rentals vs. Homeownership and Occupation.
> - Community Social Capital will be measured using Education, Family Structure, Rural vs. Urban Communities and Population Growth.
> - Community Resilience will be measured using Income, Political Power, Prestige, Employment Loss, Residential Property, Infrastructure/Lifetime, Family Structure and Medical Services.

This assessment is in accordance with standards, procedures, and guidance of the U.S. Army Corps of Engineers. The *Planning Guidance Notebook* (ER 1105-2-100) serves as the primary source for evaluation methods of flood risk management studies and was used as a reference for this analysis. Additionally, the Institution for Water Resources *Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning* (IWR 09-R4) served instrumental in conducting the analysis.

This report analyzes the social effects related to the without and with-project conditions. The 1% annual chance exceedance (ACE) floodplain serves as the basis for the analysis of impact.

Historic Digest. The topography of the Sutter Basin is composed primarily of the gentle flatlands of the Sacramento Valley. Prior to the settlement of European populations, the basin was dominated by immense wetlands and riparian forest. The historic habitats of Sutter Basin supported large populations of waterfowl and other wildlife. In the 1830s, European settlers started to cultivate the basing for

agricultural use. Other practices included livestock grazing and controlled burns. The late 1800s brought gold miners during the Gold Rush and later cattle drivers that stayed to continue to use the rich soil for agriculture production. This resulted in lower areas and interior valleys being sparsely inhabited by ranchers and farmers. By the 1930s, the majority of the basin was cultivated for agricultural production and cattle grazing. Currently, the basin is a major agricultural center in northern California. Sutter basin is composed of two counties, Sutter and Butte. Both of which are primarily agricultural communities. The *2001 Census of Agriculture* classifies 88% of Sutter County's acreage of being in farms. The five leading crops based are rice, peaches, walnuts, dried plums, and tomatoes. Within the Sutter Basin study area boundary, Sutter County includes two cities (Yuba City and Live Oak), and Butte County includes another two cities (Biggs and Gridley).

Social Profile. A first key step in helping the decision-makers gain a better understanding of the social landscape—e.g., identifying who lives in the study area, who has a stake in the problem or issue and why it is important to them. This fundamental step entails performing a profile of the area in terms of basic social statistics, and to make such presentation of information meaningful by providing useful comparisons and rankings. The preparation of the social profile is not the OSE analysis. Social profiling provides the basic level of understanding about the social conditions, but more in-depth analysis is required to target areas of special concern or relevance to the specifics of the water resources issues. The basic social statistics discussed below are indicators used to portray basic information about the social life and the processes of the area under study. The development of these basic social characteristics (Table 12) present a portrait of the study area.

The 300 square mile study area is home to over 95,110 people. Approximately 88% of the total population abides in one of four incorporated cities. Yuba City makes up the majority of the population with 64,900 individuals. The communities of Live Oak, Gridley and Biggs have 8,400, 6,600, and 1,700 persons, respectively. The remainder of the population of 11,240 individuals reside in the surrounding rural areas of Sutter and Butte Counties. The study has seen a significant increase in population over the last decade. The growth has been primarily centered in Yuba City, which saw its population grow from 36,760 people in 2000 to 60,510 in 2006, a 65% increase.

The median age of the study area is consistent with State and national averages; as is the population over 65. However, the population under 18 years of age is higher in the study are (>28%) compared to State (25%) and national (24%) averages. Education statistics indicate lower levels of attainment. The percent of individuals over 25 with a high school degree (or equivalent) and percent of college graduates are lower than State and national averages.

Variances in race and ethnicity in communities may impose language and cultural barriers that affect ability to cope with natural hazards. The Hispanic presence is evident given they make up at least 28% of the population in each community. Live Oak's population is composed of 48.8% of individuals of Hispanic origin, which is significantly higher than the State average of 37.6% and greatly exceeds the national average of 16.3%.

Median household income for the study area ranges from $36,563 (Gridley) to $48,830 (Yuba City). Both of which are below State ($61,632) and national (52,762) averages. The persons living at or below the poverty level in the study area are 22.7%, 21.4% and 15% for Biggs, Gridley and Yuba City, respectively. All of which are larger than the State (14.4%) and national (14.3%) averages.

The total labor force in the study area is estimated at 40,000, with an unemployment rate of 14.7%, 8.4%, and 9.3% in Biggs, Gridley and Yuba City, respectively. Total private wage or salary workers estimated to be 75% (Biggs), 65% (Gridley) and 69% (Yuba City) with 17% (Biggs), 25% (Gridley) and 20% (Yuba City) of the labor force rated as government workers. Approximately, 7% (Biggs), 11% (Gridley) and 11% (Yuba City) of the labor force was considered to be self-employed, not incorporated. The average wage per job so the study area is between $22,300 to $28,100.

Table 12. Basic Social Characteristics—Sutter Basin Study Area
2010 Census Demographic Data

Basic Social Statistic	Study Area Community				California	National
	Biggs	Gridley	Live Oak	Yuba City		
Population						
Current Population (2010)	1,760	6,380	8,360	67,370	37,254,000	308,746,000
Age						
Median Age	35.1	33.1	31.7	33	35.2	37.2
% 65 and above	10.9%	14.1%	10.7%	11.7%	11.4%	13.0%
% under 18	28.1%	28.7%	30.6%	28.2%	25.0%	24.0%
Race and Ethnicity						
Asian	0.5%	3.7%	11.4%	17.0%	12.8%	4.7%
Black	0.4%	0.5%	1.4%	2.2%	5.8%	12.2%
Hispanic	34.0%	45.6%	48.8%	28.4%	37.6%	16.3%
White	60.5%	46.7%	35.0%	47.4%	40.1%	63.7%
Other	4.6%	3.5%	3.4%	5.0%	3.7%	3.1%
Education						
% HS Graduates	75.1%	64.6%	-	77.6%	80.8%	85.4%
% College Graduates	9.3%	10.1%	-	19.2%	30.2%	28.2%
Income and Poverty Status						
% Unemployed	14.7%	8.4%	-	9.3%	6.5%	5.6%
Median Household Income	$44,485	$36,563	-	$48,830	$61,632	$52,762
Persons below Poverty (%)	22.7%	21.4%	-	15.0%	14.4%	14.3%
Housing						
Homeownership Rate	69.4%	57.8%	65.9%	56.9%	55.9%	65.1%
% of Mobile Homes	2.7%	3.6%	-	4.4%	3.9%	6.6%
Quality of Life						
Average Household Size	3.37	3.63	3.88	3.49	3.45	2.58
Language Other than English Spoken at Home	32.6%	43.7%	-	40.1%	43.2%	20.3%
Mean travel time to work (minutes)	26.4	21	-	28	27	25.4

Social Effects Assessment.

Social Vulnerability and Resiliency: Social vulnerability is a term described by the sensitivity of a population to natural hazards, where as resiliency refers to the population's ability to respond to and recover from the impacts of such hazard. The characteristics that are recognized as having an influence on social vulnerability generally include age, gender, race and socioeconomic status. Other characteristics include population segments with special needs or those that lack the normal social safety nets necessary in disaster recovery, such as the physically or mentally challenged, non-English speaking immigrants, transients and seasonal tourists. The quality of human settlements (housing type and construction, infrastructure and lifelines) and the built environment are also important in understanding social vulnerability, especially as these characteristics influence potential economic losses, injuries, and fatalities from natural hazards. Table 13 provides discussion of factors that may dictate vulnerability and ability to cope with natural hazards, along with an assessment as it relates to the Sutter Basin study area.

Table 13. Social Vulnerability and Resiliency Indicators
Assessment of the Sutter Basin Study Area

Indicator	Discussion	Assessment
Income, political power, and prestige	This measure focuses on ability to absorb losses and enhance resilience to hazard impacts. Wealth enables communities to absorb and recover from losses more quickly due to insurance, social safety nets, and entitlement programs.	As a measure, median household income of the study area is less than the State and national average. The communities may be at a disadvantage in recovery efforts.
Gender	Women can have a more difficult time during recovery than men, often due to sector-specific employment, lower wages and family care responsibilities.	Although data is not specifically available concerning the wage rate of male versus female for the study area, it is recognized that a smaller percent of women are employed in the labor force in the study area than in the larger metropolitan city of Sacramento. However, the percent of variation of this factor is quite small.
Race and Ethnicity	Race and ethnicity may impose language and cultural barriers that affect access to post-disaster funding and residential locations in high hazard areas.	It is recognized that the study areas has a significant Hispanic population, which may pose a risk to the resiliency of the community. Of particular note is the fact that between 33-43% of the population speak a language other than English at home.
Age	Extremes of the age spectrum inhibit the movement out of harm's way. Parents lose time and money caring for children when daycare facilities are affected, elderly may have mobility constraints or mobility concerns increasing the burden of care and lack of resilience.	Those over 65 years of age are estimated at 11-14%, which is similar to State and national averages. Those under 5 years of age are estimated at around 8%, which is slightly above State and national averages.
Employment Loss	The potential loss of employment following a disaster exacerbates the number of unemployed workers in a community, contributing to a slower recovery from the disaster.	The current unemployment rate of the study area is higher than the State, which indicates that there may be financial issues in dealing with re-establishing housing.
Rural/Urban	Rural residents may be more vulnerable due to lower incomes, and more dependent on locally based resource extraction economies (farming and fishing). High-density areas (urban)	Because 12% of the population reside in the rural areas of the study area, there may be concern in their ability to recover from

	complicate evacuation from harm's way.	natural hazards.
Residential Property	The value, quality, and density of residential construction affect potential losses and recovery. For example, expensive homes are costly to replace, while mobile homes are easily destroyed and less resilient to hazards.	Percentage of mobile homes are similar to State averages, both of which are less than the national average.
Infrastructure and Lifelines	Loss of sewers, bridges, water, communications, and transportation infrastructure may place an insurmountable financial burden on the smaller communities that lack the financial resources to rebuild.	The smaller communities of Biggs, Gridley, and Live Oak are at a greater risk of coping with a natural hazard given their lack of financial resources when compared to the larger urban community of Yuba City.
Renters	People that rent typically do so because they are either transient or do not have the financial resources for home ownership. They often lack access to information about financial aid during recovery. In the most extreme cases, renters lack sufficient shelter options when lodging become uninhabitable or too costly to afford.	Housing rentals range between 30-43% of Sutter Basin's households. The high rental population highlights indications of community cohesion issues. Research indicates that renters do not have the same community pride as owners thereby having more barriers to direct community involvement in redeveloping the community after a natural hazard.
Occupation	Some occupations, especially those involving resource extraction, may be severely impacted by a hazard event. Self-employed fisherman suffer when their means of production is lost and may not have the requisite capital to resume work in a timely fashion and thus will seek alternative employment. Migrant workers engaged in agriculture and low skilled service jobs (housekeeping, childcare, and gardening) may similarly suffer, as disposable income fades and the need for services decline. Immigration status also affects occupational recovery.	Because the study area's industry is primarily driven by agricultural production, many workers may have a difficult time coping with natural hazards.
Family Structure	Families with large numbers of dependents or single-parent households often have limited finances to outsource care for dependents, and thus must juggle work responsibilities and care for family members. All affect the resilience torecover from hazards.	The literature indicates that families having over 4 or more persons have more financial difficulty than those of lesser numbers. Accordingly, community planners need to be aware of pending issues.
Education	Education is strongly linked to socioeconomic status, with higher educational attainment resulting in greater lifetime earnings. Lower education constrains the ability to understand warning information and access to recovery information.	With between 23-35% of Sutter Basin's residents having less than high school education there may be constraints in the ability of those residents to adequately deal with local, state, and federal information requirements surrounding recovery efforts.
Population Growth	Counties experiencing rapid growth lack available quality housing and the social services network may not have had time to adjust to increased populations. New migrants may not speak the language and not be familiar with bureaucracies for obtaining relief or recovery information, all of which increases vulnerability.	Sutter Basin has grown significantly in the past 10 years. A rapid growth rate in population is highly correlated with low community cohesion. The sense of belonging, cooperation, and strong sense of community pride are dynamic factors, which assist in the restoration of the community after a catastrophic event. Due to rapid growth in Yuba City, community bonds and sense of owning community issues may not be as strong as other more slowly growing cities like Biggs, Gridley, and Live Oak.

Medical Services	Health care providers, including physicians, nursing homes, and hospitals are important post-event sources of relief. The lack of proximate medical services will lengthen immediate relief and result in longer recovery from disasters.	Sutter Basin has many medical facilities available to its general population. This indicates very high medical assistance should natural hazard occur. Additionally, the nearby city of Sacramento is equipped to provide some medical assistance to the residents of Sutter Basin.

Environmental Justice: Executive Order 12898 concerning environmental justice provides direction on the analysis of social and economic effects that would be applicable to proposed flood risk management projects. Signed by President Clinton in 1994, EO 12898 (Federal Actions to Address Environmental Justice in Minority and Low-Income Populations) requires that environmental analyses of proposed Federal actions address any disproportionately high and adverse human health or environmental effects on minority and low-income communities. Additionally, EO 13045 (Protection of Children from Environmental Health Risks and Safety Risks) requires Federal agencies to identify, assess, and address disproportionate environmental health and safety risks to children from Federal actions.

(1st Step) According to the guidelines established to assist the Federal and State agencies in examining potential for environmental justice impacts, the first step in conducting an environmental justice analysis is to define minority and low income populations. Based on these guidelines, a minority and low-income population is present in a project study area if:

- The minority population of the affected area exceeds 50 percent or the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.
- The project study area is composed of 50 percent or more people living below the poverty threshold, as defined by the U.S. Census Bureau, or it is significantly greater than the poverty percentage of the general population or other appropriate unit of geographic analysis.

(2nd Step) The second step of an environmental justice analysis requires a finding of a high and adverse impact. The executive orders address the impacts on the demographic, economic, and social factors that could measurably alter the economic condition (i.e., the availability of employment), the accessibility of goods, infrastructure and services, and the quality of life in the area of influence. These types of impacts would be significant to the affected population. More specifically, a proposed project alternative would have a significant socioeconomic impact if it were to result in any of the following effects:

- Long-term increase in population that could not be accommodated by regional infrastructure (i.e., housing, utilities, roads, hospitals and schools) or services (such as police and emergency services)
- A reduction in the availability of affordable housing, which could occur either through a large increase in housing prices or a large decline in the supply of affordable housing
- Long-term displacement of population that could not be accommodated within the region

- Long-term displacement or disruption of local businesses that could not be accommodated within the region
- A loss in community facilities, events, populations, or major industry that would result in an overall loss in community cohesion
- Disruption of emergency services or creation of a public health risk that could not be avoided by the public, especially if it would particularly affect the health and safety of children

(3rd Step) A proposed project alternative would have an environmental justice impact if it were to cause impacts that are disproportionately high and adverse, either directly, indirectly or cumulatively. To make a finding that disproportionately high and adverse effects would likely fall on a minority or low-income population, three conditions must be met simultaneously:

- There must be a minority or low-income population in the impact zone
- A high and adverse impact must exist
- The impact must be disproportionately high and adverse on the minority or low-income population

Review of real estate records and discussion with USACE Sacramento District PDT disclosed that the construction of Alternative SB-7 and SB-8 have no major direct impact to residents in the immediate area. Implementing the proposed alternative would have a beneficial impact on the regional economy due to increased expenditures in the regional economy during the construction period. However, increased construction-related traffic, delays, and detours as well as an increased population due to the presence of a construction workforce can result in increased social tension during the construction period. Nevertheless, the conclusion based on the environmental justice criteria, is that there is no highlt adverse impact due to construction of either alternative project.

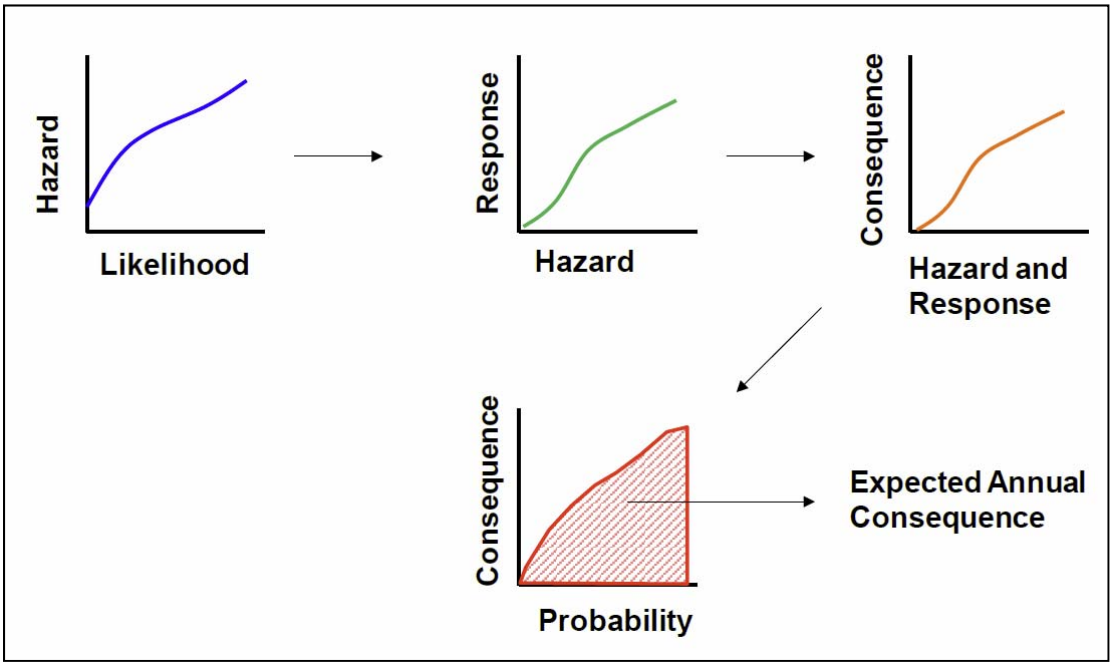
Life Safety Evaluation. Methods to calculate economic losses from natural hazards are fundamental to the planning process. However, such losses only capture part of the impact of natural hazards, and alternatives based only on reducing such damages miss a wide range of other important effects. A critical missing element from the current flood damage assessment approach is estimating the potential for loss of life and injury associated with flood events and flood damage reduction interventions. Current methodology has reached high level of sophistication but requires significant technical resources. However, the planning modernization paradigm calls for approaches that employ sound qualitative analysis guided by professional judgment rather than heavily focused high resource consuming quantitative processes.

Economists conducting the Sutter Basin Pilot Feasibility Study decided to make use of the Levee Screening Tool (LST) to facilitate preliminary assessment of the general condition and associated risks of levees in support of loss of life estimation. The LST provides an initial quantitative risk estimate to assist local, state, and Federal stakeholders in identification and prioritization of funding needs for levees of concern. All inputs for the LST will be estimated from readily available data. Estimates of the flood loading are made from information such as design documents, gage records, flood insurance studies, or project specific studies. An assessment of performance is based on results of the routine levee inspection and an engineering assessment of performance related items from the levee inspection checklist based on

a review of design documents and other relevant engineering data. Life safety consequences within the study area are estimated from readily available data.

The risk associated with levee segments and systems can be characterized by considering the magnitude and likelihood of a hazard (i.e. loading), the conditional response of the levee given the loading (i.e. performance), and the potential consequences that result from the combination of loading and response. Various loading scenarios may be possible as a result of the types of loading (e.g. flood), operational performance (e.g. gate closure), human intervention (e.g. sandbagging during a flood fight), or outcomes external to the levee system (e.g. upstream reservoir operations or failure of a nearby levee system). Performance of the levee can be described by one of the following inundation scenarios: 1) Breach prior to overtopping, 2) Overtopping with breach, 3) Overtopping without breach, and 4) Component malfunction. Multiple performance modes (e.g. seepage and piping, overtopping, floodwall stability) can influence performance of the levee system and each performance mode can have different consequences depending on the location and severity of a levee breach. Consequences can also be influenced by various factors such as the effectiveness of warnings and evacuations and the depth, velocity, and rate of rise of flooding. The three primary inputs (load, performance, consequences) can be combined using probabilistic methods to obtain a risk estimate represented as a probability distribution of potential consequences. The expected value of risk (i.e. average annual) is often computed from this distribution and used as a point estimate of the risk. Point estimate results are commonly displayed on an f,N chart with the vertical axis representing the annual likelihood of inundation and the horizontal axis representing the average magnitude of consequences. A conceptual representation of the risk framework is provided in Figure 1.

Figure 2. Conceptual Risk Framework



The consequence portion of the LST includes computation that allow for an estimate of loss of life caused by inundation due to breach or overtopping of a levee. Readily available data and information are used

along with limited analysis to assess the potential consequences related to a breach prior to overtopping of a levee segment. The consequences section of the LST is subdivided into the categories of general information, evacuation effectiveness, fatality rate computation, and critical infrastructure. For additional information on methodology please see the *Levee Screening Tool: Methodology and Application* (November 2011, RMC-CPD-1).

The computed fatalities under a breach scenario for the without-project condition are estimated to be 388 and 489 for day and night settings, respectively. Table 14 indicates the results of the application of the LST to the estimated population under each alternative scenario. To the approximately 38,300 people at risk under Alternative SB-7, the potential loss of life estimate is 157 (day) and 197 (night) lost lives. And to approximately 6,640 people at risk under Alternative SB-8, the potential loss of life estimate is 27 (day) and 34 (night).

Table 14. Loss of Life Estimate

Community	Alternative					
	SB-1		SB-7		SB-8	
	Day	Night	Day	Night	Day	Night
Biggs	6	8	6	8	0	0
Gridley	26	33	26	33	0	0
Live Oak	34	43	34	43	0	0
Yuba City	276	348	47	59	14	18
Rural Butte	20	25	20	25	0	0
Rural Sutter	26	32	24	30	13	16
Total	**388**	**489**	**157**	**197**	**27**	**34**

In addition to loss of life evaluation, other metrics were developed to assess the vulnerability of individuals living in the study area. Table 15 describes the metrics used to further evaluate life safety and Table 16 shows their results by alternative.

Table 15. Description of Metrics

Evaluation Metric	Description
Population at Risk (People)	Number of people within the 1% ACE Floodplain based on the 2010 census blocks.
Critical Infrastructure (Facilities)	Number of fire stations, police stations, hospitals, senior living facilities, and jails that are of life safety significance.
Evacuation Routes (# of Routes)	Assesses the vulnerability of populations with regards to the number of escape routes available during flood events.
Wise Use of Floodplains (Acres)	Potentially developable land within the 0.2% ACE floodplain. Acres of land with 1% ACE flood depths less than 3 feet.

Table 16. Summary of Life Safety Metrics

Evaluation Metric	Alternative		
	SB-1	SB-7	SB-8
Population at Risk (People)	94,600	38,200	6,600
Critical Infrastructure (Facilities)	28	11	1
Evacuation Routes (# of Routes)	0	1	5
Wise Use of Floodplains (Acres)	71,800	88,200	100,200

Population at Risk. The population at risk of flooding from a 1% ACE flood event is 94,600 for the without project condition (Alternative SB-1). A remaining population of 38,200 and 6,600 are at risk of flooding from Alternative SB-7 and SB-8, respectively. Of special concern is the population over the age of 65 living within the study area since those individuals have been shown to be at higher risk of life loss in flood events. The community of Gridley has above average representation of individuals age 65 or older.

Critical Infrastructure. A significant amount of critical infrastructure is located within the Sutter study area. Critical infrastructure is a term used by governments to describe assets that are essential for the functioning of a society and economy from a national perspective. Most commonly associated with the term are facilities for fire stations, police stations, hospitals, senior living facilities, and prisons. The benefits of Alternative SB-7 are primarily centered around Yuba City and still at risk are 11 of the critical infrastructure in the communities of Biggs, Gridley and Live Oak.

Evacuation Routes. The primary urban centers in the region are Yuba City, Biggs, Gridley, and Live Oak. These communities are all located on or near California State Route 99, which runs north-south through the region. Each community is also relatively close to California State Route 20, a major east-west roadway, which could also be used in an evacuation. Highway 20 takes a generally straight east-west path across the Sacramento River and the Sutter Bypass on its way to Yuba City. The route crosses Highway-99 west of central Yuba City, and runs east through the northern Yuba City to the Feather River, which it crosses on the 10th Street Bridge into Marysville. The Sutter County Evacuation and Mass Shelter/Care Plan identifies Highway 20, 99 and 113 as the primary evacuation routes in the region. These routes are subject to change since these routes are event-specific and official routes are established by the County Sheriff's office during an emergency. The Butte County Office of Emergency Management does not have published evacuation routes at this time, but anticipates Highway 99, 162 and Colusa Highway could be used as conditions allow. During the 1997 event, seven different evacuation zones were established over seven days due to constantly changing conditions and levee breaks[4]. The main evacuation routes used for this flood event were Highway-99 north and Highway-113 south. Highway-20 west and Highway-99 south were used intermittently since all portions of these roads were not accessible at all times during the flood.

Evacuation preparation can be made days in advance for predictably rain events. For example, a 0.2% ACE (1/500 year event) rain storm would be identified by meteorologist and residents could be given notice days in advance. As a significant rain event nears, warnings and evacuation efforts would be increased and reiterated. This would allow time for evacuation of immobile residents and other people with special evacuation needs (hospitals, rest homes, jails, elderly individuals, schools) via the established routes. However, none of the historical flooding evacuations in the region have been due to foreseen

[4] Source: Sutter County Office of Emergency Management.

weather events. Historical flood evacuations in the region have been from levee failures due to underseepage, which is characterized by its unpredictability and sudden occurrence. The result is evacuations after levees have failed and widespread flooding is in progress. The 1955 flood occurred due to a levee break in late December where no prior evacuation notice was given. In the 1997 flood, Yuba City was evacuated and during the evacuation a levee on the east side of the Feather River near Olivehurst (which was not evacuated) broke.

The residual 1% ACE (1/100 year event) resulting from Alternative SB-7 impacts every major urban center and nearly every primary evacuation route in the region. The floodplain is due to potential levee failure upstream of Sunset Weir. All routes out of Biggs, Gridley and Live Oak are impacted by the residual floodplain. The only egress from Yuba City would be Highway 20 east into Marysville, which is a community surrounded by a ring levee. Additionally, heading eastbound entails driving over a four lane bridge that is not expected to adequately handle the additional traffic flow, and may create a bottle neck limiting evacuation.

Wise Use of Floodplains. A determination must be made as to whether the increase in potentially developable floodplain area is acceptable under Corps policy, or can be avoided or mitigated to an acceptable level within a justified cost. It is important to remember that the floodplain metric used in this analysis is a simple index based on physical parameters. The metric does not attempt to forecast future population growth, economic conditions, or government decisions that will constrain future floodplain development. Those factors should be considered in conjunction with the metric.

Without and With-Project Comparison. Corps assessment of beneficial and adverse effects are based on comparison of with-project alternatives to the future without-project alternative condition expected to prevail. The social effects of the alternatives have both direct and indirect effects. Direct effects result immediately from construction of the projects, whereas indirect effects result from the effects of the project on the existing social landscape in the study area. A first step is describing or characterizing the alternatives in terms of descriptors such as magnitude (number of individuals affected), location (concentration of effects), timing and duration (when the effects will start and how long they are expected to last), and associated risks. Table 17 provides a description of the effects of each alternative, including the no action.

Table 17. Characterization of Alternative Effects

	SB-1	SB-7	SB-8
1. ALTERNATIVE DESCRIPTION			
	Alternative SB-1: The No Action provides no physical project constructed by the Federal Government.	Alternative SB-7: The plan is a Feather River fix-in-place levee alternative from Sunset Weir to Laurel Avenue.	Alternative SB-8: The plan is a Feather River fix-in-place levee alternative from Thermalito to Laurel Avenue.
2. OTHER SOCIAL EFFECTS			
Summary	Continued flood risk and consequences in the Sutter Basin including the communities of Yuba City, Live Oak, Gridley, and Biggs.	Flood Warning Emergency Evacuation Plan (FWEEP) mitigation is problematic for types of levee failures and limited evacuation routes. Significant life safety residual risk to the communities of Yuba City, Live Oak, Gridley, and Biggs.	Flood Warning Emergency Evacuation Plan (FWEEP) mitigation is problematic for types of levee failures and limited evacuation routes. Life safety residual risk to the communities of Yuba City, Live Oak, Gridley, and Biggs are significantly reduced.
Population at Risk	Approximately **96,600** individuals are within the 1% ACE floodplain.	**38,200** people remain in the 1% ACE floodplain. (60% of population is removed from the 1% ACE residual floodplain.)	**6,600** people remain in the 1% ACE floodplain. (93% of population is removed from the 1% ACE residual floodplain)
Loss of Life	Potential loss of lives: **Day-388, Night-489**	Potential loss of lives: **Day-157, Night-197**	Potential loss of lives: **Day-27, Night-34**
Critical Infrastructure	**28** structure deemed as critical from a national perspective are at risk from floods.	**11** structures remain at risk from floods.	**1** structure is at risk from floods.
Evacuation Routes	In the event of a flood, no evacuation route is available out of the basin.	Offers **one** problematic route for evacuation during a flood event. A flood warning and evacuation plan would not be as effective and limited.	**5** evacuation routes are available in the event of a flood. A flood warning and evacuation plan would have more robustness and redundancy.
Wise Use of Floodplains	Currently, 71,800 acres of land are potentially available for future development.	88,200 acres would be potentially available for future development.	100,200 acres of land would be potentially available for future development.
Social Vulnerability	The social vulnerability index score (SoVi) indicates the study area to be medium to high vulnerability. The No Action alternative may leave communities unable to cope with the recovery from a flood hazard.	Majority of the community of Yuba City is afforded flood risk reduction, however the communities of Live Oak, Gridley, and Biggs remain at risk of flood hazards and may be unable to cope and recover.	The four existing communities are provided flood risk reduction, and social vulnerability is minimized due to a decrease in the probability of flood hazards occurring.
Residual Risk and Consequences	Residual Risk remains high throughout the study area	Residual Risk for Life Safety is reduced for most of the Yuba City urban area.	Residual Risk for Life Safety is reduced in the high risk communities: Yuba City, Live Oak, Gridley and Biggs.

6. REGIONAL ECONOMIC DEVELOPMENT

Purpose and Methodology. The U.S. Army Corps of Engineers (USACE) *Planning Guidance Notebook* (ER 1105-2-100) states that while National Economic Development and Environmental Quality accounts are required, display of the Regional Economic Development effects are discretionary. The Corps' NED procedures manual affirms that RED benefits are real and legitimate; however, the concern (from a Federal perspective) is that they are often offset by RED costs in other regions. Nevertheless, for the local community these benefits are important and can help them in making their preferred planning decisions.

Although the RED account is often examined in less detail than NED, it remains useful. For example, Hurricane Katrina caused a significant economic hardship to not just the immediate Gulf Coast but for entire counties, watersheds, and the State of Louisiana. Besides the devastating damage to homes (which are often captures by the NED account), hundreds of thousands lost their jobs, property values fell, and tourism and tax revenues declined significantly and moved to other parts of the U.S. In this example, the RED account can provide a better depiction of the overall impact to the region.

The distinction between NED and RED is a matter of perspective, not economics. A non-federal partner may consider the impacts at the state, regional, and local levels to be a true measure of a project's impact or benefit, whereas from the Corps' perspective, this may not constitute a national benefit. Gains in RED to one region may be partially or wholly offset by losses elsewhere in the nation. For example, if a Federal project enables a firm to leave one state to locate in the newly-protected floodplain of another state, the increase in regional income for the project area may come at the expense of the former area's loss. As such, they may not influence the net value of the nation's output of goods and services and should be excluded from NED computations.

RED Concepts. The RED account has been given less emphasis in the Corps' past or current guidance. Perhaps the most extensive statement on RED appeared in the Principles and Guidance earlier version, the Principles and Standards:

> *"Through its effects—both beneficial and adverse—on a region's income, employment, population, economic base, environment, social development and other factors, a plan may exert a significant influence on the course and direction of regional development. The regional development account embraces several types of beneficial effects, such as (a) increased regional income, (b) increased regional employment, (c) population distribution, (d) diversification of regional economic base, and (e) enhancement of environmental conditions of special regional concern."*

Econometric analysis allows for the evaluation of the full range of economic impacts related to specific economic activities (construction and procurement) by calculating the direct, indirect and induced effects of the activities in the specific geographical designation.

- Direct Effects: consist of economic activity contained exclusively within the designated sector. This includes all expenditures made by the companies or organizations in the industry and all employees who work directly for them.
- Indirect Effects: define the creation of additional economic activity that results from linked business, suppliers of goods and services, and provisions of operating inputs.

- Induce Effects: measure the consumption expenditures of direct and indirect sector employees.

Input-output(I/O) models are characterized by their ability to evaluate the effects of industries on each other. Unlike most typical measures of economic activity that examine only the total output of an industry or the final consumption demand provided by a given output, I/O models provide a much more comprehensive view of the interrelated economic impacts. I/O analysis is based on the notion that there is a fundamental relationship between the volume of output of an industry and the volume of the various inputs used to produce that output. Industries are often grouped into production, distribution, transportation, and consumption. Additionally, the I/O model can be used to quantify the multiplier effect. In economics, the multiplier effects refers to the idea that an increase in spending can lead to even greater increase in income and consumption, as monies circulate or multiply through the economy.

Flood Risk Management RED Considerations. There are particular effects for each type of project improvement as they relate to the RED account. The estimation of RED flood-related effects can be very complex. At a minimum, the RED analysis should include a qualitative description of the types of businesses at risk from flooding, particularly those that could have a significant adverse impact (output, employment, etc.) upon the community or regional economies if their operations should be disrupted by flooding and how this would be affected by the recommended project. The potential RED effects to flood risk management projects are summarized in Table 18.

Table 18. Potential RED Effects to Flood Risk Management

RED Factor	Potential RED Effects
Construction	Additional construction related activity and resulting spillovers to suppliers
Revenues	Increased local business revenues as a consequence of reduced flooding, particularly from catastrophic floods
Tax Revenues	Increased income and sales taxes from the direct project and spillover industries
Employment	Short-term increase in construction employment; with catastrophic floods, significant losses in local employment (apart from the debris and repair businesses, which may show temporary gains)
Population Distribution	Disadvantage groups may benefit from the creation of a flood-free zone
Increased Wealth	Potential increase in wealth for floodplain residents as less is spent on damage property, repairs, etc and potential increase in property values.

Regional Economic System Results. A variety of software programs are available to determine the RED impacts for each project. Depending on the level of effort, project purpose, precision requirements and size of the study area, application will most likely vary. The Corps of Engineers' Institute for Water Resources along with the Louis Berger Group has developed a regional economic impact modeling tool called Regional Economic System (RECONS) that provides estimates of regional and national job creation, retention and other economic measures. The expenditures made by the USACE for various services and products generate economic activity that can be measures in jobs, income, sales and gross regional product. RECONS automates calculations and generates estimates of economic measures associated with USACE's annual civil work program spending. RECONS was built by extracting multipliers and other economic measures from more than 1,500 regional economic models that were built specifically for USACE's project locations by the Minnesota IMPLAN Group. These multipliers were then imported into a database and RECONS matches various spending profiles to the matching industry sectors by location to produce economic impact estimates. RECONS will be used as a means to

document the performance of direct investment spending of the USACE, as it allows users to evaluate project and program expenditures associated with the annual expenditure.

The economic impacts presented below show the Sutter study area and the State of California's inter-related economic impacts resulting from an infusion of flood reduction construction funds. For this analysis, the study area and the State of California were both used as the geographic designation to assess the overall economic impacts of the construction funds. This places a frame around the economic impacts where the activity is internalized. Leakages (payments made to imports or value added sectors, which do not in turn re-spend the dollars within the area) are not included in the total impacts.

Table 19 serves to demonstrate the complex nature of the Yuba City Metropolitan Statistical Area (MSA) in 2008. There are approximately 64,844 persons employed in the MSA of Yuba City, California providing an output to the national of $8,214,000,000 annually.

Table 19. Regional Profile
Yuba City Metropolitan Statistical Area, California
(Values in Millions, 2012 Dollars)

Industry	Output	Labor Income	GRP	Employment
Accommodations and Food Service	$190	$62	$94	3,507
Administrative and Waste Management Services	$179	$80	$109	2,682
Agriculture, Forestry, Fishing and Hunting	$698	$176	$326	6,260
Arts, Entertainment, and Recreation	$49	$14	$21	753
Construction	$539	$222	$243	3,686
Education	$262	$222	$250	4,491
Finance, Insurance, Real Estate, Rental and Leasing	$503	$111	$350	3,523
Government	$1,203	$859	$1,077	11,767
Health Care and Social Assistance	$594	$335	$385	6,389
Imputed Rents	$678	$89	$431	3,901
Information	$342	$37	$75	603
Management of Companies and Enterprises	$37	$14	$19	233
Manufacturing	$1,115	$152	$233	2,698
Mining	$243	$56	$147	555
Professional, Scientific, and Technical Services	$258	$118	$144	2,421
Retail Trade	$574	$240	$390	7,058
Transportation and Warehousing	$268	$101	$141	2,476
Utilities	$166	$28	$77	201
Wholesale Trade	$315	$120	$206	1,639
Total	**$8,214**	**$3,036**	**$4,718**	**64,844**

The total remaining costs for the project is estimated at 431,000,000 and 751,000,000 for alternative SB-7 and SB-8, respectively. In conducting the regional economic development analysis, the costs needed to be adjusted for two items: (1) interest during construction and (2) purchase of land. Interest during construction is the interest that is paid back to the federal treasury to cover the bond payments made in the construction of the project. These funds are not expended within the region and therefore are not included

within the regional analysis. Similarly, the purchase of land, not counting administrative costs, are considered as transfer payments from one party to another and not considered in the analysis.

Table 20 is based on the average annual regional expenditures that are expected over the remaining construction period. The construction schedule for alternative SB-7 is five years and seven years for alternative SB-8. Over that period of construction, a total of 384,062,000 (SB-7) and 686,692,000 (SB-8) is anticipated to be spent in the Sutter Basin study area in order to complete construction effort and place the project beneficial status. The average construction expenditure is the anticipated amount divided by the years of constructions, 76,812,000 (SB-7) and 98,098,000 (SB-8).

Table 20. Input Assumptions
Yuba City Metropolitan Statistical Area, California
(Values in Thousands, 2012 Dollars)

Category	Spending	Spending Ammount		Local Percentage Capture		
		SB-7	SB-8	Local	State	National
Aggregate Materials	10%	38,406	68,669	94%	96%	99%
Other Materials	1%	3,841	6,867	100%	100%	100%
Equipment	35%	134,422	240,342	90%	99%	100%
Construction Labor	54%	207,393	370,814	100%	100%	100%
Total	100%	384,062	686,692	-	-	-

Direct expenditures expected for construction of earthen levees are spent primarily in two sectors of the economy, construction labor and equipment. Both account for 89% of the total project expenditures. Local capture rates are computed with RECONS to show where the output from expenditures are realized. As indicated in Table 20, all of the construction labor is expected to occur within the MSA, and 90% of the equipment is expected to be provided from within the study area, and 99% from within the State of California.

Table 21 summarizes the expected economic impacts in terms of monetary output, number of jobs, labor income and gross regional product. USACE is planning on expending approximately $77,000,000 for SB-7 or $98,000,000 for SB-8 on the project. Of this total project expenditure, approximately $74,000,000 for SB-7 or $94,000,000 for SB-8 will be captured within the regional impact area. The rest will be leaked out to the State of California or the nation. The expenditures made by the USACE for various services and products are expected to generate additional economic activity, which can be measured in jobs, income, sales, and gross regional product as summarized in Table 22-24.

Of significant note to the study area is the creation of jobs. Currently, the unemployment rate in the study area (8.4% in Gridley, 9.3% in Yuba City and 14.7% in Biggs) is higher than state (6.5%) and national (5.6%) averages, and the number of jobs gained within the region demonstrates the multiplier effect of this infusion of construction funds for this project.

Table 21. Summary of Economic Impacts
Yuba City Metropolitan Statistical Area, California
(2012 Dollars)

Total Spending		Alternative SB-7			Alternative SB-8		
		Regional	**State**	**National**	**Regional**	**State**	**National**
		$384,062,000	$384,062,000	$384,062,000	$686,692,000	$686,692,000	$686,692,000
Direct Impact	Output	$73,713,365	$76,225,904	$76,697,970	$94,141,009	$97,349,830	$97,952,716
	Job	5,344	5,386	5,397	9,556	9,630	9,649
	Labor Income	$51,467,519	$52,135,157	$52,306,415	$65,730,335	$66,582,991	$66,801,709
	GRP	$59,477,394	$60,876,748	$61,141,251	$75,959,928	$77,747,074	$78,084,878
Total Impact	Output	$125,962,039	$153,322,937	$202,554,134	$160,868,975	$195,812,199	$258,686,476
	Job	7,324	8,099	9,469	13,095	14,480	16,930
	Labor Income	$68,495,021	$78,658,749	$94,442,866	$87,476,544	$100,456,871	$120,615,125
	GRP	$90,623,778	$106,865,898	$134,174,527	$115,737,681	$136,480,861	$171,357,330

Table 22. Economic Impacts—Regional Level
Yuba City Metropolitan Statistical Area, California
(2012 Dollars)

Industry Sector		Alternative SB-7				Alternative SB-8			
		Sales	Jobs	Labor Income	GRP	Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$21,697,457	$123	$11,326,872	$13,143,722	$38,794,440	$219	$20,252,126	$23,500,604
	Wholesale trade businesses	$379,606	$2	$156,322	$291,353	$678,724	$4	$279,499	$520,931
	Transport by rail	$575,297	$2	$176,467	$305,113	$1,028,615	$3	$315,517	$545,534
	Transport by water	$87,856	$0	$35,097	$38,076	$157,084	$0	$62,753	$68,080
	Transport by truck	$12,769,011	$90	$6,502,420	$7,554,866	$22,830,630	$162	$11,626,143	$13,507,886
	Construction of other new nonresidential structures	$4,608,744	$30	$1,589,650	$2,125,508	$8,240,304	$54	$2,842,249	$3,800,348
	Commercial & industrial machinery & equipment rental/leasing	$121,055,375	$398	$30,157,286	$66,534,853	$216,443,588	$711	$53,920,375	$118,962,436
	Labor	$207,393,480	$4,699	$207,393,480	$207,393,480	$370,813,680	$8,402	$370,813,680	$370,813,680
Total Direct Effects		$368,566,825	$5,344	$257,337,593	$297,386,971	$658,987,065	$9,556	$460,112,343	$531,719,499
Secondary Effects		$261,243,369	$1,980	$85,137,512	$155,731,920	$467,095,760	$3,539	$152,223,464	$278,444,272
Total Effects		$629,810,195	$7,324	$342,475,105	$453,118,892	$1,126,082,826	$13,095	$612,335,807	$810,163,770

Table 23. Economic Impacts—State Level
Yuba City Metropolitan Statistical Area, California
(2012 Dollars)

Industry Sector		Alternative SB-7				Alternative SB-8			
		Sales	Jobs	Labor Income	GRP	Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$21,697,457	$123	$11,326,872	$13,143,722	$38,794,440	$219	$20,252,126	$23,500,604
	Wholesale trade businesses	$564,590	$3	$237,707	$435,390	$1,009,471	$6	$425,014	$778,464
	Transport by rail	$841,594	$3	$261,098	$448,343	$1,504,746	$5	$466,837	$801,624
	Transport by water	$292,567	$1	$116,876	$128,879	$523,101	$1	$208,971	$230,432
	Transport by truck	$12,769,011	$90	$6,502,420	$7,554,866	$22,830,630	$162	$11,626,143	$13,507,886
	Construction of other new nonresidential structures	$4,608,744	$30	$1,589,650	$2,125,508	$8,240,304	$54	$2,842,249	$3,800,348
	Commercial & industrial machinery & equipment rental/leasing	$132,962,079	$437	$33,247,683	$73,153,551	$237,732,438	$781	$59,445,917	$130,796,481
	Labor	$207,393,480	$4,699	$207,393,480	$207,393,480	$370,813,680	$8,402	$370,813,680	$370,813,680
Total Direct Effects		$381,129,521	$5,386	$260,675,786	$304,383,738	$681,448,811	$9,630	$466,080,937	$544,229,520
Secondary Effects		$385,485,165	$2,713	$132,617,959	$229,945,753	$689,236,579	$4,850	$237,117,163	$411,136,507
Total Effects		$766,614,686	$8,099	$393,293,745	$534,329,491	$1,370,685,390	$14,480	$703,198,099	$955,366,027

Table 24. Economic Impacts—National Level
Yuba City Metropolitan Statistical Area, California
(2012 Dollars)

Industry Sector		Alternative SB-7				Alternative SB-8			
		Sales	Jobs	Labor Income	GRP	Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$21,697,457	$123	$11,326,872	$13,143,722	$38,794,440	$219	$20,252,126	$23,500,604
	Wholesale trade businesses	$572,245	$3	$241,075	$441,350	$1,023,158	$6	$431,036	$789,122
	Transport by rail	$1,094,648	$3	$342,266	$585,701	$1,957,200	$6	$611,962	$1,047,216
	Transport by water	$423,734	$1	$169,276	$188,624	$757,625	$2	$302,660	$337,254
	Transport by truck	$13,474,219	$96	$6,861,536	$7,972,107	$24,091,523	$172	$12,268,233	$14,253,901
	Construction of other new nonresidential structures	$4,608,744	$30	$1,589,650	$2,125,508	$8,240,304	$54	$2,842,249	$3,800,348
	Commercial & industrial machinery & equipment rental/leasing	$134,225,323	$441	$33,607,922	$73,855,763	$239,991,084	$789	$60,090,014	$132,052,017
	Labor	$207,393,480	$4,699	$207,393,480	$207,393,480	$370,813,680	$8,402	$370,813,680	$370,813,680
Total Direct Effects		$383,489,851	$5,397	$261,532,077	$305,706,255	$685,669,014	$9,649	$467,611,961	$546,594,143
Secondary Effects		$629,280,820	$4,072	$210,682,253	$365,166,380	$1,125,136,318	$7,281	$376,693,912	$652,907,165
Total Effects		$1,012,770,671	$9,469	$472,214,329	$670,872,635	$1,810,805,332	$16,930	$844,305,873	$1,199,501,308

7. ECONOMIC SUMMARY

A summary table of the cost benefit analysis, other social effects assessment and the regional economic development benefits is detailed in Table 25.

Table 25. Summary of Analyses

	SB-1	SB-7	SB-8
1. PLAN DESCRIPTION			
	Alternative SB-1: The No Action provides no physical project constructed by the Federal Government.	Alternative SB-7: The plan is a Feather River fix-in-place levee alternative from Sunset Weir to Laurel Avenue.	Alternative SB-8: The plan is a Feather River fix-in-place levee alternative from Thermalito to Laurel Avenue.
2. SUMMARY OF IMPACT ANALYSES			
A. National Economic Development (NED)			
1. Annual Damages	$ 112,046,000	$ 48,146,000	$ 41,476,000
2. Annual Benefits	$ -	$ 63,900,000	$ 70,570,000
3. Total Project Costs	$ -	$ 432,000,000	$ 748,110,000
a. IDC	$ -	$ 44,000,000	$ 107,000,000
b. O&M	$ -	$ 280,000	$ 450,000
c. Annual Cost	$ -	$ 21,000,000	$ 38,000,000
d. Construction Period		5 years	7 years
4. Annual Net Benefits	$ -	$ 43,000,000	$ 33,000,000
5. Benefit-to-Cost Ratio	-	3.0	1.9
B. Other Social Effects (OSE)			
Population at Risk	Approximately **96,600** individuals are within the 1% ACE floodplain.	**38,200** people remain in the 1% ACE floodplain. (60% of population is removed from the 1% ACE residual floodplain.)	**6,600** people remain in the 1% ACE floodplain. (93% of population is removed from the 1% ACE residual floodplain)
Loss of Life	Potential loss of lives: **Day-388, Night-489**	Potential loss of lives: **Day-157, Night-197**	Potential loss of lives: **Day-27, Night-34**
Critical Infrastructure	**28** structure deemed as critical from a national perspective are at risk from floods.	**11** structures remain at risk from floods.	**1** structure is at risk from floods.
Evacuation Routes	In the event of a flood, no evacuation route is available out of the basin.	Offers **one** problematic route for evacuation during a flood event. A flood warning and evacuation plan would not be as effective and limited.	**5** evacuation routes are available in the event of a flood. A flood warning and evacuation plan would have more robustness and redundancy.
Wise Use of Floodplains	Currently, 71,800 acres of land are potentially available for future development.	88,200 acres would be potentially available for future development.	100,200 acres of land would be potentially available for future development.
Social Vulnerability	The social vulnerability index score (SoVi) indicates the study area to be medium to high vulnerability. The No Action alternative may leave	Majority of the community of Yuba City is afforded flood risk reduction, however the communities of Live Oak, Gridley, and Biggs remain at	The four existing communities are provided flood risk reduction, and social vulnerability is minimized due to a decrease in the probability of

	SB-1	SB-7	SB-8
	communities unable to cope with the recovery from a flood hazard.	risk of flood hazards and may be unable to cope and recover.	flood hazards occurring.
Residual Risk and Consequences	Residual Risk remains high throughout the study area	Residual Risk for Life Safety is reduced for most of the Yuba City urban area.	Residual Risk for Life Safety is reduced in the high risk communities: Yuba City, Live Oak, Gridley and Biggs.
C. Regional Economic Development (RED)—Regional Direct Impacts			
Output	$8,214,000,000	SB-1 + $73,713,000 (5yrs)	SB-1 + $94,141,000 (7yrs)
Job	64,844	SB-1 + 5,344 (5yrs)	SB-1 + 9,556 (7yrs)
Labor Income	$3,036,000,000	SB-1 + $51,468,000 (5yrs)	SB-1 + $65,730,000 (7yrs)
Gross Regional Product	$4,718,000,000	SB-1 + $60,877,000 (5yrs)	SB-1 + $75,960,000 (7yrs)

PLATE #1
Legend
Sutter Basin Study Area
Sacramento Basin
Watershed Boundary
Lake or Reservoir
Designated Floodway
River or Stream
City
Medford
OREGON
Goose Lake
Mt. Shasta, 14,179 ft
Pit River
Shasta Lake
Redding
Lake Almanor
CALIFORNIA
NEVADA
Sacramento River
Black Butte Lake
Chico
Lake Oroville
Reno
Butte Basin
New Bullards Bar Lake
Yuba R
Feather River
Clear Lake
Indian Valley Reservoir
Yuba City
Lake Tahoe
Colusa Drain
Camp Far West Lake
Cache Cr
Folsom Lake
PACIFIC
Lake Berryessa
American R
Santa Rosa
Sacramento
OCEAN
Miles
0
50
Stockton
San Francisco
Prepared by Jim Mars, USACE

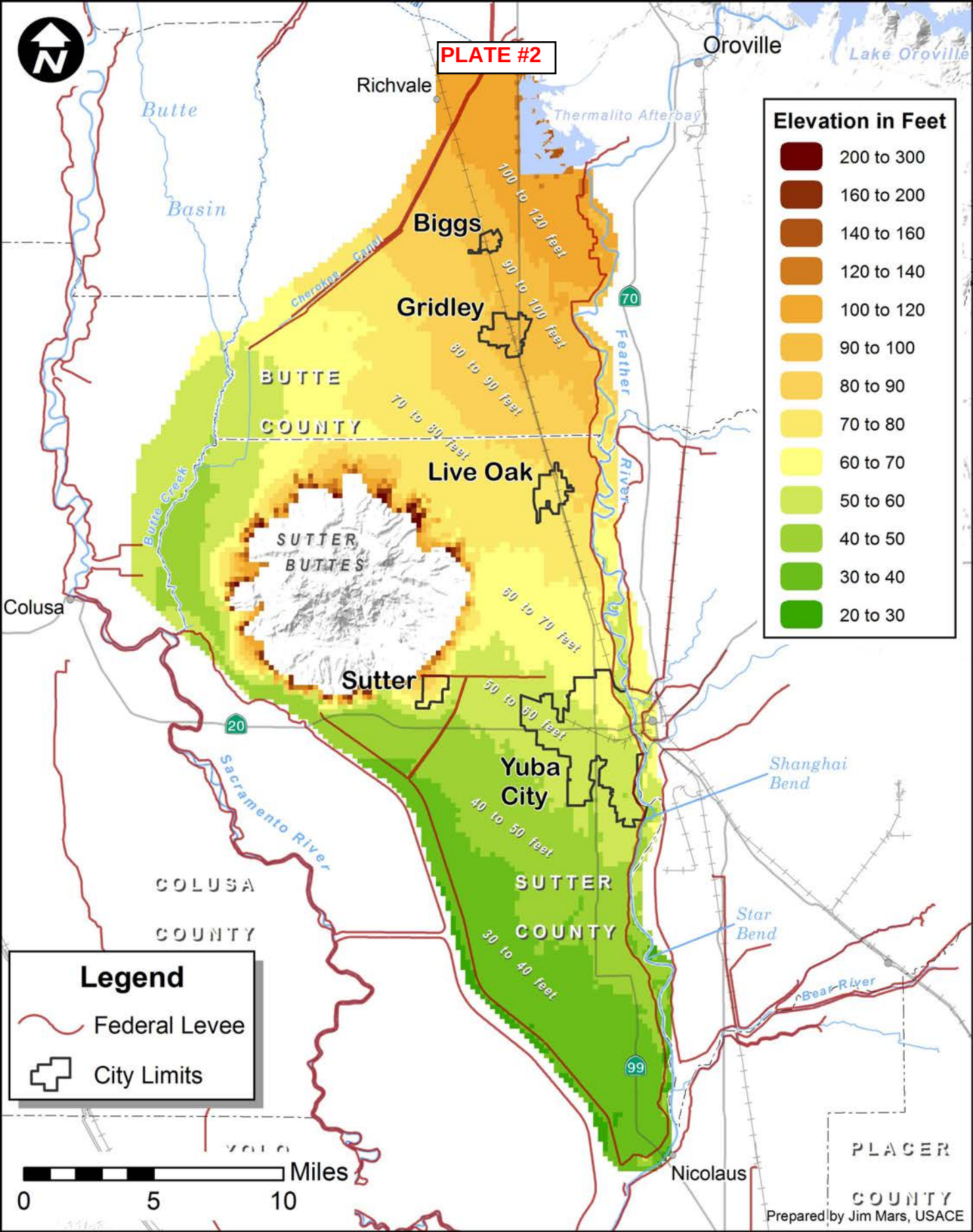


PLATE #2
Oroville
Lake Oroville
Richvale
Thermalito Afterbay
Butte
Basin
Cherokee Canal
Biggs
Gridley
Live Oak
Sutter
Yuba City
BUTTE
COUNTY
SUTTER
BUTTES
Butte Creek
Colusa
Feather
River
Sacramento River
COLUSA
COUNTY
SUTTER
COUNTY
Shanghai
Bend
Star
Bend
Bear River
Nicolaus
PLACER
COUNTY
100 to 120 feet
90 to 100 feet
80 to 90 feet
70 to 80 feet
60 to 70 feet
50 to 60 feet
40 to 50 feet
30 to 40 feet
Elevation in Feet
200 to 300
160 to 200
140 to 160
120 to 140
100 to 120
90 to 100
80 to 90
70 to 80
60 to 70
50 to 60
40 to 50
30 to 40
20 to 30
Legend
Federal Levee
City Limits
Miles
0
5
10
Prepared by Jim Mars, USACE

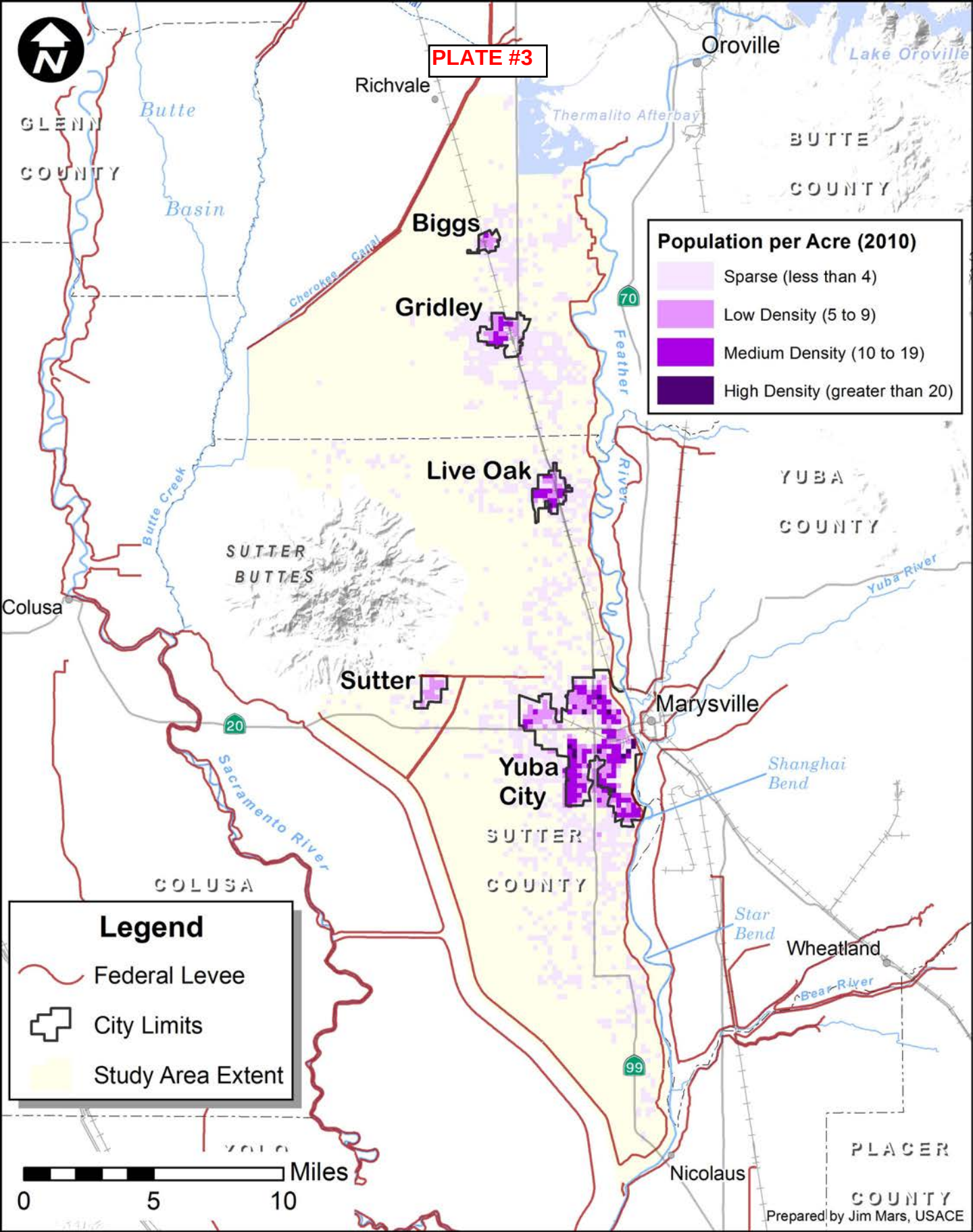


PLATE #3
Oroville
Lake Oroville
Richvale
Thermalito Afterbay
GLENN
COUNTY
Butte
Basin
BUTTE
COUNTY
Biggs
Cherokee Canal
Gridley
70
Feather
River
Population per Acre (2010)
Sparse (less than 4)
Low Density (5 to 9)
Medium Density (10 to 19)
High Density (greater than 20)
Live Oak
YUBA
COUNTY
Butte Creek
SUTTER
BUTTES
Yuba River
Colusa
Sutter
Marysville
20
Yuba
City
Shanghai
Bend
Sacramento River
SUTTER
COUNTY
COLUSA
Legend
Federal Levee
City Limits
Study Area Extent
Star
Bend
Wheatland
Bear River
99
Miles
0
5
10
Nicolaus
PLACER
COUNTY
Prepared by Jim Mars, USACE

Appendix B

Plan Formulation

B1. Pertinent Correspondence

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

MAY - 7 2013

MEMORANDUM FOR DIRECTOR OF CIVIL WORKS

SUBJECT: Sutter Basin, California – Deviation from the National Economic Development Plan

I am responding to the Army Corps of Engineers (Corps) memorandum dated March 18, 2013, which requests an exception to the policy that requires decision documents to recommend the National Economic Development (NED) Plan. The exception would allow the subject draft feasibility report and draft environmental impact statement to tentatively recommend a Locally Preferred Plan (LPP) for flood risk management improvements. The request indicates that the Sutter Butte Flood Control Agency and the Central Valley Flood Protection Board, as the non-Federal sponsors, support the LPP in lieu of the NED Plan in order to comply with California Government Code requirements for a 200-year level of protection for urban and urbanizing areas by 2025.

Based on the materials provided, the LPP would reduce the vulnerability of a larger population and additional critical infrastructure, reduce economic flood risks to a greater extent, and provide more evacuation routes relative to the NED Plan. The LPP would cost about $290,000,000 more than the NED Plan. As proposed, the non-Federal sponsors would be responsible for the entire extra cost, which would increase the non-Federal cost share from about $148,000,000 for the NED Plan to about $438,000,000 for the LPP. The Federal cost share of initial construction, estimated at $275,000,000, would remain the same for the NED Plan and the LPP.

In addition to the request for an exception, the Corps provided responses on April 17, 2013, to questions my staff raised about the study and the two plans. The responses resolved all but three of those concerns. First, significant population growth during the 50-year period of analysis appears likely and must be explicitly considered in evaluating the public safety aspects of the final alternatives and measures for managing the respective residual risks. Second, the effect of induced development on the public safety aspects of the final alternatives and the residual risks must be assessed. If a reasonable estimate of induced development cannot be achieved, then the analyses should assume full development of areas designated as potentially developable. Areas with temporary restrictions on development should be considered potentially developable unless the Corps can demonstrate that the temporary restrictions would become permanent. Third, the effects of alternatives and their respective induced development and population growth on natural floodplain functions, including the ecological and hydrologic functions, must be assessed.

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After reviewing the materials provided, I have decided to grant the requested policy exception, subject to the Corps incorporating the information discussed above into the final decision documents. The documents should be explicit about compliance with EO 11988, particularly the determination of practicable alternatives. The draft feasibility report and draft environmental impact statement may tentatively select the LPP and be released for public review. I concur that the added cost of the LPP relative to the NED Plan, currently estimated at $290,000,000, would be a 100 percent non-Federal cost, with the remainder of the first cost shared 65 percent Federal, 35 percent non-Federal consistent with current policy.

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

18 FEB '11

CECW-P

MEMORANDUM FOR MAJOR SUBORDINATE COMMANDS

SUBJECT: Civil Works Program - National Pilot Program: Initial Pilot Study Selection

CORPS,

1. Reference memorandum dated 3 February 2011, subject: Civil Works Program - Pilot Study Implementation. The Pilot Program is intended to validate concepts of a new pre-authorization (planning) study paradigm that shortens the timeframe for completion of a planning study, while maintaining the quality and integrity of the analyses. The purpose of this memorandum is to announce the selection of the initial pilot studies for the National Pilot Program.

2. In the referenced memorandum input on three potential pilot studies was requested: Central Everglades, FL; Jordan Creek (Springfield), MO; and Sutter Basin, CA. The intent was to select two pilot studies on 10 February 2011 from these three studies unless more suitable studies were brought forward prior to 8 February 2011. Additional pilot studies will be selected from the nominations due by 23 February 2011.

3. No additional pilot studies were proposed by the close of business 7 February 2011 due date, so the selection panel proceeded with the three potential pilot studies outlined in the 3 February 2011 memorandum. The selected pilot studies are Jordan Creek (Springfield), MO and Sutter Basin, CA. Central Everglades, FL will remain under consideration for future selection as a pilot study.

- Jordan Creek (Springfield), MO has available Federal and non-Federal funds necessary to complete the study. The Feasibility Scoping Meeting (FSM) is currently scheduled for March 2011, and strong engagement and support of the sponsor, as well as existing vertical team engagement makes this project ideal for initial selection. Southwestern Division supports the study for inclusion as a pilot.

- Sutter Basin, CA is in the FY 2011 and 2012 President's Budget at an adequate level to complete the study. While the FSM for the study has been held, information discovered during planning has resulted in integration and consideration of new data and an expanded study area. The study has the strong support of South Pacific Division and the study sponsor for inclusion in the National Pilot Program.

4. Congratulations to these project delivery teams on their selection as the first representatives of the National Pilot Program. The National Pilot Program studies will proceed with vertical team coordination, a kick-off webinar, and pilot project activity scoping, including refinement and

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communication of expectations, development of the path forward, and further definition of outcomes and indicators of success. The webinar will provide additional information and direction on the pilot program and will be held prior to 28 February 2011. Pilot Program project delivery teams will be contacted no later than 18 February 2011 to coordinate dates for the scoping meetings. The scoping meeting will be the official start of the National Pilot Program and will be held in early to mid-March.

5. We look forward to receipt of your additional nominations and appreciate your responsiveness and commitment to this important Civil Works initiative.

FOR THE COMMANDER:

Encls Thanks for your support!!

WILLIAM T. GRISOLI
Major General, USA
Deputy Commanding General
for Civil and Emergency Operations

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DIRECTOR, IWR

B2. Pilot Feasibility Study, Decision Point 2, Report Summary

Sutter Basin, California

Pilot Feasibility Study

Decision Point #2

Report Summary

US Army Corps
of Engineers

Sacramento District
Version: 26 October 2012
Revised: 10 March 2013

This Report Summary is in support of Decision Point #2 and Presentation. Additional background information on the Sutter Basin pilot process, plan formulation, evaluation metrics, etc. can be found in the supporting Read Aheads for Decision Point #2.

As a Read Ahead, a Draft Report Table of Contents with referenced supporting and IPR directed documents (MFRs, papers, reports, etc) generated by the PDT during the pilot and plan formulation process is provided to show how the work efforts and documents will flow into an integrated Draft Report.

The Report Summary has been modified to be consistent with the actual Decision Point # 2 presentation, reflecting modifications in the identification and analysis of alternatives after the original document was prepared; and to provide additional information as requested by the Vertical Team after the Decision Point Conference to support the District's recommendations to identify the Locally Preferred Plan as the Tentatively Selected Plan with full Federal cost participation as prescribed by Section 103 of WRDA 1986.

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1. INTRODUCTION

Purpose. The purpose of the Report Summary is to document the planning process leading up to the recommendation of the tentatively selected plan (TSP) and in doing so reaffirm Federal interest, identify the national economic development (NED) plan, identify the locally preferred plan (LPP), and evaluate residual risk. Plans were evaluated at a suitable level of detail for the identification of the NED and LPP plans. Refined analysis, including total project costs, will be presented in the Draft Feasibility Report. Section 8 recommends the Tentatively Selected Plan (TSP).

Study Authority. The authority for the USACE to study Flood Risk Management (FRM) and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, is provided in the Flood Control Act of 1962, Pub. L. No. 87-874, § 209, 76 Stat. 1180, 1196 (1962).

Local Sponsors. The non-Federal project sponsors include the State of California Central Valley Flood Protection Board (CVFPB) and the Sutter and Butte County Flood Control Agency (SBFCA).

Study Background. The Sutter Basin Feasibility Study was initiated in 2000 and a Feasibility Scoping Meeting was held in January 2005. However the study remained essentially inactive until the formation of the Sutter Butte Flood Control Agency (SBFCA), which agreed to serve as the local partner along with the Central Valley Flood Protection Board (CVFPB) in 2007. In 2010, the Sutter Basin population passed a $6.65 million per year assessment to study and implement a project to reduce flood risks to the basin. This action was a strong public endorsement of the need for immediate action to address the flood threat, particularly since the area is an economically disadvantaged community under California State guidelines with widespread unemployment, and the approved assessment rates are among the highest in California.

Pilot Program. The Sutter Basin Feasibility Study is one of the first two studies selected for inclusion in the National Pilot Program in February 2011. The pilot initiative provides an opportunity to test principles that were developed by a workgroup of planning and policy experts from USACE and the Office of the Assistant Secretary of the Army for Civil Works (ASA (CW)), referred to as the 17+1 Team, for the purpose of modernizing the Civil Works Planning Program to better address the many water resource challenges facing the nation.

The revised study paradigm envisions a more predictable, and efficient process which significantly lessens the time required to complete a feasibility study. This new process requires heavy involvement as well as input and timely decisions from the Vertical Team at multiple points throughout the study. Further, the process emphasizes the early identification of the federal interest in resolving a water resource problem.

The study process continues to use sound professional engineering, economics, and environmental judgment and analyses, but appropriately focuses the amount and type of data collected and analysis on the risk and consequences of the decisions being made. Costs and benefit estimates presented herein are based on an appropriate level of detail for screening of draft alternatives to a final array. The appropriate level of detail was selected considering that comparative cost estimates are more accurate than absolute cost estimates. This is because similar errors are made for all alternatives. The range of confidence in cost and benefit estimates is presented in a table comparing the alternatives. To avoid confusion, only mean estimates are described in the text.

After approval by the ASA-CW a more detailed total project cost estimate will be completed and certified for the Recommended Tentative Selected Plan (TSP). It is anticipated that the certified total project cost estimate and the benefits of the TSP will deviate from the values presented in this report. However the estimates are expected to fall within the range of estimates provided.

The new study paradigm recognizes that qualitative optimization of any factor, including net national economic development benefit, should not be the primary factor in the Corps decision for a recommendation for federal investment. Alternative Comparison and Selection recognizes that there is no single "best" plan, and there are a variety of approaches (quantitative and qualitative) to multi-criteria decision making.

The pilot study is divided into four phases, each with a key decision point and associated In-Progress Reviews (IPRs). Table 1 summarizes the four pilot study phases and associated decision points. Based on the pilot program principles, the Sutter Basin Pilot Feasibility Study strategy focuses on utilizing an appropriate level of detail based on the decisions being made at each stage of the study. This strategy includes qualitative analysis that will be increasingly detailed at each Decision Point or IPR and early elimination of alternatives with little probability of implementation.

Table 1. Pilot Study Phases and Associated Decision Points

Pilot Study Phase	Decision Point	Date
Scoping	1 – Federal Interest Determination	Aug 2011
Analysis	2 – Tentatively Selected Plan	Nov 2012
Review	3 – Civil Works Review Board	Summer 2013*
Confirmation	4 – Chief's Report	Fall 2013*

*Dates are pending confirmation from vertical team.

Central Valley Flood Protection Plan. The Central Valley Flood Protection Act of 2008 (CVFPA), passed by the California legislature as Senate Bill (SB) 5, directs local flood risk management efforts. The CVFPA, along with other companion legislation, required the Central Valley Flood Protection Board to adopt the Central Valley Flood Protection Plan (CVFPP) by July 2012. The purpose of the CVFPP was to guide California's participation in managing flood risk along the Sacramento and San Joaquin River systems. The CVFPA requires a 200-year (with 95% assurance (or "freeboard")) level of flood protection for urban and urbanizing areas by the year 2025.

The CVFPP proposes an initial system wide investment approach for sustainable, integrated flood management in areas currently protected by facilities of the State Plan of Flood Control (SPFC). This investment approach includes system and regional elements, some of which are located in the Sutter Pilot study area. The CVFPP was adopted by the State in July 2012. The Sutter Basin Pilot Study is continuing close coordination with these CVFPP efforts and is a key means of implementing a portion of the CVFPP.

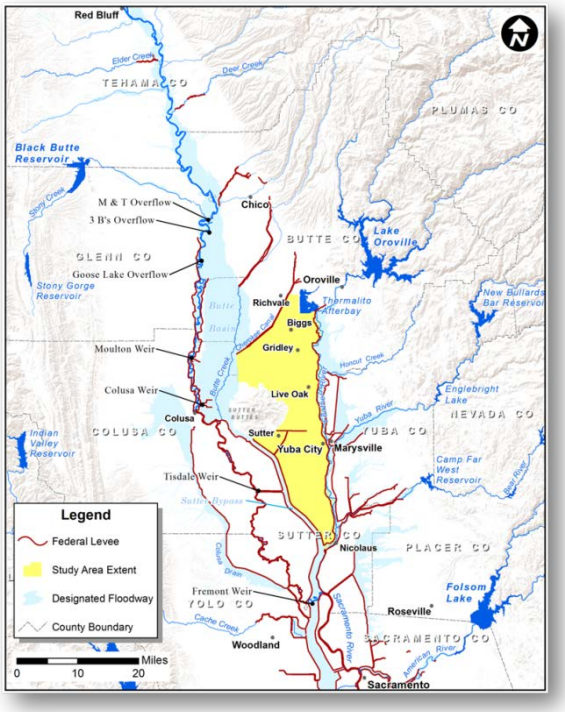
The CVFPA, recognizing the urgent need to improve the existing flood protection system, allows urban flood improvement projects (Early Implementation Projects) to be funded with State bond funds in advance of full implementation of the CVFPP. Proposed improvements must be for flood management construction projects that: rehabilitate, reconstruct, replace, improve, or add to the facilities of the State Plan of Flood Control; reduce or avoid risk to human life in urban areas; and not impair or impede future changes to regional flood protection. Construction of 3,400 feet of setback levee to replace a portion of the existing west bank Feather River levee south of Yuba City was recently completed within the Sutter Basin study area under the Early Implementation Program to address through-seepage, underseepage, and flow constriction issues. A request for approval under 33 USC § 408 was granted and an application for consideration of Section 104 credit was approved in 2009.

SBFCA is proposing another levee improvement project along the Feather River west levee under the Early Implementation Program. This project proposes to construct levee improvements between the Thermalito Afterbay and an area north of the Feather River/Sutter Bypass confluence. The project will address through-seepage, underseepage, and embankment instability of the levees, by meeting current design standards. A Pre-Design Formulation Report was completed in August of 2011 and the 60% design was completed in March 2012. An EIS/EIR is being prepared for the project as part of a Section 408 application to obtain permission from USACE to alter project levees. The non-federal project sponsors will seek in-kind credit for this local project under the provisions of Section 221 of the Flood Control Act of 1970, as amended.

2. STUDY BRIEFING

Study Area. The 300 square mile Sutter Basin study area is located in Northern California in Sutter and Butte Counties within the 14,000 sq. mile Sacramento River Watershed as shown in Figure 1. The study area, which is approximately 50 miles north of Sacramento, is bounded by the Feather River on the east, the high ground of the Sutter Buttes on the west, the Sutter Bypass on the southwest, and Cherokee Canal and the Butte River on the northwest. Existing levees along the Feather River, Sutter bypass, Cherokee canal, and Wadsworth Canal as well as the Butte Basin are features of the Sacramento River Flood Control Project (SRFCP), authorized by Congress in 1917. The SRFCP incorporated features such as levees, weirs, and pumping facilities into a system of leveed river channels and flood bypass channels to provide Flood Risk Management benefits to the Sacramento Valley. The existing levees provide FRM benefits to the Sutter River Basin study area; however, the current condition of the levees are assessed to have relatively high risk of failure as a result of through and under seepage concerns.

Figure 1: Sutter Basin Study Area

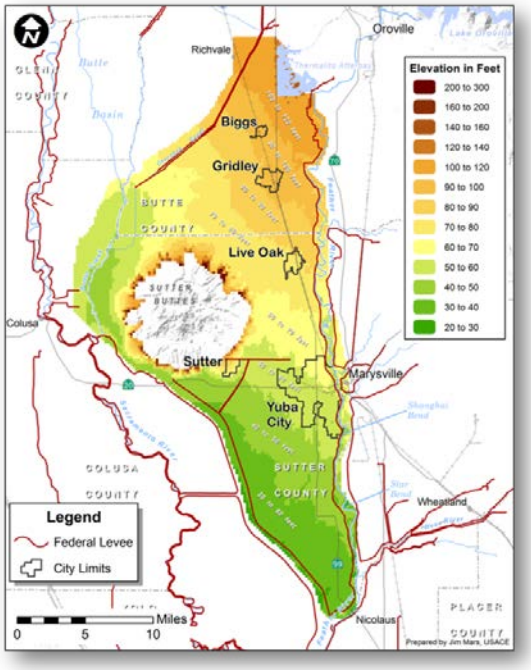


The study area is primarily rural, with extensive agricultural areas and low population density. Yuba City is the largest community in the study area, located midway in the basin adjacent to the Feather River. The northern basin 'gold rush era' cities of Biggs, Gridley, and Live Oaks are situated roughly along the north-south railroad and State Highway 99 corridors.

Existing Conditions. Existing conditions are those at the time the study is conducted and form the basis for extrapolation to other conditions. Existing conditions within the study area are discussed below.

Topography. As shown in Figure 2, the floodplain elevations (excluding the high ground of Sutter Buttes) range from 110 feet-NAVD88 in the northeast to 30 feet-NAVD88 in the southwest.

Figure 2. Sutter Basin Topography



Geotechnical Levee Performance. From initial information and modeling during plan formulation, the primary risk of flooding in the Sutter Basin is the result of geotechnical failure of the existing levees not hydrologic or hydraulic factors which result in levee overtopping. Recent geotechnical analysis and evaluation of historical performance during past floods indicate the project levees within the study area do not meet USACE levee design standards and are at risk of breach failure at stages considerably less than levee crest elevations. This was evidenced by historical boils and heavy seepage at stages less than authorized design flows[1]. Underseepage failures are sudden and unpredictable, resulting in minimal warning time, and ineffectiveness of evacuation plans. The risk of unexpected levee failure coupled with the consequence of flooding presents a continued threat to public safety, property, and critical infrastructure. Initial WSEL's where a seepage related levee failure becomes possible are as low as the 20% (1/5) event in most cases along the Feather River. At the 10% (1/10) WSEL, the probability of failure can range from 10-20%, while at the 1% (1/100) WSEL these probabilities of failure range from 30-45% depending upon the location along the river.

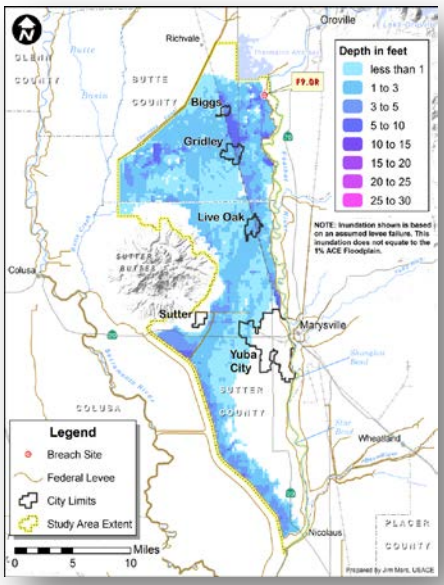
Hydraulics. Multiple levee breach scenarios were modeled along the Feather River and Sutter Bypass to assist in the analysis of the study alternatives. Floodplains resulting from levee breaches differ significantly in nature depending on the location of the breach as illustrated in Figure 3. Simulated breaches along the northern portion of the Feather River flood the northern basin in a shallow (up to 6 feet) northeast to southwest flooding flow. Breaches from the Sutter Bypass and southern most portion of

[1] Design flows obtained from USACE file drawing 50-10-334, Levee Channel Profiles, 15 March 1957. For a discussion and comparison of design flows vs. regulated and peak unregulated flows see Progress Document #2; Technical Support Documentation of the Sutter Basin Pilot Feasibility Study.

the Feather River only flood the deeper (up to 25 feet) southern basin area and do not impact the northern portion of the basin. The velocity of floodwaters varies depending on the proximity to the breach location. For those structures/people within 1,000 feet of a breach the velocity could be high enough to knock structures off of their foundations. This high risk velocity area would consist mainly of the small population of Yuba City within 1,000 feet of the river and would see velocities well above 6 feet per second (fps). But, the majority of Yuba City and all of Biggs, Gridley and Live Oak are outside this area and could expect to see flood velocities between 2-3 fps.

Figure 4 shows the composite 1% ACE floodplain for the Sutter Basin.

Figure 3. Simulated Levee Breach Scenarios



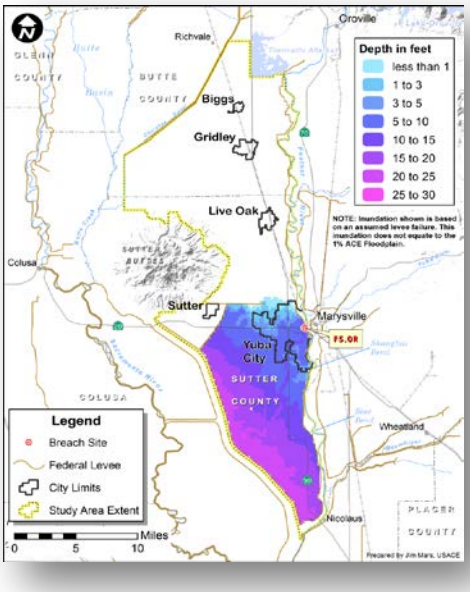
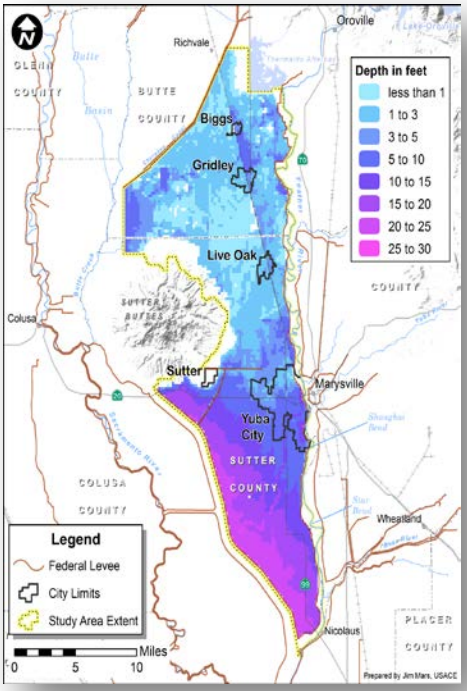


Figure 4. 1% ACE Without Project Floodplain



Economics. Based upon the 2010 Census, the population of the Sutter Basin is estimated to be 95,360 and distributed as shown in Table 2.

Table 2. Population Within Study Area

Economic Impact Area	Population
Town of Sutter	250
Yuba City Urban	67,370
Biggs Urban	1,760
Gridley Urban	6,380
Live Oak Urban	8,360
Sutter County Rural	6,340
Butte County Rural	4,900
TOTAL	**95,360**

Demographics: Median household income for the study area ranges from $36,563 (Gridley) to $48,830 (Yuba City). Both of which are below State ($61,632) and national (52,762) averages. The persons living at or below the poverty level in the study area are 22.7%, 21.4% and 15% for Biggs, Gridley and Yuba City, respectively. All of which are above the State (14.4%) and national (14.3%) averages.[2]

The total labor force in the study area is estimated at 40,000, with an unemployment rate of 14.7%, 8.4%, and 9.3% in Biggs, Gridley and Yuba City, respectively. Total private wage or salary workers estimated to be 75% (Biggs), 65% (Gridley) and 69% (Yuba City) with 17% (Biggs), 25% (Gridley) and 20% (Yuba City) of the labor force rated as government workers. Approximately, 7% (Biggs), 11% (Gridley) and 11% (Yuba City) of the labor force was considered to be self-employed, not incorporated. The average wage per job so the study area is between $22,300 to $28,100.

Variances in race and ethnicity in communities may impose language and cultural barriers that affect ability to cope with natural hazards. The Hispanic presence is evident given they make up at least 28% of the population in each community. Live Oak's population is composed of 48.8% of individuals of Hispanic origin, which is significantly higher than the State average of 37.6% and considerably exceeds the national average of 16.3%.

Inventory: An economic inventory was assembled following standard USACE methods. For the study area, a base geographic information system (GIS) inventory with parcel attribute data was provided by the local sponsor for both Sutter and Butte counties. Field visits were conducted to collect and validate the base inventory data. Parcels with structures were categorized by land use and grouped into residential, commercial, industrial or public categories. The value of damageable structures was estimated based on depreciated replacement values. The total value of damageable property (structures and contents) within the Sutter Basin study area is estimated at $6.9 Billion (October 2011 prices). Table 3 displays the structural inventory by land use category. Total study area without project expected annual damages are approximately $108 million.

[2] Some demographic data was unavailable for the City of Live Oak.

Table 3. Structural Inventory –Existing Conditions[3]
Number of Structures within 0.2% (1/500yr) Annual Chance Floodplain

Economic Impact Area	Commercial	Industrial	Public	Residential	TOTAL
Biggs	18	1	0	586	**605**
Gridley	81	7	4	1,931	**2,023**
Live Oak	51	5	23	2,088	**2,167**
Yuba City	872	210	122	18,760	**19,964**
Town of Sutter	0	0	0	0	**0**
Rural Butte	10	16	0	1,242	**1,268**
Rural Sutter	10	29	8	1,162	**1,209**
TOTAL	**1,042**	**268**	**157**	**25,769**	**27,236**

Climate. The study area is located within the northern portion of California's Central Valley. The Sacramento Valley is a semi-arid region with an annual rainfall of approximately eighteen inches. There are two distinct annual seasons, a hot dry summer and a cool wet winter. Approximately eighty percent of the annual rainfall occurs in between October to March.

Environmental. Sutter County is primarily rural, with extensive agricultural areas and a low population density. The county is one of California's major agricultural counties and its traditional job base is agriculture. A number of Federal and State listed species are known to occur or potentially occur in the study area. Many of these species are located within the riparian areas along the Feather River.

Historic Flooding. In 1955, flood waters from a levee breach encompassed a significant portion of the study area inundating 6,000 homes, drowning 38 people, injuring 3,200 individuals, and requiring 600 people to be rescued by helicopter. From 1950 to 2011, extensive flood fighting has occurred during 19 events, and deadly levee failures adjacent to the Sutter Basin took place in 1986 and 1997 which reduced stress on the levees surrounding the Sutter Basin and may have resulted in avoiding failure of these levees. Flooding historically has occurred during the months of December through February with air temperatures of 38 to 55°F and water temperatures of 45 to 55°F; temperatures which significantly increase risk of death by exposure[4].

Future Without-Project Conditions. The future without-project condition is the most likely condition expected to exist in the future in the absence of a proposed water resources project and constitutes the benchmark against which alternatives are evaluated. These forecasts of future conditions are from the base year (year when a project is expected to be operational) to the end of the period of analysis (50 years). Future without-project conditions for this study are projected assuming a base year of 2020 and a 50-year period of analysis out to year 2070. Assumptions regarding the future without-project condition are listed below:

- For purposes of evaluating the transfer of flood risk, the future without-project condition will assume the levees do not fail due to geotechnical conditions since their original design was not based on failure assumptions.

- Ongoing levee maintenance will result in no change to geotechnical conditions and levee

[3] Based on empirical analyses conducted for past Corps projects, subject matter expertise from the agricultural economist and professional judgment, the project delivery team expects agricultural damages to total 10-15% of total project damages; amounts which are not expected to drive plan selection. A simplified approach was developed for this study.
[4] United States Coast Guard

performance curves.

- Oroville and New Bullards Bar reservoirs on the Feather and Yuba River Systems will continue to be operated using the existing rule curves.

- Vegetation and topographic conditions within the channel are expected to remain the same as existing conditions.

- Remaining natural areas are not expected to substantially decline in acreage and value over the period of analysis.

- Economic analysis assumes the future without-project condition damages are equal to existing conditions. Because any future without project development would take place outside/above the mean 1% (1/100) ACE floodplain boundary and because any future damages would be discounted back to present value, the future condition is not expected to impact the plan formulation process significantly.

- Since refinements, additions, and deletions of elements associated with the System wide Investment Approach presented in the 2012 CVFPP are anticipated, these elements will not be included in the future without-project condition.

- Flood frequency will be based upon existing conditions. However, a sensitivity analysis of climate change impacts on hydrologic frequency, flood damages, and alternative selection will be conducted. This approach was based on a review of uncertainty in recent climate model analysis.

- Assumes Three Rivers Levee Improvement Authority (TRLIA) Feather River setback levee has been constructed.

- Section 104 of WRDA 86 allows for the plan formulation analysis to exclude work conducted by the sponsor from the without project condition, thereby allowing the work to potentially be incorporated in to the recommended plan, if it is found to be in the Federal interest. Since the application for consideration of Section 104 credit for the completed Star Bend setback levee was approved in 2009 prior to the moratorium on consideration of Section 104 credit by the ASA (CW), this project will not be considered part of the future without-project condition.

- Vertical Team policy guidance provided at In-Progress Review #1 recommended that the Feather River West Levee Project proposed by the project sponsor <u>will not</u> be considered part of the future without-project condition (assumes no contract prior to the Chief's Report for the pilot study). If appropriate after the feasibility report is completed, the sponsor may request credit consideration for this local project under the provisions of Section 221 of the Flood Control Act of 1970, as amended. This may be accomplished in accordance with ER 1165-2-208 guidelines.

3. PLANNING OBJECTIVES AND OPPORTUNITIES

Following inclusion of the Sutter Basin Feasibility Study in the National Pilot Program, the Project Delivery Team (PDT) and non-Federal sponsors participated in a study risk workshop with several members of the Vertical Team during which the following problem, opportunity, objective, and constraint statements were developed and refined.

Problems.

- A high risk of flooding from levee failure threatens the public safety as well as property and critical infrastructure throughout the study area
- Existing levees have isolated the floodplains from waterways, which has eliminated significant floodplain habitats for native species, including Federally listed species and other special status species; also, conversion of high value habitats to other land uses has reduced the abundance, distribution and diversity of native species

Opportunities.

- Land formerly converted by mining or agriculture can be restored to more natural habitats in conjunction with FRM
- Facilities can be included at recommended FRM and Ecosystem Restoration (ER) features to provide public access and use and improved outdoor recreation experiences

Objectives.[5] The study objectives were developed through the integration and use of the four planning accounts, which include national economic development (NED), environmental quality (EQ), regional economic development (RED), and other social effects (OSE).

- Reduce the risk to life, health, and public safety due to flooding
- Reduce the risk of property damage due to flooding
- Reduce the risk of damage to critical infrastructure due to flooding
- Encourage wise use of the floodplain
- In conjunction with FRM, restore floodplain connectivity and associated dynamic riverine processes
- In conjunction with FRM, restore aquatic, wetland, riparian and terrestrial habitats for special status and other native species
- In conjunction with FRM and ER, improve the public's access to and use of outdoor recreational opportunities in the study area

Constraints.

- Minimize adverse hydraulic effects where they could result in economic damages to others
- Minimize significant adverse impacts to the human environment
- Comply with applicable Federal laws, regulations, and policies such as the National Environmental Policy Act, Endangered Species Act, Fish and Wildlife Coordination Act, Clean Water Act, and the National Historic Preservation Act.

Evaluation Metrics. Evaluation metrics were developed to compare alternatives. During plan formulation, as measures and alternatives were developed, better and more cost effective ecosystem and recreational opportunities were identified that were not conjunctive to the FRM measures and alternatives being carried forward to the array of alternatives. These objectives, ecosystem and recreation, were therefore not integrated into the final evaluation metrics and the multi-criteria analysis which directed focus on the life safety metrics.

[5] Additional non-Federal objective entailed reducing the probability of flooding to urban and urbanizing areas to less than 0.5% (1/200) annual chance exceedance due to CA State Law requiring a 200-year level of flood risk management by the year 2025.

The *Sutter Basin Pilot Study Re-scoping Plan* stated that it was anticipated that evaluation and comparison of the final array of alternatives would be based on monetary and non-monetary effects, qualitative and quantitative data, and economic, public safety, environmental, and regional criteria. The evaluation criteria (Table 4) identified were based on both existing Corps policy, including the Principles and Guidelines, and Planning Guidance Notebook.

Table 4. Evaluation Criteria based on P&G and PGN

Study Objectives	Evaluation Metric
(a) Reduce the risk of life, health, and public safety due to flooding	Population at Risk
	Critical Infrastructure-Life Safety
	Evacuation Routes
(b) Reduce the risk of property damage due to flooding	NED Costs
	NED Benefits
(c) Reduce the risk of damage to critical infrastructure due to flooding	Critical Infrastructure-Life Safety
(d) Encourage the wise use of the floodplain	Potentially Developable Floodplain (Acres)

Definitions of the evaluation metrics used in the Sutter Basin Feasibility study are shown in Table 5. These evaluation metrics were presented and discussed during the In-progress Review Meeting #4 on 26 June 2012 and were approved by the Vertical Team.

Table 5. Description of Metrics

Evaluation Metric	Description
Population at Risk (People)	Number of people within the 1% ACE Floodplain based on the 2010 census blocks.
Critical Infrastructure (Facilities)	Number of fire stations, police stations, hospitals, senior living facilities, and jails that are of life safety significance.
Evacuation Routes (# of Routes)	Assesses the vulnerability of populations with regards to the number of escape routes available during flood events.
Potentially Developable Floodplain (Acres)	Potentially developable land within the 0.2% ACE floodplain. Acres of land with 1% ACE flood depths less than 3 feet.

4. PLAN FORMULATION

The plan formulation process develops and evaluates alternative plans to address the needs and desires of society as expressed in specific planning objectives. Accordingly, the tentatively selected plan best satisfies the objectives as well as the Federal interest, which are consistent with the Federal Water Resources Council's Principles and Guidelines (P&G) and the Planning Guidance Notebook (ER-1105-2-100).

Management Measures. A broad array of management measures was developed based on information from existing reports and studies, as well as public input and professional judgment. These measures were presented at the Sutter Basin Pilot Study Critical Thinking Charette held at the Sacramento District on July 18-19, 2011. The charette was attended by the PDT and non-Federal sponsors, along with several members of the Vertical Team and the National Pilot Program 17+1 Team. The team reviewed each measure, identified additional measures, and then evaluated the measures based on study objectives, study constraints, and Water Resources Council Principles and Guidelines (P&G) criteria. A group decision was made as to whether each measure should be retained or dropped from further consideration. Progress Document #1 provides a description of the measures evaluated at the charette and indicates whether each one was retained or dropped and the reason(s) for dropping.

Preliminary Alternative Formulation and Evaluation. Following the initial screening of measures, the team identified four themes (strategies) for plan formulation. The themes included the following: 1) Consequence Management Focused on Public Safety, 2) Urban FRM Focus, 3) Maximize Existing System with FRM Focus, and 4) Ecosystem Restoration Focus. These themes were used to assist the team in establishing a preliminary array of conceptual alternatives by grouping measures according to the primary focus of each theme. Based on the measures grouped under each theme, the team identified a total of nine conceptual alternatives[6]. Most alternatives are comprised primarily of new levees or strengthening of existing levees. Following the charette, each alternative was further developed and quantities, costs and economic benefits were estimated for each alternative. The use of these results was used solely to screen out those preliminary alternatives that do not appear economically justified even in the most favorable conditions.

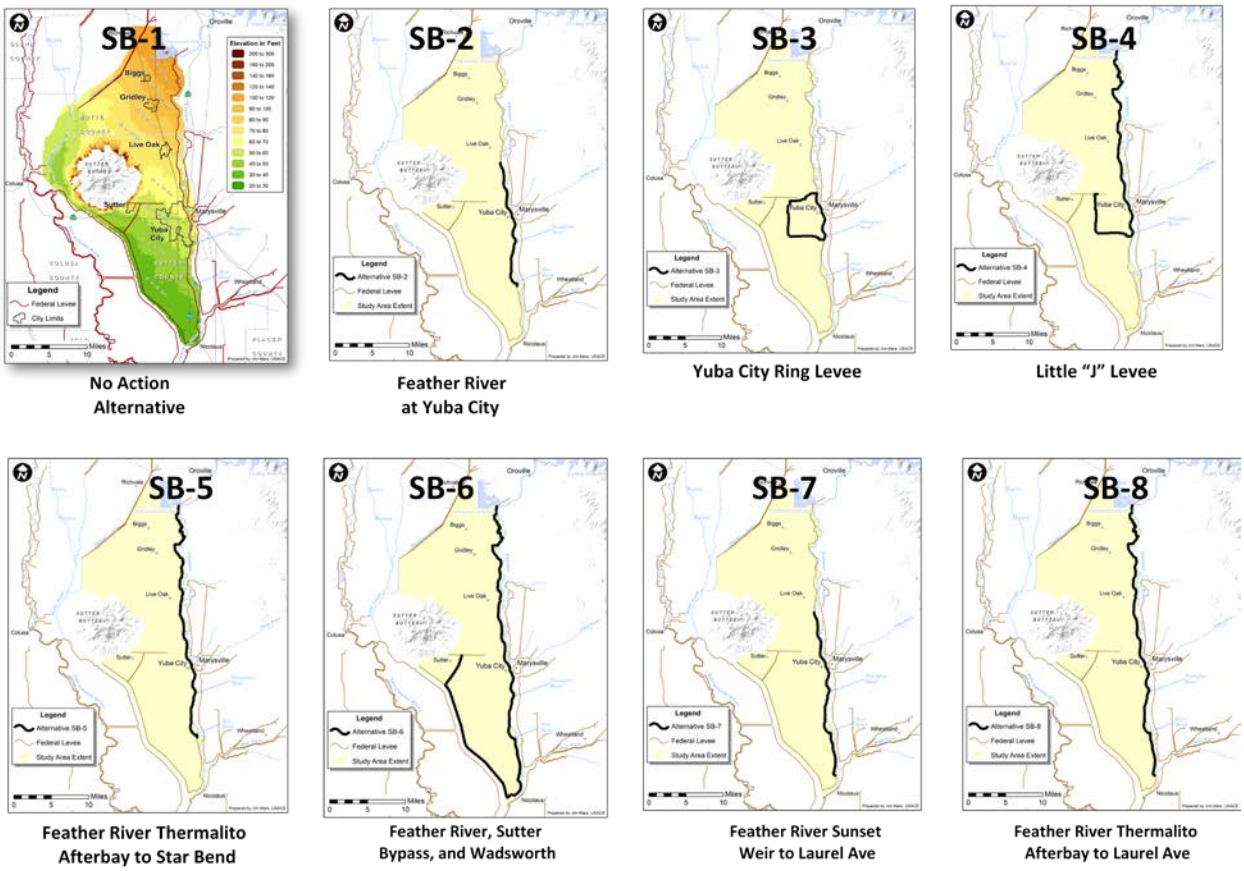
Draft Alternative Evaluation and Comparison. A combined Value Engineering (VE) Study and Planning Charette was held from October 31st to November 4th, 2011. The VE methodology was incorporated into the planning process at an early stage of the study to compare, refine, and optimize alternatives based on multiple criteria in order to ensure a robust array. This process also provided an opportunity to validate the array of preliminary alternatives and to ensure that significant alternatives had not been overlooked. The VE Study/Charette was attended by the PDT and non-Federal sponsors, the Sacramento District (SPK) VE Officer and South Pacific Division (SPD) VE Program Manager, the SPD Plan Formulation Lead, and representatives from the National Pilot Program 17+1 Team. Based on the discussions during the combined VE Study/Charette, the team identified alternatives with very similar functions in addition to those with little probability of implementation. This resulted in combining and eliminating some of the alternatives as well as refining and optimizing those that were retained by adding or removing measures in order to ensure a robust array. The draft array of alternatives (shown in Figure 5) evaluated in further detail includes:

- Alternative SB-1: No Action Alternative.

[6] A matrix with the array of conceptual alternatives and measures associated with each of these alternatives is also included in Progress Document #1 where the nine conceptual alternatives are described by theme.

- Alternative SB-2: Fix in Place Feather River from Sunset Weir to Star Bend - This alternative involves strengthening the existing Feather River levee in the immediate vicinity of Yuba City and reduces risk to the Yuba City urban core.
- Alternative SB-3: Yuba City Ring Levee – This alternative includes the construction of a new levee surrounding Yuba City and reduces risk to the primary urban center.
- Alternative SB-4: Little "J" Levee – This alternative includes strengthening the Feather River levees north of Yuba City and construction of a new levee on the south and west of Yuba City. Reduction of risk is focused on Yuba City and the northern communities of the Basin.
- Alternative SB-5: Fix in Place Feather River, Thermalito Afterbay to Star Bend- This alternative includes SB-2 but extends levee improvements north to Thermalito.
- Alternative SB-6: Fix-in-Place Feather River, Sutter Bypass, and Wadsworth Canal- This alternative consists of the Sutter Bypass / Wadsworth Canal Levee Improvements and the Feather River Levee Improvements.
- Alternative SB-7: Fix in Place Feather River, Sunset Weir to Laurel Ave- This alternative includes SB-2 but extends Feather River fix-in-place levee improvements south of Yuba City to Laurel Ave that specifically addresses residual risk of Yuba City southeastern areas.
- Alternative SB-8: Fix-in-Place Feather River from Thermalito Afterbay to Laurel Ave – This alternative focuses on the Feather River Levee Improvements north to Thermalito and south to Laurel Ave. Reduction in risk is focused on Yuba City and the northern communities of the basin.

Figure 5: Alternatives



Identification of the NED Alternative. Table 6 summarizes the expected annual net benefits and the benefit to cost ratio ranges for each of the draft array of alternatives. The economic analysis indicates the national economic development alternative to be SB-7, as it maximizes net benefits. Alternative SB-7 comprises of fixing-in-place the existing Feather River from Sunset Weir down river to Laurel. The total first cost estimate is $423 with annual net benefits of $37 million. Figure 6 shows the Alternative SB-7, NED plan and the resulting with project residual floodplain.

Table 6: Alternative Economic Evaluation and Comparison[7]

Alternative	Total First Cost			IDC	Annualized Cost + O&M			Annual Benefits			Annual Net Benefits			Benefit to Cost Ratio		
	Low (20%)	Mid (50%)	High (80%)	Mid	Low (20%)	Mid (50%)	High (80%)	Low (75%)	Mid (50%)	High (25%)	Low	Mean	High	Low	Mean	High
SB-1: No Action	0	**0**	0	0	0	**0**	0	0	**0**	0	0	**0**	0	0.0	**0.0**	0.0
SB-2: Minimal Fix in Place, Sunset Weir to Star Bend	290	**319**	361	24	14	**16**	18	24	**38**	73	14	**29**	48	1.9	**2.9**	4.1
SB-3: Yuba City Ring Levee	411	**451**	507	53	21	**23**	26	25	**41**	71	8	**23**	40	1.3	**2.0**	2.7
SB-4: Little J Levee	729	**798**	899	94	37	**40**	45	31	**46**	87	-3	**14**	36	0.9	**1.4**	1.9
SB-5: Fix-in-Place, Thermalito to Star Bend	549	**608**	694	72	28	**31**	35	29	**45**	81	4	**21**	41	1.1	**1.7**	2.3
SB-6: Fix-in-Place, Feather River, Sutter Bypass and Wadsworth Canal	1,018	**1,131**	1,297	183	53	**59**	67	46	**73**	134	-3	**24**	58	0.9	**1.4**	2.0
SB-7: Fix-in-Place, Sunset Weir to Laurel Ave	386	**423**	479	41	19	**21**	24	32	**51**	92	18	**37**	60	1.8	**2.7**	3.8
SB-8: Fix-in-Place, Thermalito to Laurel Ave	645	**713**	812	100	33	**37**	42	36	**58**	101	7	**28**	52	1.2	**1.8**	2.4

Alternatives SB-2 and SB-7 result in the highest net benefits. Further evaluation of the NED Alternative (SB-7) when compared to (SB-2) indicates that the NED plan reasonably maximizes economic benefits and provides additional outputs in terms of the other accounts (Table 7). Alternative SB-2 consists of fixing-in-place the Feather River levees from Sunset Weir to the downstream end of Star Bend. The total first cost estimate is $319 million with annual net benefits of $29 million. Benefits are concentrated in the primary urban center of the study area, Yuba City. The next added fix, Alternative SB-7, comprises of fixing-in-place the existing Feather River levees from Sunset Weir down river to Laurel Avenue. This alternative consists of SB-2 fixes plus an additional 13.4 mile of levee fixes. The total first cost estimate is $423 million with annual net benefits of $38 million. The additional investment of $104 million results in an increase in net benefits of $8 million. The incremental benefit-to-cost ratio is 2.6. Benefits for this additional reach are also centered in Yuba City, but address significant flood risk to the southern urban portion of the city. Fixing this reach provides flood risk reduction to approximately an additional 18,500 people.

[7] The net benefits were computed using screening level cost estimates, which incorporated results from a cost risk analysis. As such, a range of confidence was derived for each cost estimate and computed benefits. This range indicates the reliability of the estimate and benefits.

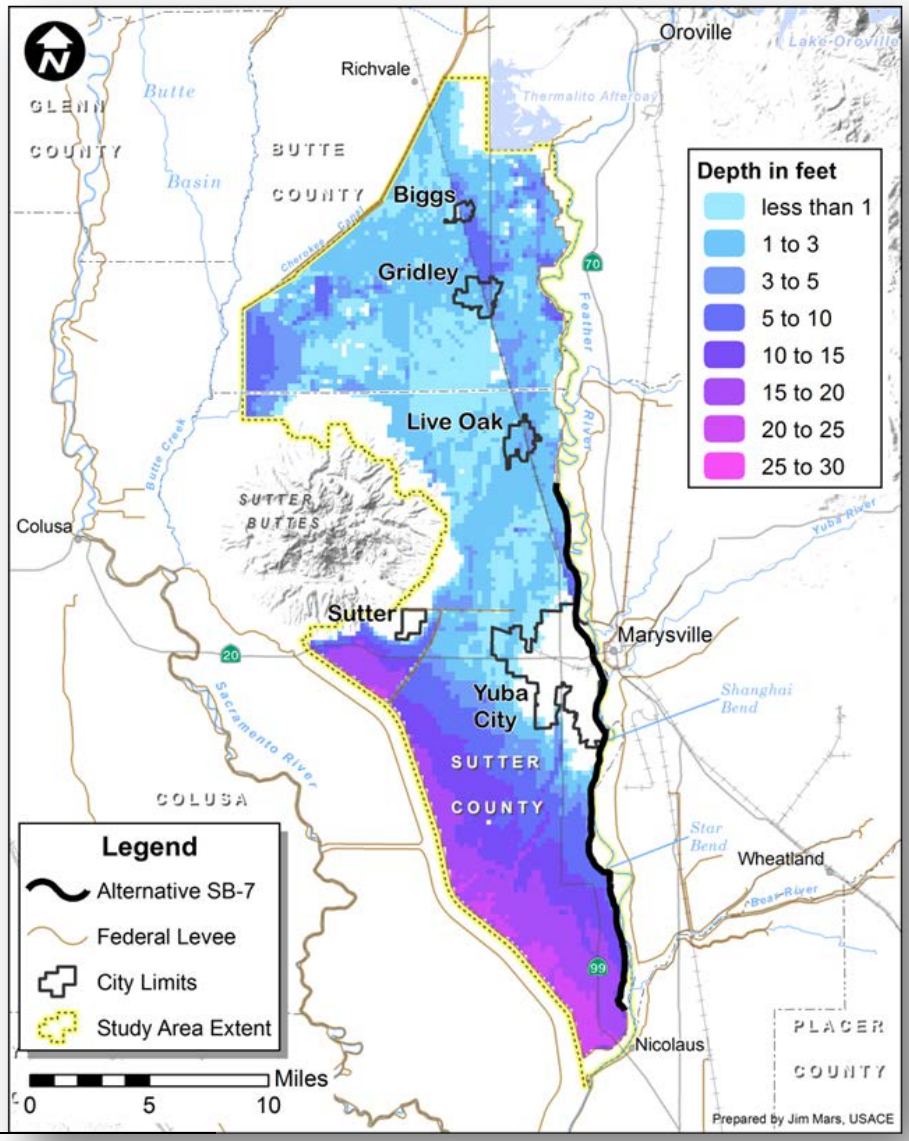
Table 7: SB-2 and SB-7

Item (from mean economic range number)	**Alternative SB-1 No Action**	**Alternative SB-2 1st Increment**	**Alternative SB-7 NED**
Investment Cost (millions)			
First Cost	-	319	423
Interest During Construction	-	24	41
Total	-	343	464
Annual Cost (millions)	-		
Interest and Amortization	-	15.8	20.7
OMRR&R	-	0.2	0.4
Subtotal	-	16	21
Annual Benefits FRM (millions)	-	38	51
Multi Objective Accounts (non-monetary)			
Population Remaining at Risk (people)	94,600	**56,700**	**38,200**
Critical Infrastructure (facilities)	28	11	11
Evacuation Routes (number of routes)	0	1	1
Wise Used of Floodplains (acres)	71,800	83,800	88,200
Net Annual FRM Benefits (millions)	-	**29**	**37**
FDR Benefit to Cost Ratio	-	**2.9**	**2.7**
FDR Benefit to Cost Ratio (at 7%)	-	1.7	1.6

5. RESIDUAL RISK OF THE NED ALTERNATIVE

Description of Residual Risk. The NED Alternative (SB-7) reduces adverse flooding effects but benefits are primarily centered on Yuba City. The alternative features do not address the significant flooding risk in the communities of Biggs, Gridley, and Live Oak. Residual risk of the NED alternative was assessed by the life safety metrics, described in Table 5. Given the NED residual 1% ACE floodplain[8] (Figure 6), substantial residual risk to Biggs, Gridley, Live Oak, and Yuba City remain (Table 8).

Figure 6. Alternative SB-7 NED Plan (1% ACE Residual Floodplain)



[8] 1% floodplains are based on the inundation from any levee having less than 95% assurance. The assurance estimate was based on geotechnical, hydraulic, and hydrologic uncertainty.

Table 8. Residual Risk of the NED Alternative, 1% ACE Floodplain

Evaluation Metric	Alternative	
	SB-1: No Action	NED Plan
Population at Risk (People)	94,600	38,200
Critical Infrastructure (Facilities)	28	11
Evacuation Routes (Number of Routes)	0	1
Wise Use of Floodplains (Acres)	71,800	88,200

Population at Risk. A remaining population of 38,200 is at risk of flooding. Of special concern is the population over the age of 65 living within the study area since those individuals have been shown to be at higher risk of life loss in flood events. Both Butte (15.6%) and Sutter (13.0%) counties are above the state average (11.7%) for percentage of persons 65 years of age and over[9].

Critical Infrastructure. A significant amount of critical infrastructure is located within the Sutter study area. Critical infrastructure is a term used by governments to describe assets that are essential for the functioning of a society and economy from a national perspective. Most commonly associated with the term are facilities for fire stations, police stations, hospitals, senior living facilities, and prisons. The benefits of the NED Alternative (SB-7) are primarily centered around Yuba City and still at risk are 11 elements of the critical infrastructure in the communities of Biggs, Gridley and Live Oak.

Evacuation Routes. The primary urban centers in the region are Yuba City, Biggs, Gridley, and Live Oak. These communities are all located on or near California State Route 99, which runs north-south through the region. The Sutter County Evacuation and Mass Shelter/Care Plan identifies Highways 20, 99 and 113 as the primary evacuation routes in the region. These routes are subject to change since these routes are event-specific and official routes are established by the County Sheriff's office during an emergency. The Butte County Office of Emergency Management does not have published evacuation routes at this time, but anticipates Highways 99, 162 and the Colusa Highway could be used as conditions allow. During the 1997 event, seven different evacuation zones were established over seven days due to constantly changing conditions and levee breaks[10]. The main evacuation routes used for this flood event were Highway-99 north and Highway-113 south. Highway-20 west and Highway-99 south were used intermittently since all portions of these roads were not accessible at all times during the flood.

Evacuation preparation can be made days in advance for predictable flood events within the major river system surrounding the study area. As river water levels raise and are predicted to reach flood stages, warnings and evacuation efforts would be increased and reiterated. This would allow time for evacuation of immobile residents and other people with special evacuation needs (hospitals, rest homes, jails, elderly individuals, schools) via the established routes. However, none of the historical flooding evacuations in the region have been due to foreseen events. Historical flood evacuations in the region have been from levee failures due to underseepage, which is characterized by its unpredictability and sudden occurrence.

[9] Source: U.S. Census Bureau (2012).

[10] Source: Sutter County Office of Emergency Management.

The result is evacuations after levees have failed and widespread flooding is in progress. The 1955 flood occurred due to a levee break in late December where no prior evacuation notice was given. In the 1997 flood, Yuba City was evacuated and during the evacuation a levee on the east side of the Feather River near Olivehurst (which was not evacuated) broke.

The residual 1% ACE (1/100 year event) resulting from the NED Alternative affects every major urban center and nearly every primary evacuation route in the region. The floodplain is due to potential levee failure upstream of Sunset Weir. All routes out of Biggs, Gridley and Live Oak are affected by the residual floodplain. The only egress from Yuba City would be Highway 20 and 5th Street bridges east into Marysville, which is a community surrounded by a ring levee. Additionally, heading eastbound entails driving over a four lane bridge that is not expected to adequately handle the additional traffic flow, and may create a bottle neck limiting evacuation.

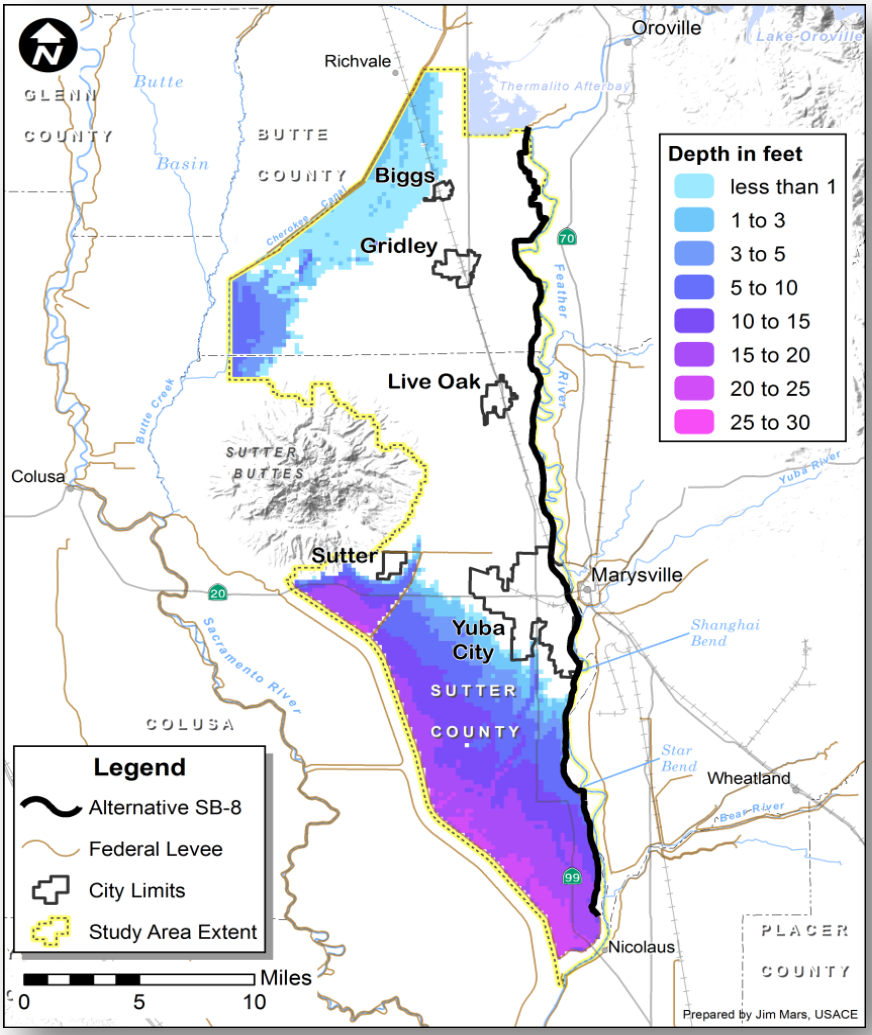
The District has initiated coordination with California Department of Transportations (CalTrans) to understand their criteria for road closures and evacuation during flood events. Standards for road closures are based less on depth and more on length of roadway affected by flooding. Road closures are determined based upon safety concerns and are authorized by the California Highway Patrol. Residual flooding in the northern area Sutter Basin associated with the NED Plan would encompass a majority or all primary roadways and would have a high likelihood of being considered impassable and/or closed using the above criteria. The sponsor has finalized its Flood Plain Management Plan, which includes coordination with State transportation authorities. The District will verify that the Future Without-Project Condition and No-Action Plan accurately represent the State and local response criteria for flood events.

Wise Use of Floodplains. A determination must be made as to whether the increase in potentially developable floodplain area is acceptable under Corps policy, or can be avoided or mitigated to an acceptable level within a justified cost. It is important to remember that the floodplain metric used in this analysis is a simple index based on physical parameters. The metric does not attempt to forecast future population growth, economic conditions, or government decisions that will constrain future floodplain development. For example, current zoning ordinances in Sutter and Butte County's General Plan indicate restrictive policies, which govern future development. Local policies, combined with recent state legislation and federal regulations are expected to limit developable land. These factors should be considered in conjunction with the metric.

6. ADDRESSING RESIDUAL RISK

The NED Alternative (SB-7) reduces adverse flooding effects but significant residual risks remain. With the aim of buying down the residual risk, the PDT found the most cost-effective incremental alternative to the NED to be Alternative SB-8. Figure 7 displays the residual 1% ACE floodplain associated with Alternative SB-8. In order to better understand the nature of residual flooding and flood risk associated with the NED Plan and LPP, the District has refined flood plain mapping to 1 foot intervals for the 2%, 1%, 0.5%, and 0.2% ACE. Please see Attachment 2, MFF urban floodplains.

Figure 7. Alternative SB-8 (1% ACE Residual Floodplain)



Using life safety metrics and accounts to address the significant residual risk of the NED Plan other measures and alternatives were investigated and evaluated with Alternative SB-8 identified as a next increment plan to the NED plan that effectively and efficiently reduces the residual risk and consequences to life safety in the northern urban areas and other parts of Sutter Basin. To further ensure that Alternative SB-8 structural and formulation strategy were valid, a cost comparison of Alternative SB-8 was performed, at a conceptual level of detail, to verify the structural measures of Alternative SB-8 were the most cost effective in addressing the residual risk and consequences left by the NED Plan.

The District identified risk reduction measures to reduce loss of life and improve the function of critical infrastructure facilities. Ring levees were considered to be ineffective for facilities like hospitals, the correctional institution, and the assisted living center because the functionality of the facilities would be compromised for an average flood event, which is estimated to be 2-3 weeks (using actual historical flood events in this study area as reference). Raising smaller facilities such as the police stations and the fire stations might be economically justified, but they would not maintain their functionality during the duration of a flood event.

Specific measures to improve evacuation during a flood event were also evaluated. Measures considered included modification to the roads used for evacuation. Because flooding in the northern portion of the study area is extensive sheet flow, embankment modifications to road and the railroad would need to be raises; culverts would not convey the wide area extent of the sheet flows. Raising roads was considered to be cost prohibitive relative to other measures. Raising the railroad is considered to be more costly than raising a road so that measure was similarly screened out. Additional investigation of potential evacuation routes and destinations, such as the Sutter Buttes, will be done as part of the life safety incremental assessment of SB-7 and SB-8, to be included in the Draft Feasibility Report. Please see Attachment 1, Decision Point #2 Slides, slides 50-56).

Evaluation of critical infrastructure and evacuation life safety measures will continue to be refined for the Draft Feasibility Report.

Fixing in place levees structural measures of Alternative SB-8 are estimated at an additional cost (compared to the NED plan) of: $260 to $330 Million. The costs for various comparable nonstructural measures addressing similar residual risk areas are listed below:

- Elevate Houses: ~$650 million
- Evacuation Route – Elevated Causeway: ~$600 Million
- Ring Levees around Live Oak, Gridley, and Biggs: ~$375 Million
- Buyouts: ~$1Billion

Alternative SB-8 is the multi-objective/account alternative that is cost effective and best reduces flooding and reduces residual risk of life safety in the Sutter Basin. Alternative SB-8 is comprised of Alternative SB-7 fixes plus fixing-in-place the existing northern Feather River levees from Sunset Weir up to Thermalito. The total first cost estimate is $713 million with annual net benefits of $26 million.
The additional investment of $290 million in project cost (Alternative SB-8 first cost minus the NED Alternative cost) buys down the residual risk of the NED Alternative and provides significant non-monetized benefits (displayed in Table 9). The population at risk of flooding from a 1% ACE flood event (Plate #8) decreases from 38,200 to 6,600, life safety related critical infrastructure at risk is reduced from 11 to 1, and the number of evacuation routes increases from 1 to 5. It should be noted that the additional investment of $290 million for the LPP increment produces an incremental annual benefit of $7 million. While this is not enough to justify the full cost of the increment, it justifies more than half of it. The LPP would reduce risk to an additional 32,000 people in an area that has historically had loss of life in a flood event. The RMC is conducting a Levee Safety Alternatives Evaluation of the NED and LPP the week of 25 February 2013.

Table 9. Summary of Life Safety Metrics, 1% ACE Floodplain

Evaluation Metric	Alternative		
	SB-1: No Action	NED	SB-8
Population at Risk (People)	94,600	38,200	6,600
Critical Infrastructure (Facilities)	28	11	1
Evacuation Routes (Number of Routes)	0	1	5
Wise Use of Floodplains (Acres)	71,800	88,200	100,200

In significantly reducing the residual risk of the NED Alternative, the next incremental alternative (SB-8) is supported by the local sponsors and can be considered the federal plan in terms of comprehensiveness and completeness. Alternative SB-8 is proposed as the Locally Preferred Plan (LPP) with strong federal interest. Furthermore, considering an objective of the study is to reduce risk to lives, perhaps the LPP increment of levee (17.7 miles) is in fact non-separable from the levee improvements included in the NED Plan from a life safety perspective.

Please also refer to Attachment 1, Decision Point #2 presentation slides 47-70, for initial comparison of NED and LPP, which is also being refined for the Draft Feasibility Report.

7. FINAL ARRAY OF ALTERNATIVES & COMPARISON

With the identification of the NED Plan and the LPP, a final array of alternatives was established for the study:

- **No Action: Alternative SB-1**
- **NED: Alternative SB-7** reconfirms federal interest, reduces flood risk to most of Yuba City area, but leaves considerable residual risk to the northern communities of the basin and parts of Yuba City.
- **LPP: Alternative SB-8** reconfirms federal interest the same as the NED plan, but significantly reduces residual risk of the NED in the northern communities of the basin and parts of Yuba City. It has also been identified in terms of multi-objective planning the comprehensive federal plan.

As a final step in the multi-objective planning process, a pair-wise comparison and evaluation was completed between the NED plan and the LPP to determine the recommended Tentatively Selected Plan (TSP**)** as shown in Table 10.

Table 10: Final Array of Alternative Plans- Comparison Summary of Accounts and Criteria

	NO ACTION	NED PLAN	LPP PLAN
1. PLAN DESCRIPTION			
	Alternative SB-1: The No Action provides no physical project constructed by the Federal Government.	Alternative SB-7: The NED plan is a Feather River fix-in-place levee alternative from Sunset Weir to Laurel Avenue.	Alternative SB-8: The LPP plan is a Feather River fix-in-place levee alternative from Thermalito to Laurel Avenue.
2. MULTI-OBJECTIVE PLANNING ASSESSEMENT			
A. National Economic Development (NED) – mean or mid-range numbers			
1. Project Cost	$0	$423,000,000	$713,000,000
2. Annual Cost	$0	$21,000,000	$37,000,000
3. Total Annual Benefit	$0	$51,000,000	$58,000,000
4. Annual Net Benefits	**$0**	**$37,000,000**	**$28,000,000**
5. Benefit – Cost Ratio	**N/A**	**2.7**	**1.8**
B. Environmental Quality (EQ)			
1. Environmental Safety	High potential for contaminated flood waters from the northern community urban facilities (water treatment plants; gas stations; etc)	High potential contaminated flood waters from the northern community urban facilities (water treatment plants; gas stations; etc)	Lower flood risk and lower risk of potentially contaminated flood waters from the northern urban community facilities (water treatment plants; gas stations; etc)
2. Ecosystem	The Sutter Basin is located along the Pacific Flyway that serves millions of migrating waterfowl during the winter migration (flooding) season for	Under residual flooding, thousands of acres remain impacted, negatively affecting "stop-over" feeding and resting areas with potential wildlife	Residual flooding is primarily concentrated in the south most part of the basin allowing for significant availability of acres for "stop-over" feeding and

	NO ACTION	NED PLAN	LPP PLAN
	foraging and rest. Flooding would negatively affect "stop-over" feeding and resting areas with potential wildlife health issues with contaminated waters.	health issues with contaminated waters.	resting. There is a lesser risk from urban area contamination
C. Regional Economic Development (RED)			
1. RED Effects to Flood Risk Management and Region	Future flooding would destroy part of the infrastructure resulting in a loss in the region's ability to produce goods and services. Little to no RED benefits.	A 4-year period of construction can result in positive spillovers to suppliers, short-term increases in construction related employment, increase revenues for local businesses and a potential increase in wealth for floodplain residents, as less is spent on damaged property repairs. Population and economic centers of the basin would be flooded resulting in slow regional recovery.	Similar to NED, but effects will extend for a 6-year period of construction resulting in additional RED benefits. Major population and economic centers will have reduced risk of flooding resulting in faster regional recovery.
D. Other Social Effects (OSE) – Life Safety Evaluation Metrics			
1. Life, Health, and Safety	Continued flood risk and consequences in the Sutter Basin including the communities of Yuba City, Live Oak, Gridley, and Biggs.	Flood Warning Emergency Evacuation Plan (FWEEP) mitigation is problematic for types of levee failures and limited evacuation routes. Significant life safety residual risk to the communities of Yuba City, Live Oak, Gridley, and Biggs.	Flood Warning Emergency Evacuation Plan (FWEEP) mitigation is problematic for types of levee failures and limited evacuation routes. Life safety residual risk to the communities of Yuba City, Live Oak, Gridley, and Biggs are significantly reduced.
1a.Remaining Population at Risk	Approximately **94,600** individuals are within the 1% ACE floodplain.	**38,200** people remain in the 1% ACE floodplain. (60% of population is removed from the 1% ACE residual floodplain for NED.)	**6,600** people remain in the 1% ACE floodplain. (93% of population is removed from the 1% ACE residual floodplain for SB-8)
1b. Loss of Life Estimate For 1% ACE event (Based on Hurricane Katrina loss of life ratio)	Potential loss of **112** lives.	Potential loss of **45** lives.	Potential loss of **8** lives.
1c. Critical Infrastructure – Life Safety	**28** structure deemed as critical from a national perspective are at risk from floods.	**11** structures remain at risk from floods.	**1** structure is at risk from floods.
1d. Evacuation Routes (See comparative plates below)	In the event of a flood, no evacuation route is available out of the basin.	Offers **one** problematic route for evacuation during a flood event. A flood warning and evacuation plan would not be as effective and limited.	**5** evacuation routes are available in the event of a flood. A flood warning and evacuation plan would have more robustness and redundancy.

	NO ACTION	NED PLAN	LPP PLAN
1e. Wise Use of Floodplains Note: fix-in-place measures are only bringing levees up to authorized elevation and performance.	Currently, 71,800 acres of land are potentially available for future development.	88,200 acres would be potentially available for future development.	100,200 acres of land would be potentially available for future development. (additional 12,000 potential acres calculated compared to NED)
2. Social Vulnerability (Study Area Resiliency)	The social vulnerability index score (SoVi) indicates the study area to be medium to high vulnerability. The No Action alternative may leave communities unable to cope with the recovery from a flood hazard.	Majority of the community of Yuba City is afforded flood risk reduction, however the communities of Live Oak, Gridley, and Biggs remain at risk of flood hazards and may be unable to cope and recover.	The four existing communities are provided flood risk reduction, and social vulnerability is minimized due to a decrease in the probability of flood hazards occurring.
3. Residual Risk and Consequences	Residual Risk remains high throughout the study area	Residual Risk for Life Safety is reduced for most of the Yuba City urban area.	Residual Risk for Life Safety is reduced in the high risk communities: Yuba City, Live Oak, Gridley and Biggs.
E. Federal Planning Criteria			
Acceptability	N/A	The local sponsors and public support levee fixes and improvements.	The local sponsors and public support levee fixes and improvements.
Effectiveness	N/A	Addresses the primary planning objectives of reducing FRM and some life safety.	Addresses the primary planning objectives of reducing FRM and life safety.
Efficiency	N/A	Economic analysis and outputs identified	Economic analysis and outputs identified
Completeness	N/A	Significant residual risk of life safety in the northern basin communities of Biggs, Gridley, and Live Oaks.	Reduces residual risk of life safety to Yuba City and the communities of Biggs, Gridley, and Live Oaks.

Alternative Comparison.

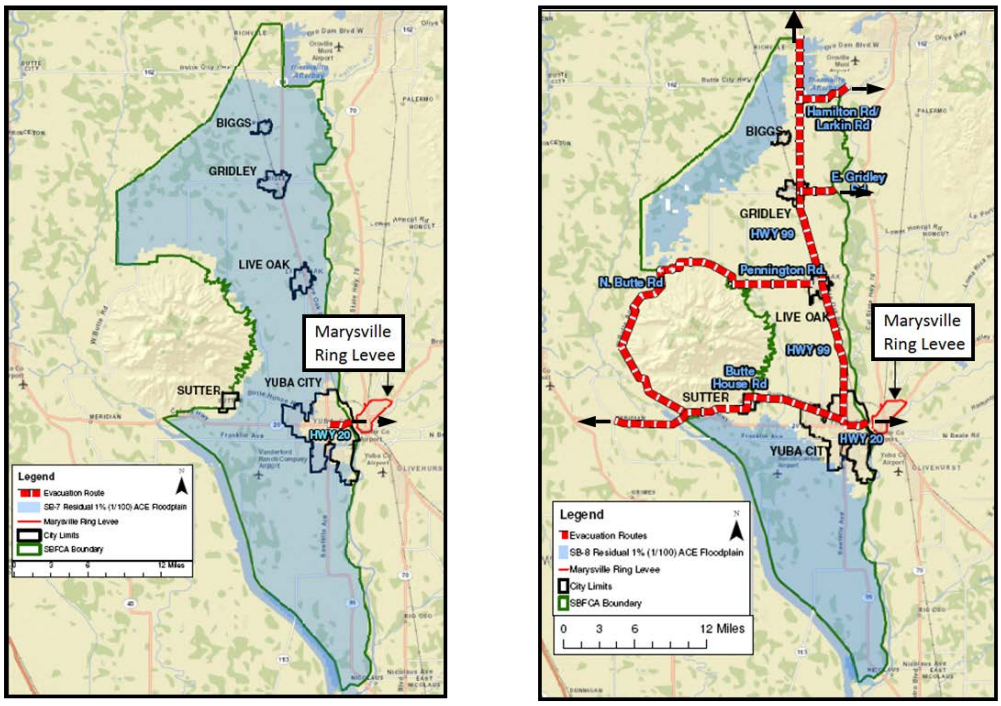
Population at Risk. A more specific comparison figures were developed in comparing the NED plan with the LPP (SB-8). The NED plan removed 60% of the basin population out of the 1% ACE floodplain while the LPP (SB-8) removed 93% of the basin population out of the 1% ACE floodplain. (See Table 11)

Table 11: Remaining Population at Risk

Community	NED Population Remaining at Risk	SB-8 Population Remaining at Risk	Reduction of Population at Risk
Yuba City	11,400	3,500	7,900
Biggs	1,500	20	1,480
Gridley	6,400	0	6,400
Live Oak	8,400	0	8,400
Sutter Rural	5,800	3,100	2,700
Butte Rural	4,800	20	4,780
Total	**38,200**	**6,600**	**31,600**

Evacuation Routes. The availability and access of evacuation route options tied to the sudden unpredictable nature of recent flood events is a critical comparison factor of the NED vs. to the LPP. With the population centers spread throughout the middle and northern sections of the Basin, having multiple routes to choose from is critical to evacuation planning and real time evacuation. Adjoining basins to the southwest, south, and east, either has lower levels of flood protection or is surrounded by water during flood events, making them dangerous locations for evacuees. The NED plan provides only one route to the city of Marysville which has historically been surrounded by water in flood events and is currently in final planning stages for a ring levee FRM project. (Figure 8).

Figure 8. Comparison of NED and LPP Evacuation Routes (1% ACE Residual Floodplains)

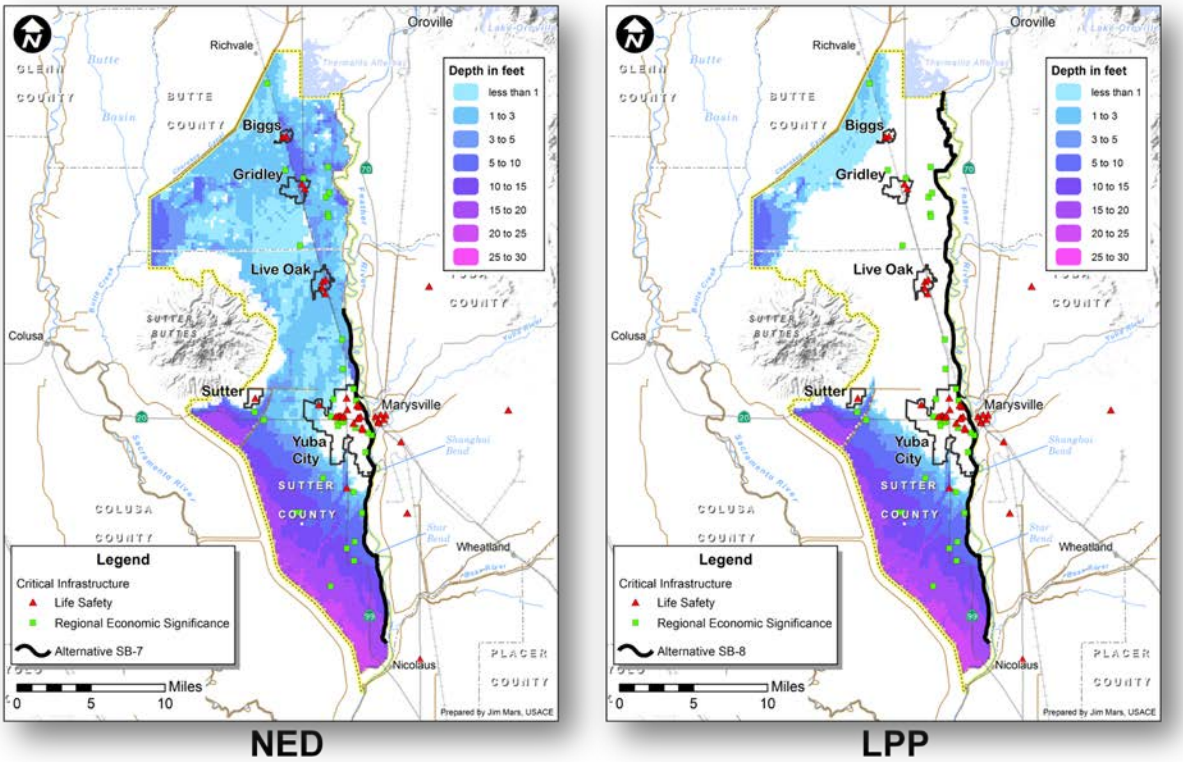


NED LPP

Critical Infrastructure. In terms of response and recovery of flood events for life safety, the NED plan leaves numerous critical infrastructure facilities at in the 1% ACE residual floodplain in the cities of Biggs, Gridley, Live Oak, and part of Yuba City (Figure 9). A partial list is provided here:

- 1 Hospital (45 beds)
- 2 Police stations
- 5 Fire stations
- 1 Assisted living center (99 beds)
- 3 City hall buildings
- 1 Correctional Facility (305 inmate capacity)
- 3 Water and sewer treatment facilities
- Multiple telecommunication facilities

Figure 9. Critical Infrastructure-Life Safety Comparison

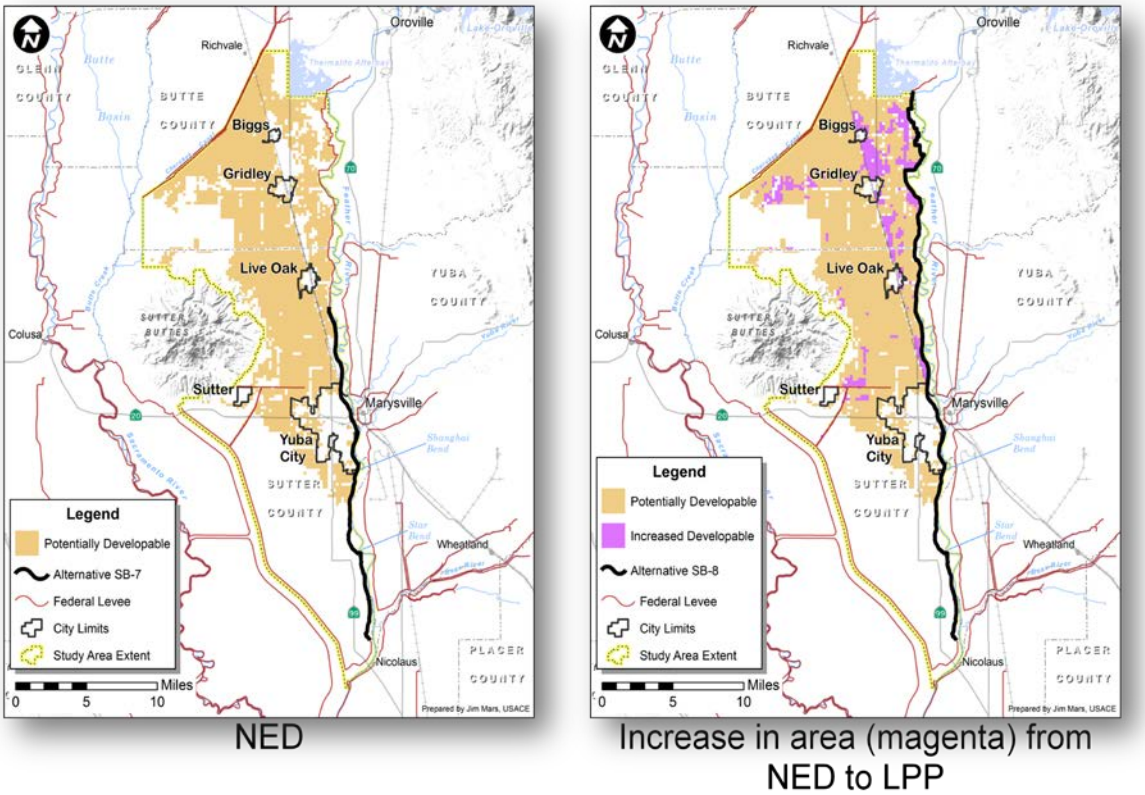


Wise Use of Floodplains. Potentially developable land in terms of 1% ACE residual floodplains were calculated as an evaluation metric to enable general comparison of potentially developable floodplain under the NED Plan vs. the LPP assuming land is developable if the 1% ACE floodplain depths are 3-feet or less (Figure 10). The calculation estimates the potential of roughly 12,000 additional acres made available with the LPP vs. the NED plan. The LPP includes conservation easements that could be purchased by the local sponsor to mitigate potential residual loss of life. See Attachment 1, slides 59-60.

Sutter Basin is an agriculturally focused region. The local and state partners have several existing land use commitments and constraints in the Sutter Basin in regards to development in the floodplain:

- Williamson Act Contracts: These rolling 10-year agreements between government and farmers to preserve the agricultural and open space in rural California by offering landowners tax breaks on the assessed land value.
- Conservation Easements: Agreements between landowners and an agency (USFWS, etc) which permanently precludes future development.
- Flood Risk Notifications: Annual flood risk notifications sent to all property owners.

Figure 10: Potentially Developable Floodplain Comparison



Loss of Life. Estimates of potential loss of life were made for this study for areas identified as rescue areas and for the areas identified as evacuation area. These estimates are based upon actual loss of life ratios experienced in 2005 by the population of New Orleans during the Hurricane Katrina levee failures. Boyd et al. assumed that of the inhabitants in a flooded area, 80% evacuated and 10% found shelter in a specialty facility (such as the Superdome or high school), leaving approximately 10% of the population in a flooded area exposed to the flood event. Based on actual fatalities in New Orleans a mortality rate of 1.18% was determined for the population exposed to the flood event.

As indicated in Table 12, application of the Katrina ratio to the approximately 94,800 population within the No Action population at risk associated with a Feather River levee failure results in the potential loss of 112 lives, to the approximately 38,300 people within the NED residual floodplain results in the potential loss of 45 lives, to the approximately 6,640 people in Alternative SB-8 residual floodplain results in the potential loss of 8 lives. Note that these are preliminary values. Many factors will influence the mortality rate from a flooding disaster, including timing of the breach (day or night), population located near the breach, and availability of flood warning and evacuation routes. The preliminary analysis provides an indication of the loss of life lives that might be expected. In the California Central Valley, the risk of a large flood is seasonal. The majority of rainfall occurs in the November through March rainy season, making the area most vulnerable to winter floods. Standing or working in water which is cooler than 75 °F (24 °C) will remove body heat more rapidly than it can be replaced, resulting in hypothermia. Cold water removes heat from the body 25 times faster than cold air. About 50% of that heat loss occurs through the head. Physical activity such as swimming or other struggling in the water increases heat loss.

Hypothermia (decreased body temperature) develops more slowly than the immediate effects of cold shock. Survival curves show that an adult dressed in average clothing may remain conscious for an hour at 40 °F and perhaps 2-3 hours at 50 °F (water temp.). Any movement in the water accelerates heat loss. Survival time can be reduced to minutes. Hands rapidly become numb and useless. Without thermal protection, swimming is not possible. The victim, though conscious, is soon helpless. Without a life jacket, drowning is unavoidable.

Table 12: Estimated Loss of Life (1% ACE Residual Floodplain)

Economic Impact Area	Estimated Loss of Life		
	No Action	NED (SB-7)	LPP (SB-8)
Biggs	2	2	0
Gridley	8	8	0
Live Oak	10	10	0
Yuba City	80	13	4
Rural Butte	6	6	0
Rural Sutter	7	7	4
Total	112	45	8

Other Alternative Comparison Considerations and Factors.

Levee Safety Program – Baseline Conditions Risk Assessment. Levee Safety Program – Baseline Conditions Risk Assessment (BCRA). The Sutter Basin area is one of five areas selected to undergo a risk assessment by the USACE Risk Management Center (RMC). Within the Levee Safety Program framework, the BCRA is a quantitative risk assessment to advance the goal of the Levee Safety Program to work with stakeholders to assess, communicate, reduce, and manage risk associated with levee systems.

The Sutter Basin BCRA will include risk assessments of the baseline (existing conditions). Data collected as part of the Sutter Basin Feasibility study will be used by the RMC to assist in the development of the baseline. Once the baseline is established the RMC will evaluate the NED and LPP alternatives developed during the Sutter Study. The risk will be characterized by the combination of the probabilities of failure estimated for each failure mode and the consequences (life loss and damages) associated with that failure. Risk will be reported in terms of annualized life loss and estimated annual damages. Preliminary results are expected to be available in the spring of 2013.

Executive Order 11988. The objective of the Sutter Basin study is to reduce flood risk within the study area. The study is responsive to the EO 11988 objective of "avoidance, to the extent possible, of long- and short-term adverse impacts associated with the occupancy and modification of the base flood plain and the avoidance of direct and indirect support of development in the base flood plain wherever there is a practicable alternative". The proposed features focus on reducing the threat of flooding to the existing urban areas, altering a scattered footprint difference between the NED and LPP within the northern floodplain (Figure 10). These features would reduce the hazard and risk associated with floods thereby minimizing the effects of floods on life safety, health, and welfare to the existing population, and would preserve the natural and beneficial values of the base floodplain. For these reasons the proposed plan is in compliance with EO 11988.

Emergency Costs and Evacuation Planning. NED losses associated with public goods and services include some of the costs incurred as part of actions required to respond to a flood emergency. The type of costs that could be incurred and considered NED losses are those associated with the following activities, which may employ staff and equipment:

- Structure clean-up: monetary damages associated with the removal of debris generated by damage structures due to flooding
- Displacement: temporary relocation of residents, and subsistence costs (incremental costs above those that would be normally incurred)
- Public assistance/emergency response services

An expert-opinion elicitation panel comprised of professionals having significant, relevant experience in the field of emergency response convened in Sacramento, CA (2009) with the goal of developing estimates of the economic cost associated with various emergency related damage categories (evacuation, debris activities, public services, utilities, etc) . Initial modeling results for district studies, as a proportion of structure and content damages, ranged from 1-3%.

Additionally, road damages and traffic-related costs associated with detours and extra time traveled by motorists due to potential flooding in the Sutter Basin was forgone based on prior experiences, which have shown such damage categories to be relatively minimal when compared to structural damages. Nevertheless, it is recognized that in order to detail the magnitude of flooding problems in the Sutter Basin, the economic analyses can be conducted. However, because these damages categories are not expected to drive plan selection it was omitted from the analysis. If deemed necessary, emergency costs, road damages and traffic disruption analyses can be conducted during refinement of tentatively selected plan (TSP).

Non-Federal Sponsors' Request.

Sutter Butte Flood Control Agency and the State's California Central Valley Flood Protection Board are the non-Federal sponsor for the Pilot Feasibility Study. The LPP Plan is supported by both the non-Federal sponsors as this plan addresses the flood risk of Yuba City and the residual flood risk and consequences of life safety to the existing cities of Biggs, Gridley, Live Oaks, and parts of Yuba City that the NED Plan does not. The non-Federal sponsors agree to pay for the determined cost share of the LPP.

The LPP also meets the requirements of Senate Bill (SB) 5 which stipulates that urban and urbanizing areas of 10,000 or greater must achieve 1/200 ACE level of flood risk management. It should be noted that the southern deeper part of the basin would remain in the 1/100 ACE floodplain.

TSP Recommendation. The multi-objective comparison and assessment between the NED Plan and the LPP are summarized in Table 10. Both the NED and LPP provide significant benefits that exceed the costs. While the NED Plan is more efficient than the LPP, both plans are efficient. Both the NED and LPP are complete since they each contain all necessary elements for the project to function independently. In a multi-objective context that equably emphasizes flood risk reduction and residual risk to life safety across all accounts and criteria, the LPP can be recommended as the Tentatively Selected Plan.

8. RECOMMENDATION OF THE TSP

Both the NED (SB-7) and the LPP (SB-8) provide significant benefits that exceed the costs. While the NED Plan is more efficient than the LPP, both plans are efficient (B/C >1). Both plans are complete in that they include all necessary elements needed for the project to function without relying on other activities. The LPP plan is more effective in that it provides greater flood risk reduction benefits and addresses residual risk of life safety within the Sutter Basin. Based upon the information developed in support of the Decision Point 2 Conference, and the conclusions that can be drawn from that information and were presented to the Vertical Team, the LPP (SB-8) will be recommended as the Tentatively Selected Plan (TSP) in the Draft Feasibility Report.

Cost Sharing. Table 13 presents two cost sharing scenarios for Federal/non-Federal cost allocation for the TSP: full Federal participation as established by Section 103 of WRDA 1986; limited Federal participation where the Federal share is limited to the Federal share of the NED alternative. The range in confidence of cost estimates are displayed in Table 6, the mean estimates are used in the table below.

Table 13. Cost Allocation Scenarios for TSP ($1,000)[11]

Cost Allocation	NED	LPP	
		Full Federal Participation	Limited Federal Participation
Non-Federal			
LERRD	$48,333	$71,073	$71,073
Cash	$99,717	$178,477	$366,977
Sub Total	$148,050	$249,550	$438,050
Federal			
Construction	$274,950	$463,450	$274,950
Total Project Cost	$423,000	$713,000	$713,000

Full Federal Cost Participation. The estimated total project first cost for the TSP is $713 million, with an estimated Federal cost of $463 million and a non-federal cost of $250 million.

Limited Cost Share. The estimated total project first cost for the TSP is $713 million. Federal costs are capped at 65% of the NED plan ($275million) with an estimated to non- federal cost $438 million.

Recommendation.

The recommendation for the tentatively selected plan is the LPP Alternative. To recommend the LPP as the TSP, a Policy Exception Request will be developed and forwarded to the ASA (CW). With a confirmation of a recommended TSP, the PDT is scheduled to move forward in refining and finalizing an integrated draft EIS/EIR-feasibility report for concurrent public, internal and external peer reviews.

[11] LERRDs are based preliminary estimates based screening level cost estimates.

9. SUMMARY

- Recent geotechnical analysis of project levees reveal significant adverse flooding impacts as a result of underseepage failures, which are sudden and unpredictable, resulting in minimal warning time, and ineffectiveness of evacuation plans.

- The total value of damageable property within the Sutter Basin study area is estimated at $6.9 billion.

- Management measures were developed and formed the basis of the preliminary alternatives, which were evaluated and resulted in a draft array of alternatives of which SB-7 was identified as the NED Alternative, affirming federal project interest.

- The NED residual 1% ACE floodplain showed significant adverse flooding impacts remained given that the alternative only addressed flooding impacts in one of the four existing communities.

- An assessment of the residual risk of the NED Alternative using life safety metrics served to illustrate the magnitude of the flooding impacts. The metrics were population at risk, critical infrastructure, availability of evacuation routes and the potential developable acres.

- With the aim of buying down the residual risk, the PDT found the most cost-effective incremental alternative to the NED to be Alternative SB-8.

- The additional investment of $290 million in project cost (Alternative SB-8 first cost minus the NED Alternative cost) buys down the residual risk of the NED Alternative and provides significant non-monetized benefits. Total annual benefits increase from $51 to $58 million. The population at risk of flooding from a 1% ACE flood event decreases from 38,200 to 6,600, critical infrastructure at risk (within the 1% ACE floodplain) is reduced from 11 to 1, and the number of evacuation routes increases from 1 to 5. A preliminary estimate of the potential loss of life indicates a substantial reduction from 45 lives (NED) to 8 lives (LPP).

- The wise use of floodplain metric used in the analysis is a simple index based on physical parameters, and does not account for current restrictive zoning ordinances, which govern and limit future development.

- The final array of alternatives includes the No Action, NED and LPP.

- The LPP (Alternative SB-8) is recommended as the TSP that comprehensively addresses flood risk and the residual risk to life safety and is the federal plan.

CESPK-PD-W 28 November 2012

MEMORANDUM FOR FILE

SUBJECT: Sutter Basin Pilot Feasibility Study; Multi-Objective Analysis of Flood Risk Management Alternatives

1. References:

   a. Recommendations for Transforming the Current Pre-Authorization Study Process, USACE, January 2011
   b. Sutter Basin Pilot Study Draft Re-Scoping Plan, 1 September 2011
   c. Developing a Feasibility Study with Multiple Planning Objectives, 31 May 2012, SMART Guide, planning.usace.army.mil/toolbox/

2. Purpose

The purpose of this memorandum is to describe the multi-objective analysis used for the evaluation and comparison of the final array of alternatives, and for the selection of the tentatively recommended plan.

3. Background

The Sutter Basin Feasibility Study was selected as a Planning Modernization pilot study to test principles that have been outlined in the *USACE Recommendations for Transforming the Current Pre-Authorization Study Process* (January 2011) and associated materials. One of the five key elements highlighted by the *Recommendations* is the use of a multi-criteria approach to alternative selection, including moving away from the rote acceptance of National Economic Development (NED) or National Ecosystem Restoration (NER) as the sole criterion for plan selection. This element of the *Recommendations* also suggests the use of less detailed quantitative analysis and more judgment, including the use of weighted criteria. These *Recommendations* were based on the recognition of shortcomings in past practices, as well as anticipation of the proposed *Principles and Requirements.*

The *Sutter Basin Pilot Study Re-scoping Plan* (Reference 1.b) stated that it was anticipated that evaluation and comparison of the final array of alternatives would be based on monetary and non-monetary effects, qualitative and quantitative data, and economic, public safety, environmental, and regional criteria. The final array of alternatives would be evaluated and compared through a comprehensive trade-off analysis, which might involve unequal weighting of criteria. The alternative with the greatest net benefits would be identified; but may not be chosen as the Tentatively Selected Plan (TSP) based on the results of the trade-off analysis.

4. Approach

The evaluation criteria identified in the *Re-scoping Plan* were based on both existing Corps policy, including the *Principles and Guidelines (P&G)* and *Planning Guidance Notebook (PGN)*, and the proposed *Principles and Requirements (P&R)*. Pursuant to the *Recommendations*, the Sutter pilot study team developed a multi-objective approach to plan evaluation and selection that would consider all of the planning objectives identified for the study, rather than only the NED and NER objectives.

The Planning Objectives identified in the *Re-scoping Plan* are:

- Reduce the risk to life, health, and public safety due to flooding.
- Reduce the risk of property damage due to flooding.
- Reduce the risk of damage to critical infrastructure due to flooding.
- Encourage wise use of the floodplain.
- In conjunction with Flood Risk Management (FRM), restore floodplain connectivity and associated dynamic riverine processes.
- In conjunction with FRM, restore aquatic, wetland, riparian, and terrestrial habitats for special status and other native species.
- In conjunction with FRM and ER, improve the public's access to and use of outdoor recreational opportunities in the study area.
- Additional Non-Federal Sponsor Objective: Reduce the probability of flooding to urban and urbanizing areas to less than 0.5 (1/200) Annual Chance Exceedance with assurance..

5. Evaluation Criteria

The Project Delivery Team (PDT) decided the evaluation criteria for the multi-objective analysis should focus on the first four objectives, which are the FRM objectives. The ER and Recreation objectives are secondary to FRM and therefore are best considered as additions to the TSP. Alternatives that would fulfill the additional Non-Federal Sponsor Objective for FRM were included in the preliminary alternatives to allow potential identification of a Locally Preferred Plan (LPP) by the sponsor.

The PDT also selected evaluation criteria that would identify significant differences between the preliminary alternatives. Some potential criteria that were considered, including environmental justice, were not selected because initial evaluations did not indicate significant differences among the preliminary alternatives.

The PDT initially selected the following evaluation criteria/metrics:

a. NED Costs
b. NED Benefits
c. Annualized Population at Risk
d. Critical Infrastructure – Life Safety
e. Critical Infrastructure – Regional
f. Wise Use of Floodplain

g. Environmental Effects
h. Ecosystem Restoration

The definitions of the specific metrics for these criteria, and the processes by which they were quantified, are detailed in separate memoranda.

After the metrics had been quantified, the PDT decided that two of the metrics should not be used in the multi-objective analysis. The ecosystem restoration metric was not used because all of the potential ecosystem restoration measures under consideration were separable from the FRM measures. The critical infrastructure - regional metric was not used because nearly all of the identified facilities were agricultural processing facilities that were not likely to be active during the flood season and that were also included in the NED benefit metric.

6. Multi-Objective Analysis: Alternate Methods Applied

Several methods of multi-objective analysis were tested to identify a method that would be informative and transparent. These methods were based in part on concepts presented in the Planning SMART Guide (Reference 1.c), as well as discussions within the task group that addressed multiple-objective planning for the Planning SMART initiative.

a. Method A: Cost Effectiveness and Incremental Cost Analyses Using Weighted Criteria

Method A used modified Cost Effectiveness and Incremental Cost Analyses (CE/ICA) based on the standard Corps methodology for optimizing mitigation and restoration plans. This method was intended to allow incremental benefits to be compared to incremental costs in an optimization process. The net values of five output metrics (b, c, d, f and g in Item 5, above) for the eight preliminary alternatives were normalized to a scale of 0 to 1 using the percent of maximum method. In each case, a normalized value of 1.00 was assigned to the most beneficial (or least adverse) net output and a normalized value of 0.00 was the least beneficial net output. See Table 1 for the calculation of the normalized values for the six alternatives.

Rather than selecting a single set of weights for the five output criteria, the PDT decided to apply different sets of weights (i.e., multiple weightings) as a sensitivity analysis. If a single alternative was cost-effective, or very few alternatives were cost-effective, across a reasonable range of weightings, that result would provide a basis for plan selection. A wide range of potential weightings was tested using this modified CE/ICA method. Certified IWR Planning Suite software was used to perform CE/ICA.

In this study, the modified CE/ICA method did not provide results that could easily be used to select a plan. The lack of a clear result was partially due to the lack of an objective basis for judging the maximum incremental cost that would be justified for a mixture of various outputs. In addition, the ICA method compares outputs to costs, similar to a benefit-to-cost ratio. Although that process identifies the relative cost-efficiency of the alternatives, it does not identify which alternative produces the greatest <u>net</u> beneficial outputs, which would be more consistent with the Corps' national planning objectives. Consequently, when there are large differences in the scales of alternatives, the ICA method tends to favor smaller, more cost-

Table 1. Normalization of Values for Metrics

Alternative	Economic Benefits		Life Safety					Critical Infrastructure			Environmental Effects		Wise Use of Floodplain			Cost	
			Population at Risk			Evacuation Routes		Life Safety Facilities			Project Footprint		Potentially Developable Floodplain Area				
	($Mil Annual)		(Total Pop in 1% Floodplain)			(Number - Low Risk)		(Number at Risk)			(Acres)		(Acres)			($Mil Annual)	
	Gross	Normal	Gross	Net	Normal	Gross	Normal	Gross	Net	Normal	Gross	Normal	Gross	Net	Normal	Gross	Normal
SB-1: No Action	0	0.00	94618	0	0.00	0	0.00	28	0	0.00	0	1.00	71,832	0	1.00	0	0.00
SB-2: Minimal Fix-in-Place	38	0.51	56686	37932	0.40	1	0.20	10	18	0.64	22	0.89	83,770	11,938	0.84	16	-0.26
SB-3: Yuba City Ring Levee	41	0.55	27250	67368	0.71	1	0.20	9	19	0.68	194	0.00	79,339	7,507	0.90	24	-0.39
SB-4: Little J Levee	46	0.62	3783	90835	0.96	2	0.40	1	27	0.96	174	0.10	101,309	29,477	0.60	42	-0.68
SB-5: Fix-in-Place, Thermalito to Star Bend	45	0.61	27647	66971	0.71	3	0.60	1	27	0.96	33	0.83	95,661	23,829	0.68	32	-0.52
SB-6: Fix-in-Place, Feather River, Sutter Bypass and Wadsworth Canal	74	1.00	101	94517	1.00	5	1.00	0	28	1.00	50	0.74	146,006	74,174	0.00	62	-1.00
SB-7: Fix-in-Place, Sunset Weir to Laurel Avenue	51	0.69	38209	56409	0.60	1	0.20	10	18	0.64	27	0.86	88,223	16,391	0.78	22	-0.35
SB-8: Fix-in-place, Themalito to Laurel Avenue	58	0.78	6648	87970	0.93	3	0.60	1	27	0.96	39	0.80	100,230	28,398	0.62	39	-0.63

efficient alternatives, such as Alternatives SB-2 and SB-7. Because the results of Method A were not consistent with the objective of maximizing net beneficial effects, the details of those results are not presented here.

In this study, the modified CE/ICA method did not provide results that could easily be used to select a plan. The lack of a clear result was partially due to the lack of an objective basis for judging the maximum incremental cost that would be justified for a mixture of various outputs. In addition, the ICA method compares outputs to costs, similar to a benefit-to-cost ratio. Although that process identifies the relative cost-efficiency of the alternatives, it does not identify which alternative produces the greatest net beneficial outputs, which would be more consistent with the Corps' national planning objectives. Consequently, when there are large differences in the scales of alternatives, the ICA method tends to favor smaller, more cost-efficient alternatives, such as Alternatives SB-2 and SB-7. Because the results of Method A were not consistent with the objective of maximizing net beneficial effects, the details of those results are not presented here.

b. Method B: Multi-Criteria Decision Analysis

In an effort to avoid the shortcomings of the CE/ICA approach, use of a Multi-Criteria Decision Analysis was tested. The same normalized values were used as in Method A (Table 1), but with the addition of NED Costs as an additional criterion. Techniques that were used for the trade-off analysis in the 2004 Hamilton City feasibility report were applied to this study. Those techniques included assigning a negative normalized value to costs, so that the ultimate total weighted product calculated for each alternative represents a net combined output (i.e., beneficial effects minus cost). Another specific technique used was to assign weights to NED costs and NED benefits in the same ratio as the ratio of the maximum NED costs to the maximum NED benefits. Because the raw benefit and cost values were normalized using the percent of maximum method, the use of the ratio of maximum values to select the weights for benefits and costs ensures that dollars of costs and dollars of benefits are weighted equally in the trade-off analysis. This technique avoids significant distortions that can otherwise easily occur due to the weighting process.

As in Method A, rather than selecting a single set of weights for the five output criteria, the PDT decided to apply different sets of weights (i.e., multiple weightings) as a sensitivity analysis. Table 2 illustrates various results from multi-criteria decision analyses using different sets of weights.

Scenarios 1A-1D show the results of varying the weights for NED costs and benefits from maximum to low levels, while assigning equal weight to the other four criteria. If only NED benefits and costs are considered (Scenario 1A), then the result is that Alternatives SB-7 is preferred over all of the other alternatives. If the additional non-NED criteria are given even weights (Scenarios 1B-1D), then the result is that Alternative SB-7 is still preferred until the total weight assigned to NED benefits and costs is reduced to below 60%. With less than 60% weight assigned to the NED criteria, and the remaining greater-than-40% weight evenly distributed among the remaining four criteria (Scenario 1D), Alternative SB-8 is preferred.

Table 2. Selected Examples of Multi-Criteria Decision Analysis Using Various Weightings

Scenario	WEIGHTS (PREFERENCES)								WEIGHTED PRODUCTS							COMMENTS
	Benefits	LS Pop	LS Evac	Critical	Environ	Floodplain	Cost	Total	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8	
1A	54%	0%	0%	0%	0%	0%	46%	100%	0.16	0.13	0.03	0.10	0.09	**0.21**	0.14	NED Only
1B	50%	1%	1%	2%	2%	2%	42%	100%	0.20	0.16	0.07	0.15	0.14	**0.25**	0.19	Even weights for non-NED
1C	40%	3%	3%	7%	6%	7%	34%	100%	0.29	0.23	0.18	0.27	0.24	**0.33**	0.31	Even weights for non-NED
1D	32%	6%	5%	10%	10%	10%	27%	100%	0.37	0.28	0.26	0.38	0.34	0.40	**0.41**	Even weights for non-NED
2A	35%	9%	9%	18%	0%	0%	29%	100%	0.27	0.28	0.31	0.35	**0.42**	0.32	0.40	Life safety very heavily weighted
2B	35%	8%	9%	9%	5%	5%	29%	100%	0.30	0.26	0.25	0.33	0.35	0.34	**0.38**	Life safety moderately weighted
3A	35%	0%	0%	0%	0%	36%	29%	100%	0.41	0.40	0.24	0.31	0.06	**0.42**	0.31	Floodplain very heavily weighted

Notes: **Bold** indicates preferred alternatives based on indicated weighting. For Scenario 1 only, Population at Risk and Evacuation metrics are combined in the Life Safety criterion to avoid double-weighting of life safety factors.

Of course, alternatives other than Alternatives SB-7 or SB-8 can be preferred depending upon the weights that are assigned to the selection criteria. Scenario 2A shows that Alternative SB-6 is favored if a relatively high weight is given to the three criteria related to Life Safety, including Critical Infrastructure. However, if the Critical Infrastructure criterion is more moderately weighted with moderate weights given to the other criteria (Scenario 2B), then Alternative SB-8 is preferred.

Scenario 3A shows that Alternative SB-7 is favored even if a relatively high weight is given to the Floodplain criterion.

c. Method C: Pair-wise Comparison

Because the Method B Multi-Criteria Decision Analysis resulted in multiple top-ranked plans based upon a reasonable range of weightings, a pair-wise comparison was used to highlight the significant differences between pairs of alternatives. Because recommendation of the NED Plan is the Corps norm, any other alternative must be compared to the NED Plan and found to be superior in order to be recommended as the Federal Interest Plan. Consequently, the use of pair-wise comparison is a good fit with the Corps' current planning policies.

In this study, pair-wise comparison was used to address the following question:

- Should a plan other than the NED Plan be recommended as the Federal Interest Plan based on consideration of all four P&G accounts?

This question was addressed by comparing alternative plans (Alternatives SB-2, SB-3, SB-4, SB-5, SB-6, and SB-8) to the NED Plan (Alternative SB-7).

Table 3. Alternative SB-2 versus Alternative SB-7

	Costs		Beneficial					Adverse	
	First Cost	**Ann Cost**	**Ann Ben**	**Net Ben**	**Decrease in Pop at Risk**	**Evacuation**	**Critical Inf**	**Env Effect**	**Floodplain**
Alt SB-2	319	16	38	22	37932	1	18	22	11,938
Alt SB-7	423	22	51	29	56409	1	18	27	16,391
Diff	-104	-6	-13	-7	-18477	0	0	-5	-4,453
% Diff	**-25%**	**-27%**	**-25%**	**-24%**	**-33%**	**0%**	**0%**	**-19%**	**-27%**

Alternative SB-2 can be considered the first increment, as it is the smallest increment and is contained within all of the other alternatives. Alternative SB-2 significantly reduces net benefits compared to Alternative SB-7 while minimally reducing environmental effects and providing a smaller reduction in the population at risk. However, Alternative SB-2 substantially reduces the acreage of potentially developable floodplain. If the potential floodplain development effects of Alternative SB-7 are considered to be acceptable, or can be avoided or mitigated to an acceptable level, then there would be no reason to consider recommending Alternative SB-2 rather than Alternative SB-7.

Table 4. Alternative SB-3 versus Alternative SB-7

	Costs		Beneficial					Adverse	
	First Cost	Ann Cost	Ann Ben	Net Ben	Decrease in Pop at Risk	Evacuation	Critical Inf	Env Effect	Floodplain
Alt SB-3	451	24	41	17	67368	1	19	194	7,507
Alt SB-7	423	22	51	29	56409	1	18	27	16,391
Diff	28	2	-10	-12	10959	0	1	167	-8,884
% Diff	**7%**	**9%**	**-20%**	**-41%**	**19%**	**0%**	**6%**	**619%**	**-54%**

When compared to Alternative SB-7, Alternative SB-3 provides substantially less net NED benefit and has a significantly larger environmental effects footprint. The major advantages of Alternative SB-3 are reductions in the population at risk and the acreage of potentially developable floodplain.

Table 5. Alternative SB-4 versus Alternative SB-7

	Costs		Beneficial					Adverse	
	First Cost	Ann Cost	Ann Ben	Net Ben	Decrease in Pop at Risk	Evacuation	Critical Inf	Env Effect	Floodplain
Alt SB-4	798	42	46	4	90835	2	27	174	29,477
Alt SB-7	423	22	51	29	56409	1	18	27	16,391
Diff	375	20	-5	-25	34426	1	9	147	13,086
% Diff	**89%**	**91%**	**-10%**	**-86%**	**61%**	**100%**	**50%**	**544%**	**80%**

Alternative SB-4 provides substantially lower net NED benefits compared to Alternative SB-7, but performs significantly better than Alternative SB-7 for life safety and critical infrastructure criteria. Alternative SB-4 would have a significantly larger environmental effects footprint and a significantly larger increase in the potentially developable floodplain area compared to Alternative SB-7.

Table 6. Alternative SB-5 versus Alternative SB-7

	Costs		Beneficial					Adverse	
	First Cost	Ann Cost	Ann Ben	Net Ben	Decrease in Pop at Risk	Evacuation	Critical Inf	Env Effect	Floodplain
Alt SB-5	608	32	45	13	66971	3	27	33	23,829
Alt SB-7	423	22	51	29	56409	1	18	27	16,391
Diff	185	10	-6	-16	10562	2	9	6	7,438
% Diff	**44%**	**45%**	**-12%**	**-55%**	**19%**	**200%**	**50%**	**22%**	**45%**

The major advantages of Alternative SB-5 over Alternative SB-7 are the increases in all life safety/critical infrastructure criteria. However, Alternative SB-5 would result in a significant decrease in net NED, while having a greater environmental effect footprint and a greater increase in the potentially developable floodplain.

Table 7. Alternative SB-6 versus Alternative SB-7

	Costs		Beneficial					Adverse	
	First Cost	Ann Cost	Ann Ben	Net Ben	Decrease in Pop at Risk	Evacuation	Critical Inf	Env Effect	Floodplain
Alt SB-6	1131	62	74	12	94517	5	28	50	74,174
Alt SB-7	423	22	51	29	56409	1	18	27	16,391
Diff	708	40	23	-17	38108	4	10	23	57,783
% Diff	**167%**	**182%**	**45%**	**-59%**	**68%**	**400%**	**56%**	**85%**	**353%**

Costs for Alternative SB-6 are nearly three times as much as for Alternative SB-7, but the flood risk reduction benefits are only 45% higher; as a result, the net NED benefits for Alternative SB-6 are significantly lower than for Alternative SB-7. Alternative SB-6 would reduce the population at risk by an additional 68%, remove 10 additional critical infrastructure facilities from the 1% annual chance floodplain, and provide four more evacuation routes than Alternative SB-7. Alternative SB-6 has a larger environmental effects footprint than Alternative SB-7. A prominent difference between the two alternatives is that Alternative SB-6 would increase the potentially developable floodplain area by over three times as much as Alternative SB-7. In order for Alternative SB-6 to be recommended over Alternative SB-7, a very high value would have to be placed on the additional life safety/critical infrastructure outputs provided by Alternative SB-6 to offset the disadvantages of Alternative SB-6 due to its much higher costs, lower net NED benefits, and much greater increase in potentially developable floodplain area.

Table 8. Alternative SB-8 versus Alternative SB-7

	Costs		Beneficial					Adverse	
	First Cost	Ann Cost	Ann Ben	Net Ben	Decrease in Pop at Risk	Evacuation	Critical Inf	Env Effect	Floodplain
Alt SB-8	713	39	58	19	87970	3	27	39	28,398
Alt SB-7	423	22	51	29	56409	1	18	27	16,391
Diff	290	17	7	-10	31561	2	9	12	12,007
% Diff	**69%**	**77%**	**14%**	**-34%**	**56%**	**200%**	**50%**	**44%**	**73%**

Alternative SB-8 would triple the number of evacuations routes, reduce the population at risk by an additional 56%, and remove 9 additional critical infrastructure facilities from the 1% annual chance floodplain, at a 77% higher cost than Alternative SB-7. Alternative SB-8 increases the environmental effects footprint and potentially developable floodplain area compared to Alternative SB-7. If the increases in life safety/critical infrastructure criteria are considered to outweigh the increase in costs, reduction in net benefits, and increases in adverse effects, then Alternative SB-8 would be preferred over Alternative SB-7.

7. Conclusions

Several methods of multi-objective analysis were applied to the Sutter Basin alternatives:

Method A (Cost Effectiveness and Incremental Cost Analyses Using Weighted Criteria) did not indicate a clear choice among the alternatives due to the lack of an objective basis for judging the maximum incremental cost that would be justified for a mixture of various outputs.

Method B (Multi-Criteria Decision Analysis) demonstrated that Alternative SB-7 is the preferred alternative over the widest range of relatively balanced weightings, or if the floodplain criterion

is heavily weighted. Method B also demonstrated that other alternatives would be favored if certain criteria were heavily weighted along with the NED benefit and cost criteria. Alternative SB-6 is favored if the three life safety criteria (evacuation, critical infrastructure, and population at risk) are heavily weighted. Alternative SB-8 is preferred if less than 60% weight is given to the NED criteria, with the three life safety criteria given moderately higher weights than the environmental effects and floodplain criteria.

Method C (Pair-wise Comparison) provided the clearest comparison of the alternatives and of the trade-offs among them in terms of beneficial and adverse effects. This method focused on whether a deviation from recommendation of the NED Plan is warranted. The analysis found that if the additional life safety/critical infrastructure benefits of Alternative SB-8 are considered to outweigh the higher costs, reduction in net NED benefits, increased environmental footprint, and increase in potentially developable floodplain, then Alternative SB-8 would provide greater net monetary and non-monetary benefits than the NED Plan, Alternative SB-7. In order for Alternative SB-6 to be recommended rather than the NED Plan, a very high value would have to be placed on the life safety/critical infrastructure criteria to offset the disadvantages of Alternative SB-6, which are its much higher costs, lower net NED benefits, and significantly greater increases in the environmental footprint and potentially developable floodplain area.

In conclusion, the combined results of the three methods of multi-objective analysis indicate that consideration given to the metric for the potentially developable floodplain area is a key factor in identifying the recommended Tentatively Selected Plan (TSP).

A determination must be made as to whether the increases in potentially developable floodplain area due to Alternatives SB-6, SB-7, and SB-8 are acceptable under Corps policy, or can be avoided or mitigated to an acceptable level within a justified cost. In making that determination, it is important to remember that the floodplain metric used in this analysis is a simple index based on physical parameters. The floodplain metric does not attempt to forecast future population growth, economic conditions, or government decisions that will constrain future floodplain development. The metric also does not account for existing land use regulations and easements within the Basin. Those aspects should be considered in conjunction with the floodplain metric. The floodplain metric should be used to identify the specific locations where increases in the potentially developable floodplain area could occur. That information can be used to further assess the residual risks, including residual flood depths, associated with different alternative plans.

A second key factor in identifying the recommended TSP is the relative importance placed on the three life safety criteria (population at risk, evacuation, and critical infrastructure), relative to the importance placed on maximizing net NED benefits and minimizing the environmental effects footprint and potentially developable floodplain area. The NED plan, Alternative SB-7, would be the best choice for the TSP if all of the non-NED criteria are given equal importance and less than 40% combined weight, based on Method B. If the non-NED criteria are given equal importance and more than 40% combined weight, than Alternative SB-8 would be the preferred plan. If very high importance is given maximizing life safety, compared to all other criteria, then the most comprehensive and costly plan, Alternative SB-6 would be the favored choice for the TSP.

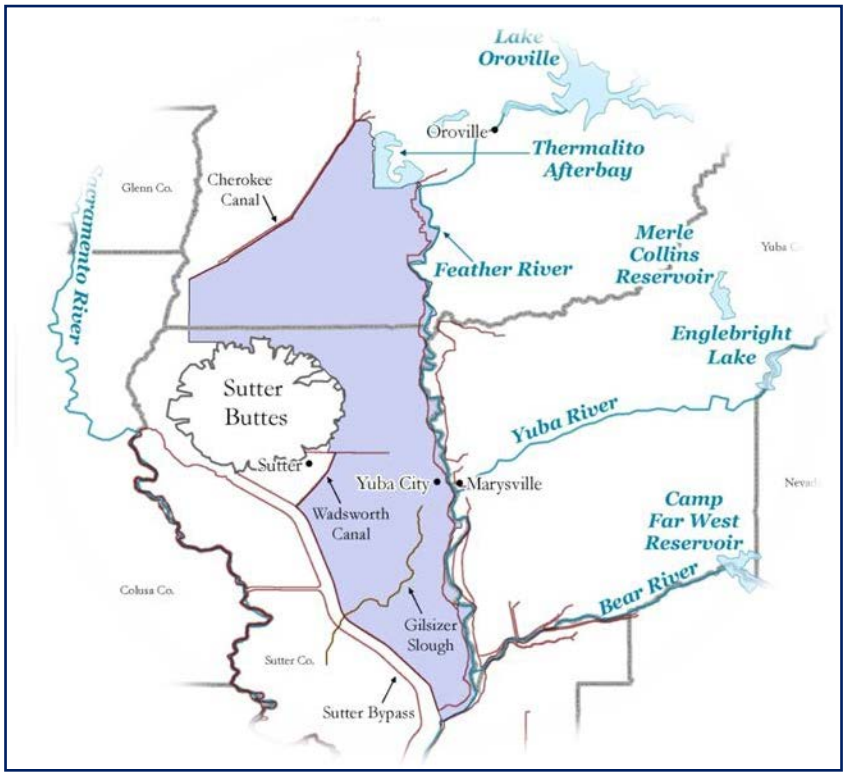
Appendix C
Engineering

Sutter Basin, California

Pilot Feasibility Study

Decision Point #2

Report Summary



US Army Corps
of Engineers

Sacramento District
Version: 26 October 2012
Revised: 10 March 2013

This Report Summary is in support of Decision Point #2 and Presentation. Additional background information on the Sutter Basin pilot process, plan formulation, evaluation metrics, etc. can be found in the supporting Read Aheads for Decision Point #2.

As a Read Ahead, a Draft Report Table of Contents with referenced supporting and IPR directed documents (MFRs, papers, reports, etc) generated by the PDT during the pilot and plan formulation process is provided to show how the work efforts and documents will flow into an integrated Draft Report.

The Report Summary has been modified to be consistent with the actual Decision Point # 2 presentation, reflecting modifications in the identification and analysis of alternatives after the original document was prepared; and to provide additional information as requested by the Vertical Team after the Decision Point Conference to support the District's recommendations to identify the Locally Preferred Plan as the Tentatively Selected Plan with full Federal cost participation as prescribed by Section 103 of WRDA 1986.

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1. INTRODUCTION

Purpose. The purpose of the Report Summary is to document the planning process leading up to the recommendation of the tentatively selected plan (TSP) and in doing so reaffirm Federal interest, identify the national economic development (NED) plan, identify the locally preferred plan (LPP), and evaluate residual risk. Plans were evaluated at a suitable level of detail for the identification of the NED and LPP plans. Refined analysis, including total project costs, will be presented in the Draft Feasibility Report. Section 8 recommends the Tentatively Selected Plan (TSP).

Study Authority. The authority for the USACE to study Flood Risk Management (FRM) and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, is provided in the Flood Control Act of 1962, Pub. L. No. 87-874, § 209, 76 Stat. 1180, 1196 (1962).

Local Sponsors. The non-Federal project sponsors include the State of California Central Valley Flood Protection Board (CVFPB) and the Sutter and Butte County Flood Control Agency (SBFCA).

Study Background. The Sutter Basin Feasibility Study was initiated in 2000 and a Feasibility Scoping Meeting was held in January 2005. However the study remained essentially inactive until the formation of the Sutter Butte Flood Control Agency (SBFCA), which agreed to serve as the local partner along with the Central Valley Flood Protection Board (CVFPB) in 2007. In 2010, the Sutter Basin population passed a $6.65 million per year assessment to study and implement a project to reduce flood risks to the basin. This action was a strong public endorsement of the need for immediate action to address the flood threat, particularly since the area is an economically disadvantaged community under California State guidelines with widespread unemployment, and the approved assessment rates are among the highest in California.

Pilot Program. The Sutter Basin Feasibility Study is one of the first two studies selected for inclusion in the National Pilot Program in February 2011. The pilot initiative provides an opportunity to test principles that were developed by a workgroup of planning and policy experts from USACE and the Office of the Assistant Secretary of the Army for Civil Works (ASA (CW)), referred to as the 17+1 Team, for the purpose of modernizing the Civil Works Planning Program to better address the many water resource challenges facing the nation.

The revised study paradigm envisions a more predictable, and efficient process which significantly lessens the time required to complete a feasibility study. This new process requires heavy involvement as well as input and timely decisions from the Vertical Team at multiple points throughout the study. Further, the process emphasizes the early identification of the federal interest in resolving a water resource problem.

The study process continues to use sound professional engineering, economics, and environmental judgment and analyses, but appropriately focuses the amount and type of data collected and analysis on the risk and consequences of the decisions being made. Costs and benefit estimates presented herein are based on an appropriate level of detail for screening of draft alternatives to a final array. The appropriate level of detail was selected considering that comparative cost estimates are more accurate than absolute cost estimates. This is because similar errors are made for all alternatives. The range of confidence in cost and benefit estimates is presented in a table comparing the alternatives. To avoid confusion, only mean estimates are described in the text.

After approval by the ASA-CW a more detailed total project cost estimate will be completed and certified for the Recommended Tentative Selected Plan (TSP). It is anticipated that the certified total project cost estimate and the benefits of the TSP will deviate from the values presented in this report. However the estimates are expected to fall within the range of estimates provided.

The new study paradigm recognizes that qualitative optimization of any factor, including net national economic development benefit, should not be the primary factor in the Corps decision for a recommendation for federal investment. Alternative Comparison and Selection recognizes that there is no single "best" plan, and there are a variety of approaches (quantitative and qualitative) to multi-criteria decision making.

The pilot study is divided into four phases, each with a key decision point and associated In-Progress Reviews (IPRs). Table 1 summarizes the four pilot study phases and associated decision points. Based on the pilot program principles, the Sutter Basin Pilot Feasibility Study strategy focuses on utilizing an appropriate level of detail based on the decisions being made at each stage of the study. This strategy includes qualitative analysis that will be increasingly detailed at each Decision Point or IPR and early elimination of alternatives with little probability of implementation.

Table 1. Pilot Study Phases and Associated Decision Points

Pilot Study Phase	Decision Point	Date
Scoping	1 – Federal Interest Determination	Aug 2011
Analysis	2 – Tentatively Selected Plan	Nov 2012
Review	3 – Civil Works Review Board	Summer 2013*
Confirmation	4 – Chief's Report	Fall 2013*

*Dates are pending confirmation from vertical team.

Central Valley Flood Protection Plan. The Central Valley Flood Protection Act of 2008 (CVFPA), passed by the California legislature as Senate Bill (SB) 5, directs local flood risk management efforts. The CVFPA, along with other companion legislation, required the Central Valley Flood Protection Board to adopt the Central Valley Flood Protection Plan (CVFPP) by July 2012. The purpose of the CVFPP was to guide California's participation in managing flood risk along the Sacramento and San Joaquin River systems. The CVFPA requires a 200-year (with 95% assurance (or "freeboard")) level of flood protection for urban and urbanizing areas by the year 2025.

The CVFPP proposes an initial system wide investment approach for sustainable, integrated flood management in areas currently protected by facilities of the State Plan of Flood Control (SPFC). This investment approach includes system and regional elements, some of which are located in the Sutter Pilot study area. The CVFPP was adopted by the State in July 2012. The Sutter Basin Pilot Study is continuing close coordination with these CVFPP efforts and is a key means of implementing a portion of the CVFPP.

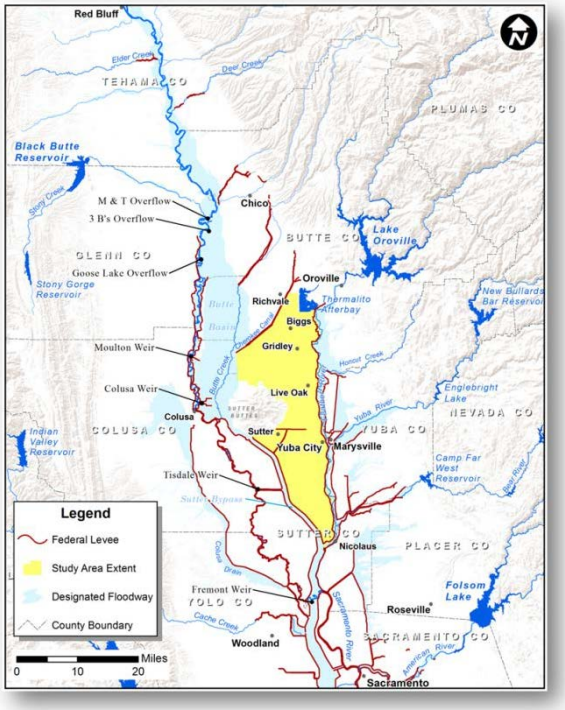
The CVFPA, recognizing the urgent need to improve the existing flood protection system, allows urban flood improvement projects (Early Implementation Projects) to be funded with State bond funds in advance of full implementation of the CVFPP. Proposed improvements must be for flood management construction projects that: rehabilitate, reconstruct, replace, improve, or add to the facilities of the State Plan of Flood Control; reduce or avoid risk to human life in urban areas; and not impair or impede future changes to regional flood protection. Construction of 3,400 feet of setback levee to replace a portion of the existing west bank Feather River levee south of Yuba City was recently completed within the Sutter Basin study area under the Early Implementation Program to address through-seepage, underseepage, and flow constriction issues. A request for approval under 33 USC § 408 was granted and an application for consideration of Section 104 credit was approved in 2009.

SBFCA is proposing another levee improvement project along the Feather River west levee under the Early Implementation Program. This project proposes to construct levee improvements between the Thermalito Afterbay and an area north of the Feather River/Sutter Bypass confluence. The project will address through-seepage, underseepage, and embankment instability of the levees, by meeting current design standards. A Pre-Design Formulation Report was completed in August of 2011 and the 60% design was completed in March 2012. An EIS/EIR is being prepared for the project as part of a Section 408 application to obtain permission from USACE to alter project levees. The non-federal project sponsors will seek in-kind credit for this local project under the provisions of Section 221 of the Flood Control Act of 1970, as amended.

2. STUDY BRIEFING

Study Area. The 300 square mile Sutter Basin study area is located in Northern California in Sutter and Butte Counties within the 14,000 sq. mile Sacramento River Watershed as shown in Figure 1. The study area, which is approximately 50 miles north of Sacramento, is bounded by the Feather River on the east, the high ground of the Sutter Buttes on the west, the Sutter Bypass on the southwest, and Cherokee Canal and the Butte River on the northwest. Existing levees along the Feather River, Sutter bypass, Cherokee canal, and Wadsworth Canal as well as the Butte Basin are features of the Sacramento River Flood Control Project (SRFCP), authorized by Congress in 1917. The SRFCP incorporated features such as levees, weirs, and pumping facilities into a system of leveed river channels and flood bypass channels to provide Flood Risk Management benefits to the Sacramento Valley. The existing levees provide FRM benefits to the Sutter River Basin study area; however, the current condition of the levees are assessed to have relatively high risk of failure as a result of through and under seepage concerns.

Figure 1: Sutter Basin Study Area

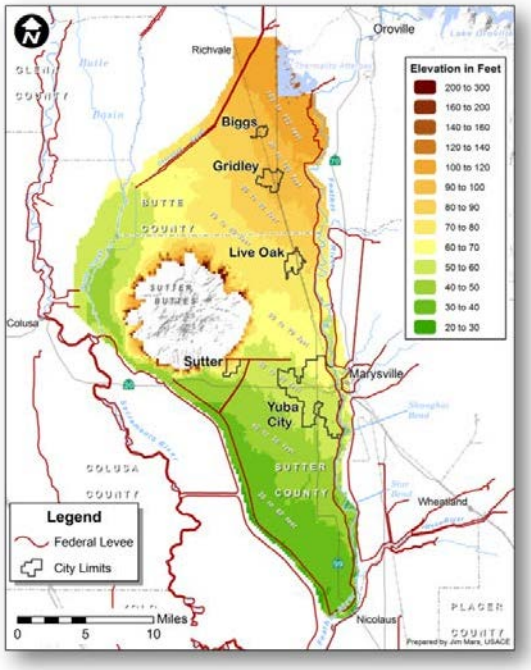


The study area is primarily rural, with extensive agricultural areas and low population density. Yuba City is the largest community in the study area, located midway in the basin adjacent to the Feather River. The northern basin 'gold rush era' cities of Biggs, Gridley, and Live Oaks are situated roughly along the north-south railroad and State Highway 99 corridors.

Existing Conditions. Existing conditions are those at the time the study is conducted and form the basis for extrapolation to other conditions. Existing conditions within the study area are discussed below.

Topography. As shown in Figure 2, the floodplain elevations (excluding the high ground of Sutter Buttes) range from 110 feet-NAVD88 in the northeast to 30 feet-NAVD88 in the southwest.

Figure 2. Sutter Basin Topography



Geotechnical Levee Performance. From initial information and modeling during plan formulation, the primary risk of flooding in the Sutter Basin is the result of geotechnical failure of the existing levees not hydrologic or hydraulic factors which result in levee overtopping. Recent geotechnical analysis and evaluation of historical performance during past floods indicate the project levees within the study area do not meet USACE levee design standards and are at risk of breach failure at stages considerably less than levee crest elevations. This was evidenced by historical boils and heavy seepage at stages less than authorized design flows[1]. Underseepage failures are sudden and unpredictable, resulting in minimal warning time, and ineffectiveness of evacuation plans. The risk of unexpected levee failure coupled with the consequence of flooding presents a continued threat to public safety, property, and critical infrastructure. Initial WSEL's where a seepage related levee failure becomes possible are as low as the 20% (1/5) event in most cases along the Feather River. At the 10% (1/10) WSEL, the probability of failure can range from 10-20%, while at the 1% (1/100) WSEL these probabilities of failure range from 30-45% depending upon the location along the river.

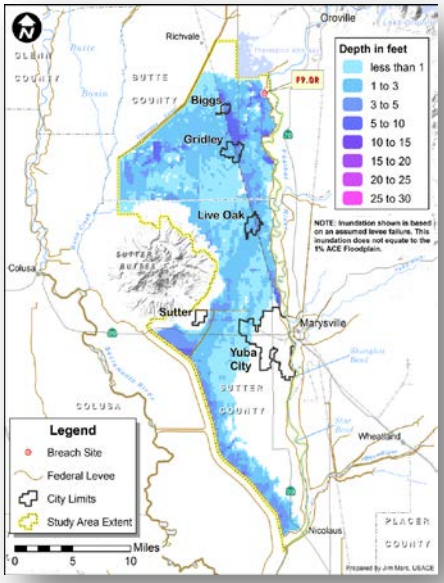
Hydraulics. Multiple levee breach scenarios were modeled along the Feather River and Sutter Bypass to assist in the analysis of the study alternatives. Floodplains resulting from levee breaches differ significantly in nature depending on the location of the breach as illustrated in Figure 3. Simulated breaches along the northern portion of the Feather River flood the northern basin in a shallow (up to 6 feet) northeast to southwest flooding flow. Breaches from the Sutter Bypass and southern most portion of

[1] Design flows obtained from USACE file drawing 50-10-334, Levee Channel Profiles, 15 March 1957. For a discussion and comparison of design flows vs. regulated and peak unregulated flows see Progress Document #2; Technical Support Documentation of the Sutter Basin Pilot Feasibility Study.

the Feather River only flood the deeper (up to 25 feet) southern basin area and do not impact the northern portion of the basin. The velocity of floodwaters varies depending on the proximity to the breach location. For those structures/people within 1,000 feet of a breach the velocity could be high enough to knock structures off of their foundations. This high risk velocity area would consist mainly of the small population of Yuba City within 1,000 feet of the river and would see velocities well above 6 feet per second (fps). But, the majority of Yuba City and all of Biggs, Gridley and Live Oak are outside this area and could expect to see flood velocities between 2-3 fps.

Figure 4 shows the composite 1% ACE floodplain for the Sutter Basin.

Figure 3. Simulated Levee Breach Scenarios



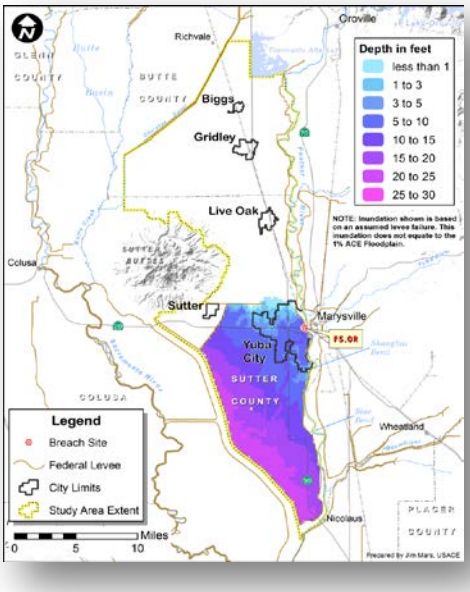
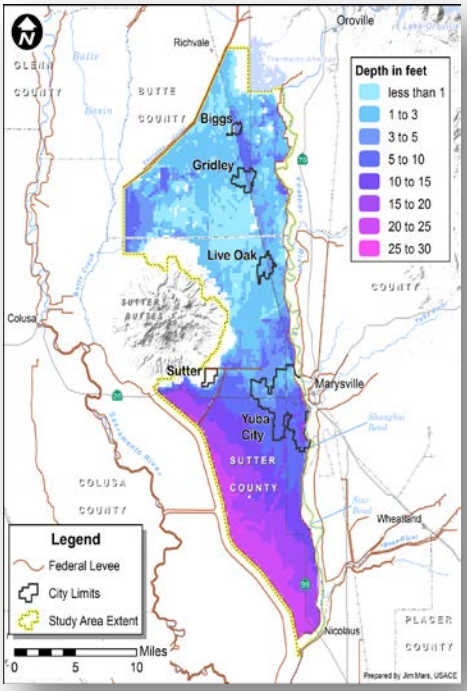


Figure 4. 1% ACE Without Project Floodplain



Economics. Based upon the 2010 Census, the population of the Sutter Basin is estimated to be 95,360 and distributed as shown in Table 2.

Table 2. Population Within Study Area

Economic Impact Area	Population
Town of Sutter	250
Yuba City Urban	67,370
Biggs Urban	1,760
Gridley Urban	6,380
Live Oak Urban	8,360
Sutter County Rural	6,340
Butte County Rural	4,900
TOTAL	**95,360**

Demographics: Median household income for the study area ranges from $36,563 (Gridley) to $48,830 (Yuba City). Both of which are below State ($61,632) and national (52,762) averages. The persons living at or below the poverty level in the study area are 22.7%, 21.4% and 15% for Biggs, Gridley and Yuba City, respectively. All of which are above the State (14.4%) and national (14.3%) averages.[2]

The total labor force in the study area is estimated at 40,000, with an unemployment rate of 14.7%, 8.4%, and 9.3% in Biggs, Gridley and Yuba City, respectively. Total private wage or salary workers estimated to be 75% (Biggs), 65% (Gridley) and 69% (Yuba City) with 17% (Biggs), 25% (Gridley) and 20% (Yuba City) of the labor force rated as government workers. Approximately, 7% (Biggs), 11% (Gridley) and 11% (Yuba City) of the labor force was considered to be self-employed, not incorporated. The average wage per job so the study area is between $22,300 to $28,100.

Variances in race and ethnicity in communities may impose language and cultural barriers that affect ability to cope with natural hazards. The Hispanic presence is evident given they make up at least 28% of the population in each community. Live Oak's population is composed of 48.8% of individuals of Hispanic origin, which is significantly higher than the State average of 37.6% and considerably exceeds the national average of 16.3%.

Inventory: An economic inventory was assembled following standard USACE methods. For the study area, a base geographic information system (GIS) inventory with parcel attribute data was provided by the local sponsor for both Sutter and Butte counties. Field visits were conducted to collect and validate the base inventory data. Parcels with structures were categorized by land use and grouped into residential, commercial, industrial or public categories. The value of damageable structures was estimated based on depreciated replacement values. The total value of damageable property (structures and contents) within the Sutter Basin study area is estimated at $6.9 Billion (October 2011 prices). Table 3 displays the structural inventory by land use category. Total study area without project expected annual damages are approximately $108 million.

[2] Some demographic data was unavailable for the City of Live Oak.

Table 3. Structural Inventory –Existing Conditions[3]
Number of Structures within 0.2% (1/500yr) Annual Chance Floodplain

Economic Impact Area	Commercial	Industrial	Public	Residential	TOTAL
Biggs	18	1	0	586	**605**
Gridley	81	7	4	1,931	**2,023**
Live Oak	51	5	23	2,088	**2,167**
Yuba City	872	210	122	18,760	**19,964**
Town of Sutter	0	0	0	0	**0**
Rural Butte	10	16	0	1,242	**1,268**
Rural Sutter	10	29	8	1,162	**1,209**
TOTAL	**1,042**	**268**	**157**	**25,769**	**27,236**

Climate. The study area is located within the northern portion of California's Central Valley. The Sacramento Valley is a semi-arid region with an annual rainfall of approximately eighteen inches. There are two distinct annual seasons, a hot dry summer and a cool wet winter. Approximately eighty percent of the annual rainfall occurs in between October to March.

Environmental. Sutter County is primarily rural, with extensive agricultural areas and a low population density. The county is one of California's major agricultural counties and its traditional job base is agriculture. A number of Federal and State listed species are known to occur or potentially occur in the study area. Many of these species are located within the riparian areas along the Feather River.

Historic Flooding. In 1955, flood waters from a levee breach encompassed a significant portion of the study area inundating 6,000 homes, drowning 38 people, injuring 3,200 individuals, and requiring 600 people to be rescued by helicopter. From 1950 to 2011, extensive flood fighting has occurred during 19 events, and deadly levee failures adjacent to the Sutter Basin took place in 1986 and 1997 which reduced stress on the levees surrounding the Sutter Basin and may have resulted in avoiding failure of these levees. Flooding historically has occurred during the months of December through February with air temperatures of 38 to 55°F and water temperatures of 45 to 55°F; temperatures which significantly increase risk of death by exposure[4].

Future Without-Project Conditions. The future without-project condition is the most likely condition expected to exist in the future in the absence of a proposed water resources project and constitutes the benchmark against which alternatives are evaluated. These forecasts of future conditions are from the base year (year when a project is expected to be operational) to the end of the period of analysis (50 years). Future without-project conditions for this study are projected assuming a base year of 2020 and a 50-year period of analysis out to year 2070. Assumptions regarding the future without-project condition are listed below:

- For purposes of evaluating the transfer of flood risk, the future without-project condition will assume the levees do not fail due to geotechnical conditions since their original design was not based on failure assumptions.

- Ongoing levee maintenance will result in no change to geotechnical conditions and levee

[3] Based on empirical analyses conducted for past Corps projects, subject matter expertise from the agricultural economist and professional judgment, the project delivery team expects agricultural damages to total 10-15% of total project damages; amounts which are not expected to drive plan selection. A simplified approach was developed for this study.
[4] United States Coast Guard

performance curves.

- Oroville and New Bullards Bar reservoirs on the Feather and Yuba River Systems will continue to be operated using the existing rule curves.

- Vegetation and topographic conditions within the channel are expected to remain the same as existing conditions.

- Remaining natural areas are not expected to substantially decline in acreage and value over the period of analysis.

- Economic analysis assumes the future without-project condition damages are equal to existing conditions. Because any future without project development would take place outside/above the mean 1% (1/100) ACE floodplain boundary and because any future damages would be discounted back to present value, the future condition is not expected to impact the plan formulation process significantly.

- Since refinements, additions, and deletions of elements associated with the System wide Investment Approach presented in the 2012 CVFPP are anticipated, these elements will not be included in the future without-project condition.

- Flood frequency will be based upon existing conditions. However, a sensitivity analysis of climate change impacts on hydrologic frequency, flood damages, and alternative selection will be conducted. This approach was based on a review of uncertainty in recent climate model analysis.

- Assumes Three Rivers Levee Improvement Authority (TRLIA) Feather River setback levee has been constructed.

- Section 104 of WRDA 86 allows for the plan formulation analysis to exclude work conducted by the sponsor from the without project condition, thereby allowing the work to potentially be incorporated in to the recommended plan, if it is found to be in the Federal interest. Since the application for consideration of Section 104 credit for the completed Star Bend setback levee was approved in 2009 prior to the moratorium on consideration of Section 104 credit by the ASA (CW), this project will not be considered part of the future without-project condition.

- Vertical Team policy guidance provided at In-Progress Review #1 recommended that the Feather River West Levee Project proposed by the project sponsor <u>will not</u> be considered part of the future without-project condition (assumes no contract prior to the Chief's Report for the pilot study). If appropriate after the feasibility report is completed, the sponsor may request credit consideration for this local project under the provisions of Section 221 of the Flood Control Act of 1970, as amended. This may be accomplished in accordance with ER 1165-2-208 guidelines.

3. PLANNING OBJECTIVES AND OPPORTUNITIES

Following inclusion of the Sutter Basin Feasibility Study in the National Pilot Program, the Project Delivery Team (PDT) and non-Federal sponsors participated in a study risk workshop with several members of the Vertical Team during which the following problem, opportunity, objective, and constraint statements were developed and refined.

Problems.

- A high risk of flooding from levee failure threatens the public safety as well as property and critical infrastructure throughout the study area
- Existing levees have isolated the floodplains from waterways, which has eliminated significant floodplain habitats for native species, including Federally listed species and other special status species; also, conversion of high value habitats to other land uses has reduced the abundance, distribution and diversity of native species

Opportunities.

- Land formerly converted by mining or agriculture can be restored to more natural habitats in conjunction with FRM
- Facilities can be included at recommended FRM and Ecosystem Restoration (ER) features to provide public access and use and improved outdoor recreation experiences

Objectives.[5] The study objectives were developed through the integration and use of the four planning accounts, which include national economic development (NED), environmental quality (EQ), regional economic development (RED), and other social effects (OSE).

- Reduce the risk to life, health, and public safety due to flooding
- Reduce the risk of property damage due to flooding
- Reduce the risk of damage to critical infrastructure due to flooding
- Encourage wise use of the floodplain
- In conjunction with FRM, restore floodplain connectivity and associated dynamic riverine processes
- In conjunction with FRM, restore aquatic, wetland, riparian and terrestrial habitats for special status and other native species
- In conjunction with FRM and ER, improve the public's access to and use of outdoor recreational opportunities in the study area

Constraints.

- Minimize adverse hydraulic effects where they could result in economic damages to others
- Minimize significant adverse impacts to the human environment
- Comply with applicable Federal laws, regulations, and policies such as the National Environmental Policy Act, Endangered Species Act, Fish and Wildlife Coordination Act, Clean Water Act, and the National Historic Preservation Act.

Evaluation Metrics. Evaluation metrics were developed to compare alternatives. During plan formulation, as measures and alternatives were developed, better and more cost effective ecosystem and recreational opportunities were identified that were not conjunctive to the FRM measures and alternatives being carried forward to the array of alternatives. These objectives, ecosystem and recreation, were therefore not integrated into the final evaluation metrics and the multi-criteria analysis which directed focus on the life safety metrics.

[5] Additional non-Federal objective entailed reducing the probability of flooding to urban and urbanizing areas to less than 0.5% (1/200) annual chance exceedance due to CA State Law requiring a 200-year level of flood risk management by the year 2025.

The *Sutter Basin Pilot Study Re-scoping Plan* stated that it was anticipated that evaluation and comparison of the final array of alternatives would be based on monetary and non-monetary effects, qualitative and quantitative data, and economic, public safety, environmental, and regional criteria. The evaluation criteria (Table 4) identified were based on both existing Corps policy, including the Principles and Guidelines, and Planning Guidance Notebook.

Table 4. Evaluation Criteria based on P&G and PGN

Study Objectives	Evaluation Metric
(a) Reduce the risk of life, health, and public safety due to flooding	Population at Risk
	Critical Infrastructure-Life Safety
	Evacuation Routes
(b) Reduce the risk of property damage due to flooding	NED Costs
	NED Benefits
(c) Reduce the risk of damage to critical infrastructure due to flooding	Critical Infrastructure-Life Safety
(d) Encourage the wise use of the floodplain	Potentially Developable Floodplain (Acres)

Definitions of the evaluation metrics used in the Sutter Basin Feasibility study are shown in Table 5. These evaluation metrics were presented and discussed during the In-progress Review Meeting #4 on 26 June 2012 and were approved by the Vertical Team.

Table 5. Description of Metrics

Evaluation Metric	Description
Population at Risk (People)	Number of people within the 1% ACE Floodplain based on the 2010 census blocks.
Critical Infrastructure (Facilities)	Number of fire stations, police stations, hospitals, senior living facilities, and jails that are of life safety significance.
Evacuation Routes (# of Routes)	Assesses the vulnerability of populations with regards to the number of escape routes available during flood events.
Potentially Developable Floodplain (Acres)	Potentially developable land within the 0.2% ACE floodplain. Acres of land with 1% ACE flood depths less than 3 feet.

4. PLAN FORMULATION

The plan formulation process develops and evaluates alternative plans to address the needs and desires of society as expressed in specific planning objectives. Accordingly, the tentatively selected plan best satisfies the objectives as well as the Federal interest, which are consistent with the Federal Water Resources Council's Principles and Guidelines (P&G) and the Planning Guidance Notebook (ER-1105-2-100).

Management Measures. A broad array of management measures was developed based on information from existing reports and studies, as well as public input and professional judgment. These measures were presented at the Sutter Basin Pilot Study Critical Thinking Charette held at the Sacramento District on July 18-19, 2011. The charette was attended by the PDT and non-Federal sponsors, along with several members of the Vertical Team and the National Pilot Program 17+1 Team. The team reviewed each measure, identified additional measures, and then evaluated the measures based on study objectives, study constraints, and Water Resources Council Principles and Guidelines (P&G) criteria. A group decision was made as to whether each measure should be retained or dropped from further consideration. Progress Document #1 provides a description of the measures evaluated at the charette and indicates whether each one was retained or dropped and the reason(s) for dropping.

Preliminary Alternative Formulation and Evaluation. Following the initial screening of measures, the team identified four themes (strategies) for plan formulation. The themes included the following: 1) Consequence Management Focused on Public Safety, 2) Urban FRM Focus, 3) Maximize Existing System with FRM Focus, and 4) Ecosystem Restoration Focus. These themes were used to assist the team in establishing a preliminary array of conceptual alternatives by grouping measures according to the primary focus of each theme. Based on the measures grouped under each theme, the team identified a total of nine conceptual alternatives[6]. Most alternatives are comprised primarily of new levees or strengthening of existing levees. Following the charette, each alternative was further developed and quantities, costs and economic benefits were estimated for each alternative. The use of these results was used solely to screen out those preliminary alternatives that do not appear economically justified even in the most favorable conditions.

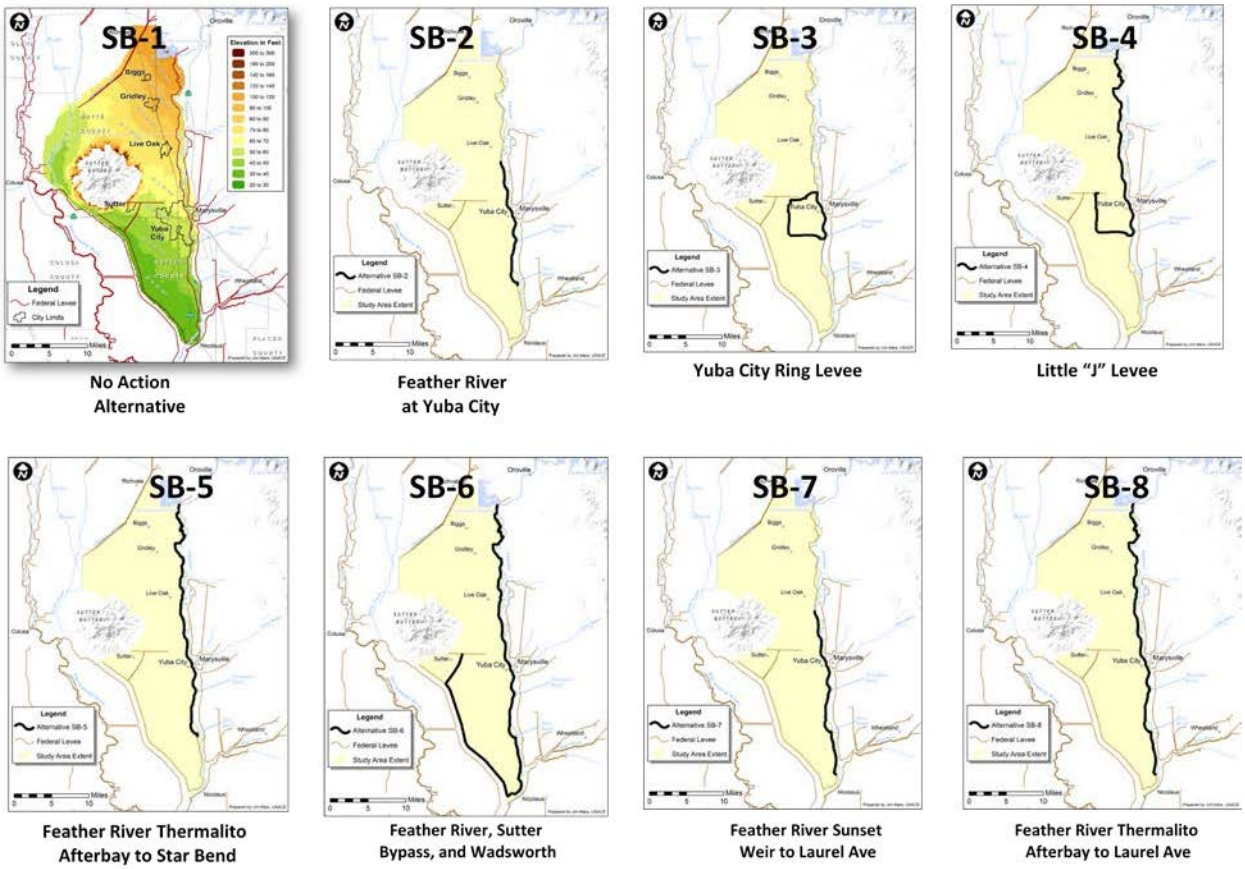
Draft Alternative Evaluation and Comparison. A combined Value Engineering (VE) Study and Planning Charette was held from October 31st to November 4th, 2011. The VE methodology was incorporated into the planning process at an early stage of the study to compare, refine, and optimize alternatives based on multiple criteria in order to ensure a robust array. This process also provided an opportunity to validate the array of preliminary alternatives and to ensure that significant alternatives had not been overlooked. The VE Study/Charette was attended by the PDT and non-Federal sponsors, the Sacramento District (SPK) VE Officer and South Pacific Division (SPD) VE Program Manager, the SPD Plan Formulation Lead, and representatives from the National Pilot Program 17+1 Team. Based on the discussions during the combined VE Study/Charette, the team identified alternatives with very similar functions in addition to those with little probability of implementation. This resulted in combining and eliminating some of the alternatives as well as refining and optimizing those that were retained by adding or removing measures in order to ensure a robust array. The draft array of alternatives (shown in Figure 5) evaluated in further detail includes:

- Alternative SB-1: No Action Alternative.

[6] A matrix with the array of conceptual alternatives and measures associated with each of these alternatives is also included in Progress Document #1 where the nine conceptual alternatives are described by theme.

- Alternative SB-2: Fix in Place Feather River from Sunset Weir to Star Bend - This alternative involves strengthening the existing Feather River levee in the immediate vicinity of Yuba City and reduces risk to the Yuba City urban core.
- Alternative SB-3: Yuba City Ring Levee – This alternative includes the construction of a new levee surrounding Yuba City and reduces risk to the primary urban center.
- Alternative SB-4: Little "J" Levee – This alternative includes strengthening the Feather River levees north of Yuba City and construction of a new levee on the south and west of Yuba City. Reduction of risk is focused on Yuba City and the northern communities of the Basin.
- Alternative SB-5: Fix in Place Feather River, Thermalito Afterbay to Star Bend- This alternative includes SB-2 but extends levee improvements north to Thermalito.
- Alternative SB-6: Fix-in-Place Feather River, Sutter Bypass, and Wadsworth Canal- This alternative consists of the Sutter Bypass / Wadsworth Canal Levee Improvements and the Feather River Levee Improvements.
- Alternative SB-7: Fix in Place Feather River, Sunset Weir to Laurel Ave- This alternative includes SB-2 but extends Feather River fix-in-place levee improvements south of Yuba City to Laurel Ave that specifically addresses residual risk of Yuba City southeastern areas.
- Alternative SB-8: Fix-in-Place Feather River from Thermalito Afterbay to Laurel Ave – This alternative focuses on the Feather River Levee Improvements north to Thermalito and south to Laurel Ave. Reduction in risk is focused on Yuba City and the northern communities of the basin.

Figure 5: Alternatives



Identification of the NED Alternative. Table 6 summarizes the expected annual net benefits and the benefit to cost ratio ranges for each of the draft array of alternatives. The economic analysis indicates the national economic development alternative to be SB-7, as it maximizes net benefits. Alternative SB-7 comprises of fixing-in-place the existing Feather River from Sunset Weir down river to Laurel. The total first cost estimate is $423 with annual net benefits of $37 million. Figure 6 shows the Alternative SB-7, NED plan and the resulting with project residual floodplain.

Table 6: Alternative Economic Evaluation and Comparison[7]

Alternative	Total First Cost			IDC	Annualized Cost + O&M			Annual Benefits			Annual Net Benefits			Benefit to Cost Ratio		
	Low (20%)	Mid (50%)	High (80%)	Mid	Low (20%)	Mid (50%)	High (80%)	Low (75%)	Mid (50%)	High (25%)	Low	Mean	High	Low	Mean	High
SB-1: No Action	0	**0**	0	0	0	**0**	0	0	**0**	0	0	**0**	0	0.0	**0.0**	0.0
SB-2: Minimal Fix in Place, Sunset Weir to Star Bend	290	**319**	361	24	14	**16**	18	24	**38**	73	14	**29**	48	1.9	**2.9**	4.1
SB-3: Yuba City Ring Levee	411	**451**	507	53	21	**23**	26	25	**41**	71	8	**23**	40	1.3	**2.0**	2.7
SB-4: Little J Levee	729	**798**	899	94	37	**40**	45	31	**46**	87	-3	**14**	36	0.9	**1.4**	1.9
SB-5: Fix-in-Place, Thermalito to Star Bend	549	**608**	694	72	28	**31**	35	29	**45**	81	4	**21**	41	1.1	**1.7**	2.3
SB-6: Fix-in-Place, Feather River, Sutter Bypass and Wadsworth Canal	1,018	**1,131**	1,297	183	53	**59**	67	46	**73**	134	-3	**24**	58	0.9	**1.4**	2.0
SB-7: Fix-in-Place, Sunset Weir to Laurel Ave	386	**423**	479	41	19	**21**	24	32	**51**	92	18	**37**	60	1.8	**2.7**	3.8
SB-8: Fix-in-Place, Thermalito to Laurel Ave	645	**713**	812	100	33	**37**	42	36	**58**	101	7	**28**	52	1.2	**1.8**	2.4

Alternatives SB-2 and SB-7 result in the highest net benefits. Further evaluation of the NED Alternative (SB-7) when compared to (SB-2) indicates that the NED plan reasonably maximizes economic benefits and provides additional outputs in terms of the other accounts (Table 7). Alternative SB-2 consists of fixing-in-place the Feather River levees from Sunset Weir to the downstream end of Star Bend. The total first cost estimate is $319 million with annual net benefits of $29 million. Benefits are concentrated in the primary urban center of the study area, Yuba City. The next added fix, Alternative SB-7, comprises of fixing-in-place the existing Feather River levees from Sunset Weir down river to Laurel Avenue. This alternative consists of SB-2 fixes plus an additional 13.4 mile of levee fixes. The total first cost estimate is $423 million with annual net benefits of $38 million. The additional investment of $104 million results in an increase in net benefits of $8 million. The incremental benefit-to-cost ratio is 2.6. Benefits for this additional reach are also centered in Yuba City, but address significant flood risk to the southern urban portion of the city. Fixing this reach provides flood risk reduction to approximately an additional 18,500 people.

[7] The net benefits were computed using screening level cost estimates, which incorporated results from a cost risk analysis. As such, a range of confidence was derived for each cost estimate and computed benefits. This range indicates the reliability of the estimate and benefits.

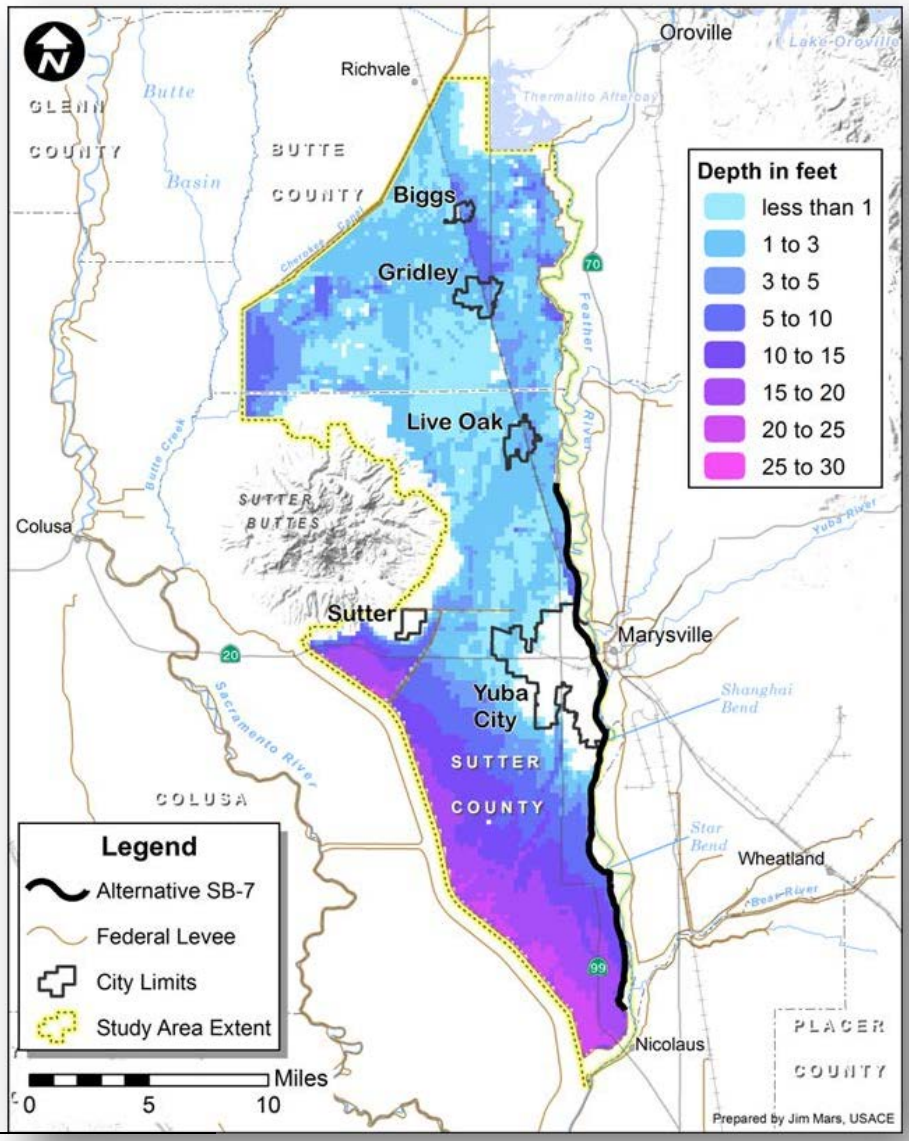
Table 7: SB-2 and SB-7

Item (from mean economic range number)	**Alternative SB-1 No Action**	**Alternative SB-2 1st Increment**	**Alternative SB-7 NED**
Investment Cost (millions)			
First Cost	-	319	423
Interest During Construction	-	24	41
Total	-	343	464
Annual Cost (millions)	-		
Interest and Amortization	-	15.8	20.7
OMRR&R	-	0.2	0.4
Subtotal	-	16	21
Annual Benefits FRM (millions)	-	38	51
Multi Objective Accounts (non-monetary)			
Population Remaining at Risk (people)	94,600	**56,700**	**38,200**
Critical Infrastructure (facilities)	28	11	11
Evacuation Routes (number of routes)	0	1	1
Wise Used of Floodplains (acres)	71,800	83,800	88,200
Net Annual FRM Benefits (millions)	-	**29**	**37**
FDR Benefit to Cost Ratio	-	**2.9**	**2.7**
FDR Benefit to Cost Ratio (at 7%)	-	1.7	1.6

5. RESIDUAL RISK OF THE NED ALTERNATIVE

Description of Residual Risk. The NED Alternative (SB-7) reduces adverse flooding effects but benefits are primarily centered on Yuba City. The alternative features do not address the significant flooding risk in the communities of Biggs, Gridley, and Live Oak. Residual risk of the NED alternative was assessed by the life safety metrics, described in Table 5. Given the NED residual 1% ACE floodplain[8] (Figure 6), substantial residual risk to Biggs, Gridley, Live Oak, and Yuba City remain (Table 8).

Figure 6. Alternative SB-7 NED Plan (1% ACE Residual Floodplain)



[8] 1% floodplains are based on the inundation from any levee having less than 95% assurance. The assurance estimate was based on geotechnical, hydraulic, and hydrologic uncertainty.

Table 8. Residual Risk of the NED Alternative, 1% ACE Floodplain

Evaluation Metric	Alternative	
	SB-1: No Action	NED Plan
Population at Risk (People)	94,600	38,200
Critical Infrastructure (Facilities)	28	11
Evacuation Routes (Number of Routes)	0	1
Wise Use of Floodplains (Acres)	71,800	88,200

Population at Risk. A remaining population of 38,200 is at risk of flooding. Of special concern is the population over the age of 65 living within the study area since those individuals have been shown to be at higher risk of life loss in flood events. Both Butte (15.6%) and Sutter (13.0%) counties are above the state average (11.7%) for percentage of persons 65 years of age and over[9].

Critical Infrastructure. A significant amount of critical infrastructure is located within the Sutter study area. Critical infrastructure is a term used by governments to describe assets that are essential for the functioning of a society and economy from a national perspective. Most commonly associated with the term are facilities for fire stations, police stations, hospitals, senior living facilities, and prisons. The benefits of the NED Alternative (SB-7) are primarily centered around Yuba City and still at risk are 11 elements of the critical infrastructure in the communities of Biggs, Gridley and Live Oak.

Evacuation Routes. The primary urban centers in the region are Yuba City, Biggs, Gridley, and Live Oak. These communities are all located on or near California State Route 99, which runs north-south through the region. The Sutter County Evacuation and Mass Shelter/Care Plan identifies Highways 20, 99 and 113 as the primary evacuation routes in the region. These routes are subject to change since these routes are event-specific and official routes are established by the County Sheriff's office during an emergency. The Butte County Office of Emergency Management does not have published evacuation routes at this time, but anticipates Highways 99, 162 and the Colusa Highway could be used as conditions allow. During the 1997 event, seven different evacuation zones were established over seven days due to constantly changing conditions and levee breaks[10]. The main evacuation routes used for this flood event were Highway-99 north and Highway-113 south. Highway-20 west and Highway-99 south were used intermittently since all portions of these roads were not accessible at all times during the flood.

Evacuation preparation can be made days in advance for predictable flood events within the major river system surrounding the study area. As river water levels raise and are predicted to reach flood stages, warnings and evacuation efforts would be increased and reiterated. This would allow time for evacuation of immobile residents and other people with special evacuation needs (hospitals, rest homes, jails, elderly individuals, schools) via the established routes. However, none of the historical flooding evacuations in the region have been due to foreseen events. Historical flood evacuations in the region have been from levee failures due to underseepage, which is characterized by its unpredictability and sudden occurrence.

[9] Source: U.S. Census Bureau (2012).

[10] Source: Sutter County Office of Emergency Management.

The result is evacuations after levees have failed and widespread flooding is in progress. The 1955 flood occurred due to a levee break in late December where no prior evacuation notice was given. In the 1997 flood, Yuba City was evacuated and during the evacuation a levee on the east side of the Feather River near Olivehurst (which was not evacuated) broke.

The residual 1% ACE (1/100 year event) resulting from the NED Alternative affects every major urban center and nearly every primary evacuation route in the region. The floodplain is due to potential levee failure upstream of Sunset Weir. All routes out of Biggs, Gridley and Live Oak are affected by the residual floodplain. The only egress from Yuba City would be Highway 20 and 5th Street bridges east into Marysville, which is a community surrounded by a ring levee. Additionally, heading eastbound entails driving over a four lane bridge that is not expected to adequately handle the additional traffic flow, and may create a bottle neck limiting evacuation.

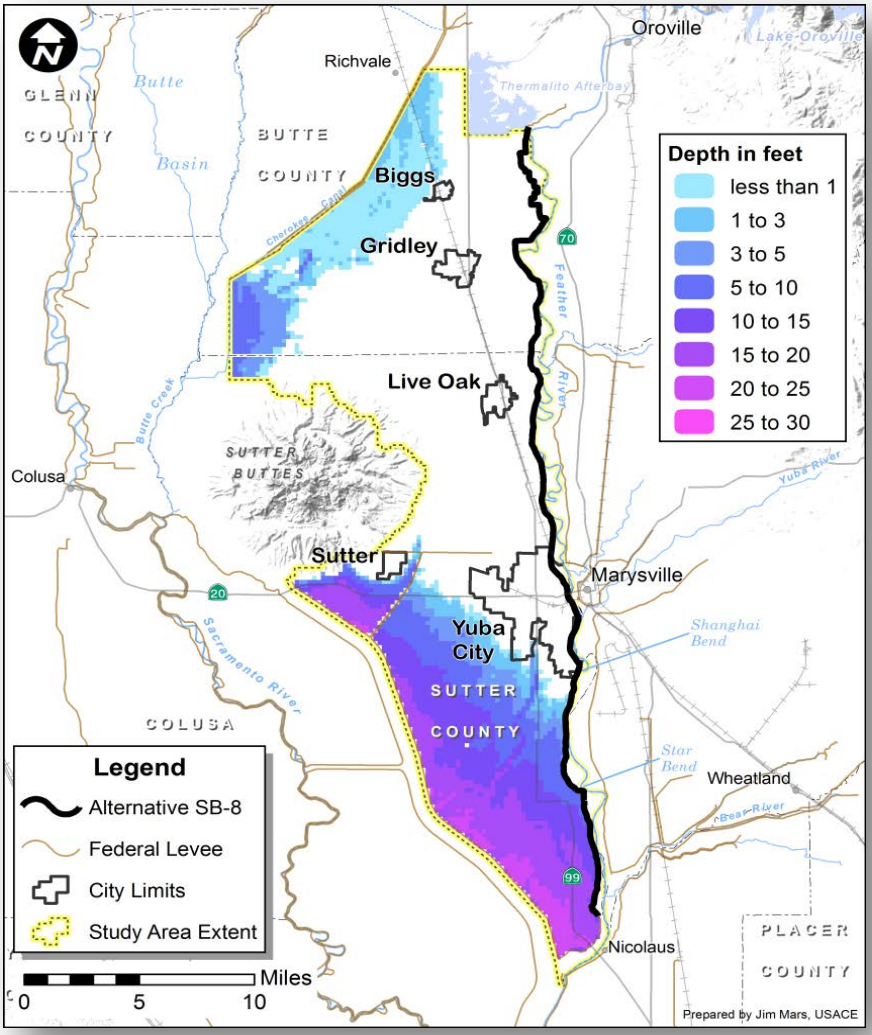
The District has initiated coordination with California Department of Transportations (CalTrans) to understand their criteria for road closures and evacuation during flood events. Standards for road closures are based less on depth and more on length of roadway affected by flooding. Road closures are determined based upon safety concerns and are authorized by the California Highway Patrol. Residual flooding in the northern area Sutter Basin associated with the NED Plan would encompass a majority or all primary roadways and would have a high likelihood of being considered impassable and/or closed using the above criteria. The sponsor has finalized its Flood Plain Management Plan, which includes coordination with State transportation authorities. The District will verify that the Future Without-Project Condition and No-Action Plan accurately represent the State and local response criteria for flood events.

Wise Use of Floodplains. A determination must be made as to whether the increase in potentially developable floodplain area is acceptable under Corps policy, or can be avoided or mitigated to an acceptable level within a justified cost. It is important to remember that the floodplain metric used in this analysis is a simple index based on physical parameters. The metric does not attempt to forecast future population growth, economic conditions, or government decisions that will constrain future floodplain development. For example, current zoning ordinances in Sutter and Butte County's General Plan indicate restrictive policies, which govern future development. Local policies, combined with recent state legislation and federal regulations are expected to limit developable land. These factors should be considered in conjunction with the metric.

6. ADDRESSING RESIDUAL RISK

The NED Alternative (SB-7) reduces adverse flooding effects but significant residual risks remain. With the aim of buying down the residual risk, the PDT found the most cost-effective incremental alternative to the NED to be Alternative SB-8. Figure 7 displays the residual 1% ACE floodplain associated with Alternative SB-8. In order to better understand the nature of residual flooding and flood risk associated with the NED Plan and LPP, the District has refined flood plain mapping to 1 foot intervals for the 2%, 1%, 0.5%, and 0.2% ACE. Please see Attachment 2, MFF urban floodplains.

Figure 7. Alternative SB-8 (1% ACE Residual Floodplain)



Using life safety metrics and accounts to address the significant residual risk of the NED Plan other measures and alternatives were investigated and evaluated with Alternative SB-8 identified as a next increment plan to the NED plan that effectively and efficiently reduces the residual risk and consequences to life safety in the northern urban areas and other parts of Sutter Basin. To further ensure that Alternative SB-8 structural and formulation strategy were valid, a cost comparison of Alternative SB-8 was performed, at a conceptual level of detail, to verify the structural measures of Alternative SB-8 were the most cost effective in addressing the residual risk and consequences left by the NED Plan.

The District identified risk reduction measures to reduce loss of life and improve the function of critical infrastructure facilities. Ring levees were considered to be ineffective for facilities like hospitals, the correctional institution, and the assisted living center because the functionality of the facilities would be compromised for an average flood event, which is estimated to be 2-3 weeks (using actual historical flood events in this study area as reference). Raising smaller facilities such as the police stations and the fire stations might be economically justified, but they would not maintain their functionality during the duration of a flood event.

Specific measures to improve evacuation during a flood event were also evaluated. Measures considered included modification to the roads used for evacuation. Because flooding in the northern portion of the study area is extensive sheet flow, embankment modifications to road and the railroad would need to be raises; culverts would not convey the wide area extent of the sheet flows. Raising roads was considered to be cost prohibitive relative to other measures. Raising the railroad is considered to be more costly than raising a road so that measure was similarly screened out. Additional investigation of potential evacuation routes and destinations, such as the Sutter Buttes, will be done as part of the life safety incremental assessment of SB-7 and SB-8, to be included in the Draft Feasibility Report. Please see Attachment 1, Decision Point #2 Slides, slides 50-56).

Evaluation of critical infrastructure and evacuation life safety measures will continue to be refined for the Draft Feasibility Report.

Fixing in place levees structural measures of Alternative SB-8 are estimated at an additional cost (compared to the NED plan) of: $260 to $330 Million. The costs for various comparable nonstructural measures addressing similar residual risk areas are listed below:

- Elevate Houses: ~$650 million
- Evacuation Route – Elevated Causeway: ~$600 Million
- Ring Levees around Live Oak, Gridley, and Biggs: ~$375 Million
- Buyouts: ~$1Billion

Alternative SB-8 is the multi-objective/account alternative that is cost effective and best reduces flooding and reduces residual risk of life safety in the Sutter Basin. Alternative SB-8 is comprised of Alternative SB-7 fixes plus fixing-in-place the existing northern Feather River levees from Sunset Weir up to Thermalito. The total first cost estimate is $713 million with annual net benefits of $26 million.
The additional investment of $290 million in project cost (Alternative SB-8 first cost minus the NED Alternative cost) buys down the residual risk of the NED Alternative and provides significant non-monetized benefits (displayed in Table 9). The population at risk of flooding from a 1% ACE flood event (Plate #8) decreases from 38,200 to 6,600, life safety related critical infrastructure at risk is reduced from 11 to 1, and the number of evacuation routes increases from 1 to 5. It should be noted that the additional investment of $290 million for the LPP increment produces an incremental annual benefit of $7 million. While this is not enough to justify the full cost of the increment, it justifies more than half of it. The LPP would reduce risk to an additional 32,000 people in an area that has historically had loss of life in a flood event. The RMC is conducting a Levee Safety Alternatives Evaluation of the NED and LPP the week of 25 February 2013.

Table 9. Summary of Life Safety Metrics, 1% ACE Floodplain

Evaluation Metric	Alternative		
	SB-1: No Action	NED	SB-8
Population at Risk (People)	94,600	38,200	6,600
Critical Infrastructure (Facilities)	28	11	1
Evacuation Routes (Number of Routes)	0	1	5
Wise Use of Floodplains (Acres)	71,800	88,200	100,200

In significantly reducing the residual risk of the NED Alternative, the next incremental alternative (SB-8) is supported by the local sponsors and can be considered the federal plan in terms of comprehensiveness and completeness. Alternative SB-8 is proposed as the Locally Preferred Plan (LPP) with strong federal interest. Furthermore, considering an objective of the study is to reduce risk to lives, perhaps the LPP increment of levee (17.7 miles) is in fact non-separable from the levee improvements included in the NED Plan from a life safety perspective.

Please also refer to Attachment 1, Decision Point #2 presentation slides 47-70, for initial comparison of NED and LPP, which is also being refined for the Draft Feasibility Report.

7. FINAL ARRAY OF ALTERNATIVES & COMPARISON

With the identification of the NED Plan and the LPP, a final array of alternatives was established for the study:

- **No Action: Alternative SB-1**
- **NED: Alternative SB-7** reconfirms federal interest, reduces flood risk to most of Yuba City area, but leaves considerable residual risk to the northern communities of the basin and parts of Yuba City.
- **LPP: Alternative SB-8** reconfirms federal interest the same as the NED plan, but significantly reduces residual risk of the NED in the northern communities of the basin and parts of Yuba City. It has also been identified in terms of multi-objective planning the comprehensive federal plan.

As a final step in the multi-objective planning process, a pair-wise comparison and evaluation was completed between the NED plan and the LPP to determine the recommended Tentatively Selected Plan (TSP**)** as shown in Table 10.

Table 10: Final Array of Alternative Plans- Comparison Summary of Accounts and Criteria

	NO ACTION	NED PLAN	LPP PLAN
1. PLAN DESCRIPTION			
	Alternative SB-1: The No Action provides no physical project constructed by the Federal Government.	Alternative SB-7: The NED plan is a Feather River fix-in-place levee alternative from Sunset Weir to Laurel Avenue.	Alternative SB-8: The LPP plan is a Feather River fix-in-place levee alternative from Thermalito to Laurel Avenue.
2. MULTI-OBJECTIVE PLANNING ASSESSEMENT			
A. National Economic Development (NED) – mean or mid-range numbers			
1. Project Cost	$0	$423,000,000	$713,000,000
2. Annual Cost	$0	$21,000,000	$37,000,000
3. Total Annual Benefit	$0	$51,000,000	$58,000,000
4. Annual Net Benefits	**$0**	**$37,000,000**	**$28,000,000**
5. Benefit – Cost Ratio	**N/A**	**2.7**	**1.8**
B. Environmental Quality (EQ)			
1. Environmental Safety	High potential for contaminated flood waters from the northern community urban facilities (water treatment plants; gas stations; etc)	High potential contaminated flood waters from the northern community urban facilities (water treatment plants; gas stations; etc)	Lower flood risk and lower risk of potentially contaminated flood waters from the northern urban community facilities (water treatment plants; gas stations; etc)
2. Ecosystem	The Sutter Basin is located along the Pacific Flyway that serves millions of migrating waterfowl during the winter migration (flooding) season for	Under residual flooding, thousands of acres remain impacted, negatively affecting "stop-over" feeding and resting areas with potential wildlife	Residual flooding is primarily concentrated in the south most part of the basin allowing for significant availability of acres for "stop-over" feeding and

	NO ACTION	NED PLAN	LPP PLAN
	foraging and rest. Flooding would negatively affect "stop-over" feeding and resting areas with potential wildlife health issues with contaminated waters.	health issues with contaminated waters.	resting. There is a lesser risk from urban area contamination
C. Regional Economic Development (RED)			
1. RED Effects to Flood Risk Management and Region	Future flooding would destroy part of the infrastructure resulting in a loss in the region's ability to produce goods and services. Little to no RED benefits.	A 4-year period of construction can result in positive spillovers to suppliers, short-term increases in construction related employment, increase revenues for local businesses and a potential increase in wealth for floodplain residents, as less is spent on damaged property repairs. Population and economic centers of the basin would be flooded resulting in slow regional recovery.	Similar to NED, but effects will extend for a 6-year period of construction resulting in additional RED benefits. Major population and economic centers will have reduced risk of flooding resulting in faster regional recovery.
D. Other Social Effects (OSE) – Life Safety Evaluation Metrics			
1. Life, Health, and Safety	Continued flood risk and consequences in the Sutter Basin including the communities of Yuba City, Live Oak, Gridley, and Biggs.	Flood Warning Emergency Evacuation Plan (FWEEP) mitigation is problematic for types of levee failures and limited evacuation routes. Significant life safety residual risk to the communities of Yuba City, Live Oak, Gridley, and Biggs.	Flood Warning Emergency Evacuation Plan (FWEEP) mitigation is problematic for types of levee failures and limited evacuation routes. Life safety residual risk to the communities of Yuba City, Live Oak, Gridley, and Biggs are significantly reduced.
1a.Remaining Population at Risk	Approximately **94,600** individuals are within the 1% ACE floodplain.	**38,200** people remain in the 1% ACE floodplain. (60% of population is removed from the 1% ACE residual floodplain for NED.)	**6,600** people remain in the 1% ACE floodplain. (93% of population is removed from the 1% ACE residual floodplain for SB-8)
1b. Loss of Life Estimate For 1% ACE event (Based on Hurricane Katrina loss of life ratio)	Potential loss of **112** lives.	Potential loss of **45** lives.	Potential loss of **8** lives.
1c. Critical Infrastructure – Life Safety	**28** structure deemed as critical from a national perspective are at risk from floods.	**11** structures remain at risk from floods.	**1** structure is at risk from floods.
1d. Evacuation Routes (See comparative plates below)	In the event of a flood, no evacuation route is available out of the basin.	Offers **one** problematic route for evacuation during a flood event. A flood warning and evacuation plan would not be as effective and limited.	**5** evacuation routes are available in the event of a flood. A flood warning and evacuation plan would have more robustness and redundancy.

	NO ACTION	NED PLAN	LPP PLAN
1e. Wise Use of Floodplains Note: fix-in-place measures are only bringing levees up to authorized elevation and performance.	Currently, 71,800 acres of land are potentially available for future development.	88,200 acres would be potentially available for future development.	100,200 acres of land would be potentially available for future development. (additional 12,000 potential acres calculated compared to NED)
2. Social Vulnerability (Study Area Resiliency)	The social vulnerability index score (SoVi) indicates the study area to be medium to high vulnerability. The No Action alternative may leave communities unable to cope with the recovery from a flood hazard.	Majority of the community of Yuba City is afforded flood risk reduction, however the communities of Live Oak, Gridley, and Biggs remain at risk of flood hazards and may be unable to cope and recover.	The four existing communities are provided flood risk reduction, and social vulnerability is minimized due to a decrease in the probability of flood hazards occurring.
3. Residual Risk and Consequences	Residual Risk remains high throughout the study area	Residual Risk for Life Safety is reduced for most of the Yuba City urban area.	Residual Risk for Life Safety is reduced in the high risk communities: Yuba City, Live Oak, Gridley and Biggs.
E. Federal Planning Criteria			
Acceptability	N/A	The local sponsors and public support levee fixes and improvements.	The local sponsors and public support levee fixes and improvements.
Effectiveness	N/A	Addresses the primary planning objectives of reducing FRM and some life safety.	Addresses the primary planning objectives of reducing FRM and life safety.
Efficiency	N/A	Economic analysis and outputs identified	Economic analysis and outputs identified
Completeness	N/A	Significant residual risk of life safety in the northern basin communities of Biggs, Gridley, and Live Oaks.	Reduces residual risk of life safety to Yuba City and the communities of Biggs, Gridley, and Live Oaks.

Alternative Comparison.

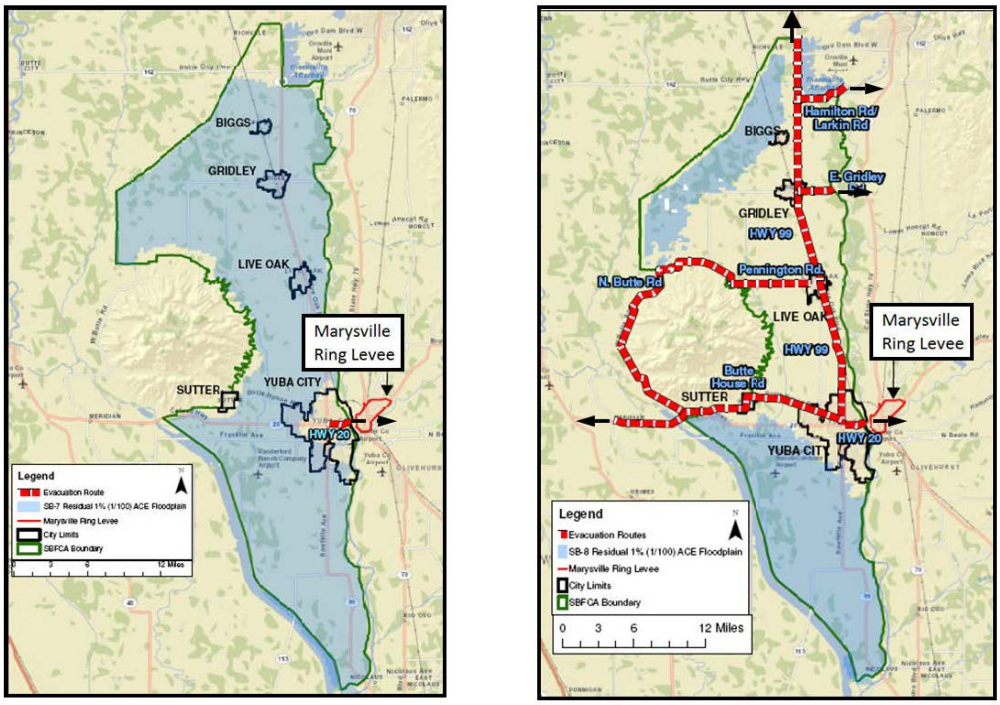
Population at Risk. A more specific comparison figures were developed in comparing the NED plan with the LPP (SB-8). The NED plan removed 60% of the basin population out of the 1% ACE floodplain while the LPP (SB-8) removed 93% of the basin population out of the 1% ACE floodplain. (See Table 11)

Table 11: Remaining Population at Risk

Community	NED Population Remaining at Risk	SB-8 Population Remaining at Risk	Reduction of Population at Risk
Yuba City	11,400	3,500	7,900
Biggs	1,500	20	1,480
Gridley	6,400	0	6,400
Live Oak	8,400	0	8,400
Sutter Rural	5,800	3,100	2,700
Butte Rural	4,800	20	4,780
Total	**38,200**	**6,600**	**31,600**

Evacuation Routes. The availability and access of evacuation route options tied to the sudden unpredictable nature of recent flood events is a critical comparison factor of the NED vs. to the LPP. With the population centers spread throughout the middle and northern sections of the Basin, having multiple routes to choose from is critical to evacuation planning and real time evacuation. Adjoining basins to the southwest, south, and east, either has lower levels of flood protection or is surrounded by water during flood events, making them dangerous locations for evacuees. The NED plan provides only one route to the city of Marysville which has historically been surrounded by water in flood events and is currently in final planning stages for a ring levee FRM project. (Figure 8).

Figure 8. Comparison of NED and LPP Evacuation Routes (1% ACE Residual Floodplains)

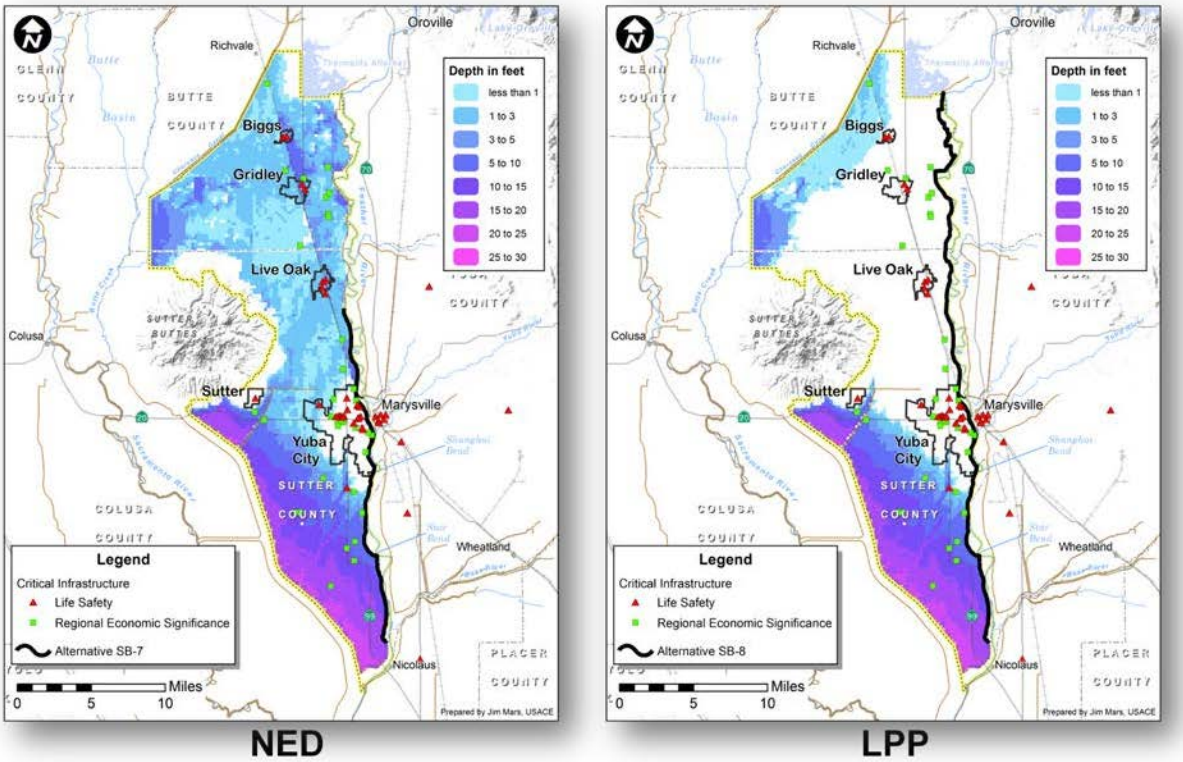


NED LPP

Critical Infrastructure. In terms of response and recovery of flood events for life safety, the NED plan leaves numerous critical infrastructure facilities at in the 1% ACE residual floodplain in the cities of Biggs, Gridley, Live Oak, and part of Yuba City (Figure 9). A partial list is provided here:

- 1 Hospital (45 beds)
- 2 Police stations
- 5 Fire stations
- 1 Assisted living center (99 beds)
- 3 City hall buildings
- 1 Correctional Facility (305 inmate capacity)
- 3 Water and sewer treatment facilities
- Multiple telecommunication facilities

Figure 9. Critical Infrastructure-Life Safety Comparison

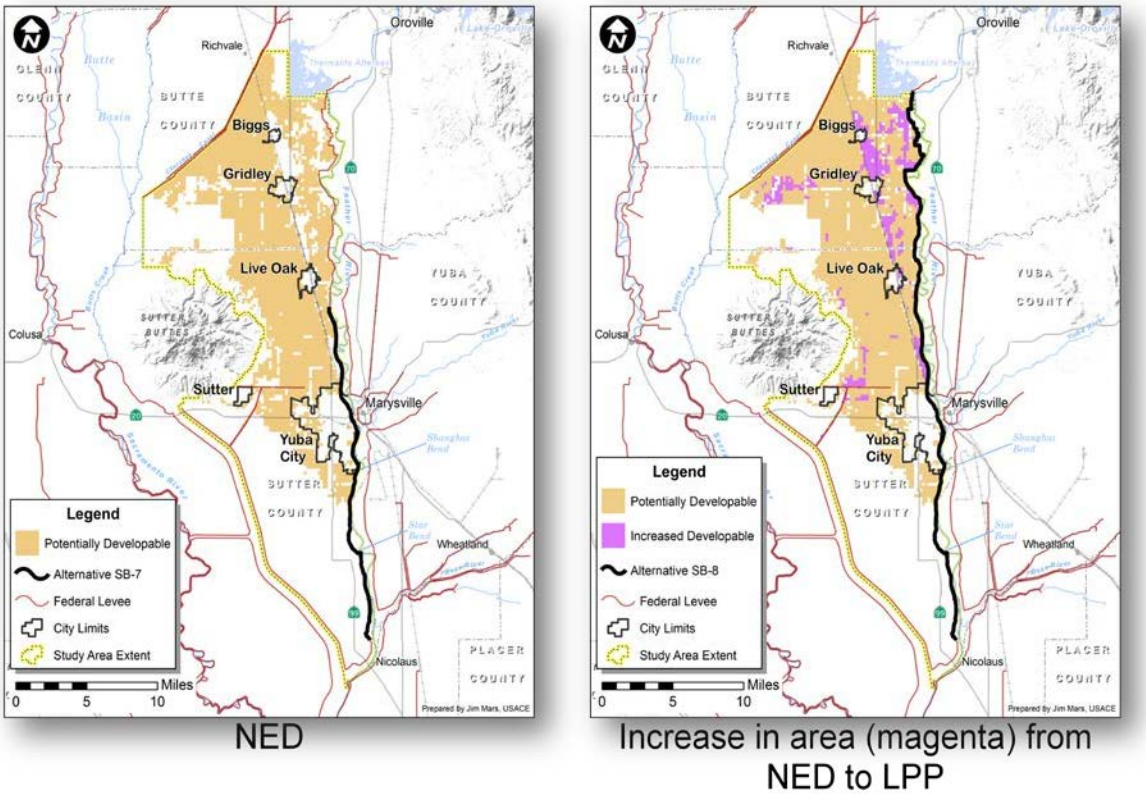


Wise Use of Floodplains. Potentially developable land in terms of 1% ACE residual floodplains were calculated as an evaluation metric to enable general comparison of potentially developable floodplain under the NED Plan vs. the LPP assuming land is developable if the 1% ACE floodplain depths are 3-feet or less (Figure 10). The calculation estimates the potential of roughly 12,000 additional acres made available with the LPP vs. the NED plan. The LPP includes conservation easements that could be purchased by the local sponsor to mitigate potential residual loss of life. See Attachment 1, slides 59-60.

Sutter Basin is an agriculturally focused region. The local and state partners have several existing land use commitments and constraints in the Sutter Basin in regards to development in the floodplain:

- Williamson Act Contracts: These rolling 10-year agreements between government and farmers to preserve the agricultural and open space in rural California by offering landowners tax breaks on the assessed land value.
- Conservation Easements: Agreements between landowners and an agency (USFWS, etc) which permanently precludes future development.
- Flood Risk Notifications: Annual flood risk notifications sent to all property owners.

Figure 10: Potentially Developable Floodplain Comparison



Loss of Life. Estimates of potential loss of life were made for this study for areas identified as rescue areas and for the areas identified as evacuation area. These estimates are based upon actual loss of life ratios experienced in 2005 by the population of New Orleans during the Hurricane Katrina levee failures. Boyd et al. assumed that of the inhabitants in a flooded area, 80% evacuated and 10% found shelter in a specialty facility (such as the Superdome or high school), leaving approximately 10% of the population in a flooded area exposed to the flood event. Based on actual fatalities in New Orleans a mortality rate of 1.18% was determined for the population exposed to the flood event.

As indicated in Table 12, application of the Katrina ratio to the approximately 94,800 population within the No Action population at risk associated with a Feather River levee failure results in the potential loss of 112 lives, to the approximately 38,300 people within the NED residual floodplain results in the potential loss of 45 lives, to the approximately 6,640 people in Alternative SB-8 residual floodplain results in the potential loss of 8 lives. Note that these are preliminary values. Many factors will influence the mortality rate from a flooding disaster, including timing of the breach (day or night), population located near the breach, and availability of flood warning and evacuation routes. The preliminary analysis provides an indication of the loss of life lives that might be expected. In the California Central Valley, the risk of a large flood is seasonal. The majority of rainfall occurs in the November through March rainy season, making the area most vulnerable to winter floods. Standing or working in water which is cooler than 75 °F (24 °C) will remove body heat more rapidly than it can be replaced, resulting in hypothermia. Cold water removes heat from the body 25 times faster than cold air. About 50% of that heat loss occurs through the head. Physical activity such as swimming or other struggling in the water increases heat loss.

Hypothermia (decreased body temperature) develops more slowly than the immediate effects of cold shock. Survival curves show that an adult dressed in average clothing may remain conscious for an hour at 40 °F and perhaps 2-3 hours at 50 °F (water temp.). Any movement in the water accelerates heat loss. Survival time can be reduced to minutes. Hands rapidly become numb and useless. Without thermal protection, swimming is not possible. The victim, though conscious, is soon helpless. Without a life jacket, drowning is unavoidable.

Table 12: Estimated Loss of Life (1% ACE Residual Floodplain)

Economic Impact Area	Estimated Loss of Life		
	No Action	NED (SB-7)	LPP (SB-8)
Biggs	2	2	0
Gridley	8	8	0
Live Oak	10	10	0
Yuba City	80	13	4
Rural Butte	6	6	0
Rural Sutter	7	7	4
Total	112	45	8

Other Alternative Comparison Considerations and Factors.

Levee Safety Program – Baseline Conditions Risk Assessment. Levee Safety Program – Baseline Conditions Risk Assessment (BCRA). The Sutter Basin area is one of five areas selected to undergo a risk assessment by the USACE Risk Management Center (RMC). Within the Levee Safety Program framework, the BCRA is a quantitative risk assessment to advance the goal of the Levee Safety Program to work with stakeholders to assess, communicate, reduce, and manage risk associated with levee systems.

The Sutter Basin BCRA will include risk assessments of the baseline (existing conditions). Data collected as part of the Sutter Basin Feasibility study will be used by the RMC to assist in the development of the baseline. Once the baseline is established the RMC will evaluate the NED and LPP alternatives developed during the Sutter Study. The risk will be characterized by the combination of the probabilities of failure estimated for each failure mode and the consequences (life loss and damages) associated with that failure. Risk will be reported in terms of annualized life loss and estimated annual damages. Preliminary results are expected to be available in the spring of 2013.

Executive Order 11988. The objective of the Sutter Basin study is to reduce flood risk within the study area. The study is responsive to the EO 11988 objective of "avoidance, to the extent possible, of long- and short-term adverse impacts associated with the occupancy and modification of the base flood plain and the avoidance of direct and indirect support of development in the base flood plain wherever there is a practicable alternative". The proposed features focus on reducing the threat of flooding to the existing urban areas, altering a scattered footprint difference between the NED and LPP within the northern floodplain (Figure 10). These features would reduce the hazard and risk associated with floods thereby minimizing the effects of floods on life safety, health, and welfare to the existing population, and would preserve the natural and beneficial values of the base floodplain. For these reasons the proposed plan is in compliance with EO 11988.

Emergency Costs and Evacuation Planning. NED losses associated with public goods and services include some of the costs incurred as part of actions required to respond to a flood emergency. The type of costs that could be incurred and considered NED losses are those associated with the following activities, which may employ staff and equipment:

- Structure clean-up: monetary damages associated with the removal of debris generated by damage structures due to flooding
- Displacement: temporary relocation of residents, and subsistence costs (incremental costs above those that would be normally incurred)
- Public assistance/emergency response services

An expert-opinion elicitation panel comprised of professionals having significant, relevant experience in the field of emergency response convened in Sacramento, CA (2009) with the goal of developing estimates of the economic cost associated with various emergency related damage categories (evacuation, debris activities, public services, utilities, etc) . Initial modeling results for district studies, as a proportion of structure and content damages, ranged from 1-3%.

Additionally, road damages and traffic-related costs associated with detours and extra time traveled by motorists due to potential flooding in the Sutter Basin was forgone based on prior experiences, which have shown such damage categories to be relatively minimal when compared to structural damages. Nevertheless, it is recognized that in order to detail the magnitude of flooding problems in the Sutter Basin, the economic analyses can be conducted. However, because these damages categories are not expected to drive plan selection it was omitted from the analysis. If deemed necessary, emergency costs, road damages and traffic disruption analyses can be conducted during refinement of tentatively selected plan (TSP).

Non-Federal Sponsors' Request.

Sutter Butte Flood Control Agency and the State's California Central Valley Flood Protection Board are the non-Federal sponsor for the Pilot Feasibility Study. The LPP Plan is supported by both the non-Federal sponsors as this plan addresses the flood risk of Yuba City and the residual flood risk and consequences of life safety to the existing cities of Biggs, Gridley, Live Oaks, and parts of Yuba City that the NED Plan does not. The non-Federal sponsors agree to pay for the determined cost share of the LPP.

The LPP also meets the requirements of Senate Bill (SB) 5 which stipulates that urban and urbanizing areas of 10,000 or greater must achieve 1/200 ACE level of flood risk management. It should be noted that the southern deeper part of the basin would remain in the 1/100 ACE floodplain.

TSP Recommendation. The multi-objective comparison and assessment between the NED Plan and the LPP are summarized in Table 10. Both the NED and LPP provide significant benefits that exceed the costs. While the NED Plan is more efficient than the LPP, both plans are efficient. Both the NED and LPP are complete since they each contain all necessary elements for the project to function independently. In a multi-objective context that equably emphasizes flood risk reduction and residual risk to life safety across all accounts and criteria, the LPP can be recommended as the Tentatively Selected Plan.

8. RECOMMENDATION OF THE TSP

Both the NED (SB-7) and the LPP (SB-8) provide significant benefits that exceed the costs. While the NED Plan is more efficient than the LPP, both plans are efficient (B/C >1). Both plans are complete in that they include all necessary elements needed for the project to function without relying on other activities. The LPP plan is more effective in that it provides greater flood risk reduction benefits and addresses residual risk of life safety within the Sutter Basin. Based upon the information developed in support of the Decision Point 2 Conference, and the conclusions that can be drawn from that information and were presented to the Vertical Team, the LPP (SB-8) will be recommended as the Tentatively Selected Plan (TSP) in the Draft Feasibility Report.

Cost Sharing. Table 13 presents two cost sharing scenarios for Federal/non-Federal cost allocation for the TSP: full Federal participation as established by Section 103 of WRDA 1986; limited Federal participation where the Federal share is limited to the Federal share of the NED alternative. The range in confidence of cost estimates are displayed in Table 6, the mean estimates are used in the table below.

Table 13. Cost Allocation Scenarios for TSP ($1,000)[11]

Cost Allocation	NED	LPP	
		Full Federal Participation	Limited Federal Participation
Non-Federal			
LERRD	$48,333	$71,073	$71,073
Cash	$99,717	$178,477	$366,977
Sub Total	$148,050	$249,550	$438,050
Federal			
Construction	$274,950	$463,450	$274,950
Total Project Cost	$423,000	$713,000	$713,000

Full Federal Cost Participation. The estimated total project first cost for the TSP is $713 million, with an estimated Federal cost of $463 million and a non-federal cost of $250 million.

Limited Cost Share. The estimated total project first cost for the TSP is $713 million. Federal costs are capped at 65% of the NED plan ($275million) with an estimated to non- federal cost $438 million.

Recommendation.

The recommendation for the tentatively selected plan is the LPP Alternative. To recommend the LPP as the TSP, a Policy Exception Request will be developed and forwarded to the ASA (CW). With a confirmation of a recommended TSP, the PDT is scheduled to move forward in refining and finalizing an integrated draft EIS/EIR-feasibility report for concurrent public, internal and external peer reviews.

[11] LERRDs are based preliminary estimates based screening level cost estimates.

9. SUMMARY

- Recent geotechnical analysis of project levees reveal significant adverse flooding impacts as a result of underseepage failures, which are sudden and unpredictable, resulting in minimal warning time, and ineffectiveness of evacuation plans.

- The total value of damageable property within the Sutter Basin study area is estimated at $6.9 billion.

- Management measures were developed and formed the basis of the preliminary alternatives, which were evaluated and resulted in a draft array of alternatives of which SB-7 was identified as the NED Alternative, affirming federal project interest.

- The NED residual 1% ACE floodplain showed significant adverse flooding impacts remained given that the alternative only addressed flooding impacts in one of the four existing communities.

- An assessment of the residual risk of the NED Alternative using life safety metrics served to illustrate the magnitude of the flooding impacts. The metrics were population at risk, critical infrastructure, availability of evacuation routes and the potential developable acres.

- With the aim of buying down the residual risk, the PDT found the most cost-effective incremental alternative to the NED to be Alternative SB-8.

- The additional investment of $290 million in project cost (Alternative SB-8 first cost minus the NED Alternative cost) buys down the residual risk of the NED Alternative and provides significant non-monetized benefits. Total annual benefits increase from $51 to $58 million. The population at risk of flooding from a 1% ACE flood event decreases from 38,200 to 6,600, critical infrastructure at risk (within the 1% ACE floodplain) is reduced from 11 to 1, and the number of evacuation routes increases from 1 to 5. A preliminary estimate of the potential loss of life indicates a substantial reduction from 45 lives (NED) to 8 lives (LPP).

- The wise use of floodplain metric used in the analysis is a simple index based on physical parameters, and does not account for current restrictive zoning ordinances, which govern and limit future development.

- The final array of alternatives includes the No Action, NED and LPP.

- The LPP (Alternative SB-8) is recommended as the TSP that comprehensively addresses flood risk and the residual risk to life safety and is the federal plan.

C1. Engineering Appendix

SUTTER BASIN FEASIBILITY STUDY
SUTTER AND BUTTE COUNTIES, CALIFORNIA

APPENDIX C – ENGINEERING APPENDIX

Prepared by

U.S. Army Corps of Engineers
Sacramento District, Engineering Division

April 2013

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ATTACHMENTS

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- Hydraulic Design Appendix
- Geotechnical Design Appendix
- Civil Design Appendix
- Cost Engineering Appendix
- Plan
- Cost Estimate

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ACRONYMS

ACE Annual Chance of Exceedance
ADWS Authorized Design Water Surface
ATOL Authorized Top of Levee
AEP Annual Exceedance Probability

APE Area of Potential Effect
AST Above Ground Storage Tank
BMP Best Management Practice
CCEL Cherokee Canal East Levee
CDFW California Department of Fish and Wildlife
CEQA California Environmental Quality Act
CFS Cubic Feet Per Second
COE The Corps of Engineers
CVFED Central Valley Floodplain Evaluation and Deliniation
CVFPB Central Valley Flood Protection Board
CSA Cultural Site Assessment
Cy Cubic Yards
DFG California Department of Fish and Game
DWR California Department of Water Resource
DWS Design Water Surface
DWSE Design Water Surface Elevation
DSM Deep Soil Mixing
ESA Environmental Site Assessment
ETL Engineering Technical Letter
EIP Early Implementation Project
EPA Environmental Protection Agency
FDA Flood Damage Assessment
FRWL Feather River West Levee
FRM Flood Reduction Measures
HPTRM High Performance Turf Reinforced Mat
HTOL Hydraulic Top of Levee
HTRW Hazardous, Toxic and Radioactive Wastes
LEERD Land, Easements, Rights-of-way, Relocation and Disposal Areas
LiDAR Light Detection and Ranging
LMA Levee Maintenance Authorities
LD Levee District
LSO Levee Safety Officer
LSPM Levee Safety Program Manager
MEIP Modified Early Implementation Project
NMFF National Marine Fishery Service
NHPA National Historic Preservation Act
NPDES National Pollution Discharge Elimination System
OMRR&R Operation and Maintenance, Repair, Replacement and Rehabilitation
PA Programmatic Agreement
PCA Project Cooperation Agreement
PCB Polychlorinated biphenyl
PDT Project Delivery Team
PED Preconstruction Engineering and Design
REP Real Estate Plan
PFR Plan Formulation Report
PLM Project Levee Mile

ROW Right-of-Way
RWQCB Regional Water Quality Control Board
SOP Standard of Practice
SBFS Sutter Basin Feasibility Study
SBEL Sutter Bypass East Levee
SBMC Sutter Butte Main Canal
SBFCA Sutter Butte Flood Control Agency
SBFIP Star Bend Fix-in-place
SBLS Sutter Basin Levee System
SBL Sutter Bypass Levee
SHPO State Historic Preservation Office
ULE Urban Levee Evaluation
UPRR Union Pacific Railroad
USACE United States Army Corps. of Engineers
USFWS U.S. Fish and Wildlife Service
USGS U.S. Geological Survey
UST Underground Storage Tank
VFZ Vegetation Free Zone
VE Value Engineering
WPC Without Project Condition
WCEL Wadsworth Canal East Levee
WCWL Wadsworth Canal West Levee
WSEL Water Surface Elevation

CHAPTER 1 – INTRODUCTION

1.1 Project Description

The study area is located in Sutter and Butte Counties and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The existing Sutter Basin Levee System (SBLS) consists of four mainline levees : Feather River West Levee (FRWL or right levee), Sutter Bypass East Levee (SBEL or left levee), Wadsworth Canal East Levee (WCEL or left levee) and Wadsworth Canal West Levee (WCWL or right levee), and Cherokee Canal East Levee (CCEL or left levee) surrounding the communities of Yuba City, Live Oak, Gridley, Biggs and other smaller towns in Sutter and Butte Counties, California.

For this Feasibility Study, planning measures were considered and combined to form a preliminary array of conceptual alternatives. Through the plan formulation process, a draft array of eight alternatives were defined as follows:

- Alternative SB-1 – No action alternative (i.e. existing condition)
- Alternative SB-2 – Minimal Fix-in-place Feather River Levees, Sunset Weir to Star Bend
- Alternative SB-3 – Yuba City ring levee
- Alternative SB-4 – Little “J” levee, Thermalito Afterbay to south of Yuba City
- Alternative SB-5 – Fix-in –place Feather River Levees: Thermalito Afterbay to Star Bend

- Alternative SB-6 – Fix-in –place Feather River Levees: Sutter Bypass, and Wadsworth Canal
- Alternative SB-7 – Fix-in –place Feather River Levees: Sunset Weir to Laurel Avenue
- Alternative SB-8 – Fix-in –place Feather River Levees: Thermalito Afterbay to Laurel Avenue

This draft array of alternatives was analyzed and refined to a final array that includes 3 of the alternatives (Alternatives SB-1, SB-7 and SB-8). These final alternatives were further evaluated at a feasibility level of design to verify and determine the Tentatively Selected Plan (TSP) for recommendation. See Plates 1-1 to 1-8 for maps of draft array of alternatives (note that the reach identifications shown in these plates were revised during the final array analysis for Alternatives SB-7 and SB-8 as shown on plate 2-2 and discussed in Paragraph 2.4).

1.2 Purpose and Scope

This Engineering Appendix provides a summary of the engineering analyses performed by the Project Delivery Team (PDT) for the draft and final alternatives, including the existing conditions. The appendix provides narrative descriptions of the final two alternatives. The objective of this appendix (along with referenced subject matter appendices) is to summarize the designs and cost estimates completed for the Feasibility Study.

1.3 Coordination

The Project Delivery Team (PDT) worked closely with the local sponsor comprised of the State of California Central Valley Flood Protection Board (CVFPB) and the Sutter Butte Flood Control Agency (SBFCA) in the preparation of this appendix. The local sponsor's design team includes Peterson Brustad, Inc., HDR, Inc., Wood Rogers, Inc., and MHM, Inc.

SBFCA is a consortium of Sutter and Butte Counties, the Cities of Yuba City, Live Oak, Gridley, and Biggs, and Levee Districts 1 and 9 of Sutter County. The agency was formed in 2007 to finance and construct regional levee improvements. The FRWL Improvement Project's goal is to improve the 44 miles of the right bank levee of the Feather River from the Thermalito Afterbay outlet to the confluence with the Sutter Bypass under a Section 408 permit. The design of the FWRL Improvement Project is being done ahead of the Feasibility Study as an Early Implementation Project (EIP) for future cost share under the Feasibility Study. The SBFCA EIP is at the 100% design level for a portion of the FRWL between Shanghai Bend and Live Oak. The remaining portion of the SBFCA EIP is at the 65% design level.

Additional contacts were also made with local authorities (e.g. the U.S. Fish and Wildlife Service, the United Auburn Indian Community and Enterprise Rancheria etc.) to obtain inputs to the final feasibility design of Alternatives SB-7 and SB-8.

CHAPTER 2 – GENERAL DESIGN CONSIDERATIONS

2.1 General

This chapter summarizes general design considerations used for evaluation of the draft array and final array of alternatives. Refer to the subject matter appendixes for further detail of the analyses. Features resulting from these analyses are provided in project descriptions of Alternatives SB-7 and SB-8, Chapters 4 and 5, respectively.

A key concept of the Pilot Feasibility Study is to utilize an appropriate level of detail to make risk informed decisions. ER 1110-2-1302 Civil Works Cost Engineering describes five levels of detail. The classes are based on ASTM E 2516-06, Standard Classification for Cost Estimate Classification System. The purpose of the classification system is to improve communication among all the stakeholders involved with preparing, evaluating, and using cost estimates (ASTM, 2011). Class definitions, as they relate to the Pilot Study are considered to also describe a level of design and engineering commensurate with the level of detail in the cost engineering classification. These class definitions are described below. Cost accuracies do not necessarily apply to engineering and design but are of a level that is consistent with those accuracies

- Class 5 is the least accurate and is the minimum required for assessing rough order of magnitude. The level of project definition is 0% to 2% of a complete definition. The expected cost accuracy (+/-) is 4 to 20 times the accuracy of the best (Class 1) estimate.

- Class 4 is the minimum required for Reconnaissance/905b Reports and alternative analysis in feasibility studies. The level of project definition is 1% to 15% of a complete definition. The expected cost accuracy (+/-) is 3 to 12 times the accuracy of the best (Class 1) estimate.

- Class 3 is the minimum required for the feasibility NED Plan and Feasibility Sponsor Preferred Plan. The level of project definition is 10% to 40% of a complete definition. The expected cost accuracy (+/-) is 2 to 6 times the accuracy of the best (Class 1) estimate.

- Class 2 is minimum required for Planning, Engineering, and Design up to 90% Plans and Specifications. The level of project definition is 30% to 70% of a complete definition. The expected cost accuracy (+/-) is 1 to 3 times the accuracy of the best (Class 1) estimate.

- Class 1 is minimum required for Planning, Engineering, and Design 100 % Plans and Specifications and the Independent Government Estimate. The level of project definition is 50% to 100% of a complete definition. This is considered the most accurate estimate. It does not imply that all unknowns and risk are eliminated.

The analysis of the existing condition (i.e. Alternative SB-1) forms the basis of comparison to project alternatives. The analysis of the existing conditions was conducted at a Class 4 level during the screening and selection of the draft array of alternatives. The analysis of the existing condition was refined during the final analysis to a Class 3 level of detail.

Analysis of the draft array of alternatives is based on a Class 4 level of detail. The final array of alternatives (including refinements to the without project conditions) are based on a Class 3 level of detail and is referred to as Final Analysis in this report.

Another key concept in the Pilot Feasibility Study is to utilize existing information where applicable. Since the local sponsor had already completed a 65% design for their Early Implementation Project (EIP) the PDT reviewed and adopted information where applicable (specifically, civil and geotechnical designs, quantity estimates, and utility relocations) All design information was reviewed to ensure it was consistent with the planning objectives of the study. Refer to the Civil and Geotechnical Design Appendixes for the review and adoption of design information in the 65% EIP.

2.2 Datum

The North American Datum of 1983 (NAD 83) State Plane California Coordinate System Zone II (U.S. Survey Feet) was used for horizontal control. The North American Vertical Datum of 1988 (NAVD 88) was used as the vertical datum.

2.3 Alignment and Stationing

2.3.1 General

This section describes the alignment and stationing developed for the Class 4 and Class 3 analyses. Refer to the Civil Design Appendix for further details.

2.3.2 Draft Array of Alternatives SB-1 through SB-8

Alignment stationing were defined for three levee segments during the analysis of the draft array of alternatives. These include: (1) Feather River West Levee or right levee, (2) Sutter Bypass East Levee or left levee, and (3) Wadsworth Canal East Levee or left levee. The project levee alignments were developed based on surveyed data from the National Levee Data Base. The stationing of each levee segment begins with station 0+00 at the intersection with the levee segment at the downstream end, and increases in an upstream direction. See Plate 2-1 for details.

2.3.3 Final Array of Alternatives: SB-7 and Alternative SB-8

For Alternatives, SB-7 and SB-8, the project levee alignment follows the existing levee centerline of the FRWL except at Star Bend where the levee alignment follows the centerline of the setback levee. The stationing begins with station 10+00 at the confluence of the FRWL at the SBEL and increases in an upstream (north) direction. This levee stationing conforms to the existing levee centerline and accounts for recent changes in the alignment, such as the Star Bend

Setback Levee (between station 478+68 and station 512+00). At locations where levee relocations (e.g. roughly between station 1432+70 and station 1754+30 etc.) are proposed, supplementary levee alignments stationing necessary for designs and analyses were established. See Plate 2-2 for details.

2.4 Alternative Reaches

2.4.1 General

This section describes the alternative reaches developed for the analyses of the draft array and final array of alternatives. Refer to the Civil Design Appendix for further details.

2.4.2 Draft Array of Alternatives SB-1 through SB-8

The evaluation of the existing condition (SB-1) and Alternatives SB-2 through SB-8 were based on a 28 reaches (see Plate 2-1). Sixteen of these reaches are existing levee segments. The other 12 reaches are either proposed setback or new (Ring and ”J”) levee segments. Reaches were defined based on similarity in geotechnical and proposed structural fix.

2.4.3 Final Array of Alternatives SB-7 and SB-8

A new reach identification system was developed for the analysis of Alternatives SB-7 and SB-8 (see Plate 2-2). Alternative SB-7 is defined by 21 reaches (2A-North, 2B, 3… 21) starting from station 180+00 (approximately 2,000 linear feet south of Laurel Avenue) and ending at station 1433+83 (immediately north of Sunset Weir). Alternative SB-8 is defined by 41 reaches (2A-North, 2B, and 3 to 41) starting from station 180+00 (approximately 2,000LF south of Laurel Avenue) and ending at station 2368+00 (Thermalito Afterbay). The reaches were also tabulated and shown in Table 4-2 (for Alternative SB-7) and Table 5-2 (for Alternative SB-8). These reaches are a refinement of the reaches in 2.4.2 above based on refinement of the proposed structural fixes.

2.5 Survey Data

2.5.1 General

This section of the report describes the survey data used for this study. Refer to the Civil Design Appendix for further details.

2.5.2 Topographic Data

The project employed topographic information obtained from three sources. LiDAR data acquired in 2008 were obtained from DWR’s Central Valley Floodplain Evaluation and Delineation (CVFED) Program and Urban Levee Evaluation (ULE) Program. Topographic data at 2 foot contour intervals were obtained from surveys performed for the USACE during the 2002 Sacramento and San Joaquin Basins Comprehensive Study. The 2002 topography was based on the National Geodetic Vertical Datum of 1929 (NGVD 29). The surveyed data was

converted to the North American Vertical Datum of 1988 (NAVD 88) in 2010. The 2010 converted bathymetry was used throughout the study.

Land survey was completed to confirm the LiDAR topographic data. Results show that cross section profiles based on CVFED and ULE Program's LiDAR-based topographic data are comparable with land surveyed elevation.These data sets were used in hydraulic and geotechnical evaluations, site layouts and quantity estimates.

2.5.3 Bathymetric Data

Bathymetry of the Feather River was obtained from a bathymetry survey performed for the USACE during the 2002 Sacramento and San Joaquin Basins Comprehensive Study at a contour interval of 2 feet. The 2002 surveyed elevations were based on the National Geodetic Vertical Datum of 1929 (NGVD 29). The surveyed data was converted to the North American Vertical Datum of 1988 (NAVD 88) in 2010. The 2010 converted bathymetry was used throughout the study.

2.6 Hydrology

2.6.1 General

A hydrologic analysis was completed for the sources of flooding within the study area. The methodology and results are essentially identical for the analysis of the draft array and final array of alternatives.

2.6.2 Hydrologic Analysis

2.6.3 Analysis of Alternatives SB-1 through SB-8

The Wadsworth Canal flood frequency curve was developed from graphical frequency analysis of gage records at Wadsworth Canal near Sutter (DWR stream gage A05929) following Bulletin 17B guidelines.

Flood frequency curves and 30 day balanced hydrographs for Cherokee Canal were developed from gage records at Cherokee Canal near Richvale Gage (DWR stream gage A02984) following Bulletin 17B guidelines. All alternatives except Alternative SB-3 (Yuba City Ring levee) and SB-4 (Little "J" Levee) are based on the existing conditions hydrology.

Hydrology for the Sutter Bypass, Feather River and Butte Basin was based on the Sacramento-San Joaquin Comprehensive study and Lower Feather River Floodplain mapping study. The hydrologic analysis was derived from historical flood events and statistical analysis of unimpaired or unregulated locations throughout the Sacramento River Basin. Unregulated flows were hydrologically routed through the major reservoirs to develop unregulated and regulated flows at downstream locations. The hydrographs were passed to hydraulic analysis for routing through the flood control system.

Statistical analysis was used to develop curves describing peak unregulated flow versus exceedance probability for seven exceedance events (50, 10, 4, 2, 1, 0.5, and 0.2 percent)

throughout the project area. Flow frequency curves showing the unregulated flow frequency are available in the Hydrology Appendix as plates at selected locations throughout the study area. Tables of peak unregulated flows and the period of record, and design flow and peak regulated flow are provided in tables in the Hydrology Appendix.

Authorized Design flows and regulated flow–frequency tabular values are shown in the Table 2-1 below.

Table 2-1 1957 Design Flows compared to Regulated Peak Flows

Stream and Reach	1957 Authorized Design Flow (CFS)	Regulated Peak Flows (CFS)						
		50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Sacramento River								
Colusa to Tisdale Weir	66,000	44,000	48,000	50,000	53,000	55,000	59,000	68,000
Tisdale Weir to Sutter Bypass	30,000	28,000	30,000	31,000	32,000	34,000	36,000	41,000
Feather River								
Oroville to Honcut Creek	210,000	60,000	100,000	150,000	150,000	150,000	174,000	320,400
Honcut Creek to Yuba River	210,000	49,000	107,000	157,000	159,600	163,000	182,000	293,600
Yuba River to Bear River	300,000	71,000	192,000	256,000	281,000	283,000	360,000	534,000
Bear River to Sutter Bypass	320,000	78,000	211,000	288,000	321,000	336,000	409,000	574,000
Sutter Bypass								
Meridian to Wadsworth Canal	150,000	57,000	102,000	126,000	155,000	184,000	228,000	327,000
Wadsworth Canal to Tisdale Weir	155,000	58,000	103,000	127,000	156,000	185,000	229,000	327,000
Tisdale Weir to Feather River	180,000	71,000	117,000	141,000	163,000	197,000	237,000	329,000
Feather River to Sacramento River	380,000	141,000	283,000	393,000	436,000	490,000	581,000	799,000
Wadsworth Canal								
Tributary Specific Storm Centering	1,500	820	2,550	3,200	3,980	4,830	5,750	7,070
Cherokee Canal								
Nelson Shipee Road to Western Canal	8,500							
Western Canal to Afton Road	11,500	6,000	10,300	12,100	13,200	14,300	15,200	16,300
Afton Road to Gridley – Colusa Road	12,500							

2.6.4 Interior Drainage Analysis

An interior drainage analysis was performed only for Alternatives SB-3 and SB-4. An interior drainage analysis was not performed for the other alternatives because analysis of the floodplains indicated it was not a factor in the evaluation and comparison of draft alternatives would have similar hydrology as existing conditions except the for the interior drainage area. Rainfall depths were extracted from the design rainfall analysis. The analysis is based on rainfall depth-area-duration statistics. The runoff area within the alternatives was estimated from topographic mapping. The loss rate coefficient was calibrated to match the peak flows shown the West Yuba City master drainage study. A mean daily flow rate of 918 cfs was estimated for the 24.2 square mile area inside the levee using a 1-day, 10% ACE precipitation volume of 2.82 inches, and a rainfall-runoff coefficient of 0.5.

2.6.5 Final Analysis of Alternatives SB-7 and SB-8

The hydrologic analysis performed for the draft array of alternatives was adopted for use in the analysis of the final array of alternatives for Wadsworth Canal, Cherokee Canal, Feather River, and Sutter Bypass. However, a more detailed interior drainage analysis was performed to evaluate residual flooding. The analysis was performed by Peterson-Brustad Incorporated (PBI) for the Sutter Butte Flood Control Agency (SBFCA). The interior drainage analysis evaluated rainfall runoff and flood depths for 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE flood events. Storm events with 24-hour and 96 hour durations were evaluated.

The analysis utilized an HEC-HMS model to compute sub basin runoff and a FLO-2D two dimensional hydraulic model to route the runoff through the study area. A total of 16 drainage basins covering approximately 340 square miles were identified within the interior drainage boundary. The drainage basins were further divided into a total of 77 sub basins. The model included ten storm water pump stations that pump drainage water into the Feather River or Sutter Bypass. The FLO-2D model uses a 1,000-foot by1,000-foot grid size and includes the main drainage channels throughout the study area as channel elements.The resulting interior drainage maps were reviewed and adopted for use in this study. Maps showing the residual interior drainage are provided in the Hydraulic Design Appendix.

2.7 Hydraulic Design

2.7.1 General

This section describes general hydraulic design and analysis of the draft array and final array of alternatives. Refer to the Hydraulic Design Appendix for further details.

2.7.2 Draft Array of Alternatives SB-1 through SB-8

Hydraulic analysis was conducted for design of project features and evaluation of each alternative's flood risk performance relative to the existing conditions. Based on a review of historical conditions and proposed actions, the hydrologic and hydraulic conditions in the future are assumed to be the same as existing conditions.

The flood risk performance of each alternative condition (including the existing condition) was evaluated using Risk and Uncertainty methods. Flood risk is defined as the probability of a flood event occurring and the consequences of occurrence. Flood risk was assessed using the USACE FDA (flood damage assessment) model version 1.2.5a (USACE, 2010). The FDA model combines flow-frequency, stage-discharge, geotechnical fragility, and stage-damage relationships to estimate damages. Uncertainty in each relationship is incorporated by assigning uncertainty estimates and applying a Monte Carlo type approach to combine the results.

Flow-frequency, stage discharge, and geotechnical frequency relationships reflect the exterior (probability) side of the risk calculations. Inundation depth and stage-damage relationships reflect the interior (consequence) side of the risk calculations. For the probability side of the risk calculations, the hydraulic model assumptions are based on flows contained to the channel (allowed to overtop without failure). For the consequence side of the risk calculations, the

hydraulic model assumptions are based on levee breach failure or simply the depth for natural overbank (non-levee) conditions.

Hydraulic analyses were conducted using five separate hydraulic models that were adapted from existing hydraulic models utilized for studies within the Sacramento Valley. Water surface profiles for Sutter Bypass and Feather River were computed using an HEC-RAS unsteady one-dimensional flow model of the Sacramento River system. Water surface profiles for Wadsworth Canal were computed using an HEC-RAS steady one-dimensional flow model. Water surface profiles for Cherokee Canal were computed using an HEC-RAS unsteady one-dimensional flow model. Water surface elevations for Butte Basin were based on the UNET unsteady model results obtained from the Sacramento-San Joaquin Comprehensive Study. Inundation depths from levee breach simulations were evaluated using a FLO-2D 2-dimensional unsteady flow model of the study area.

The hydraulic design of project features, project performance, and description of residual floodplains for the draft array of alternatives is provided in the Hydraulic Design Appendix.

2.7.3 Final Analysis of Alternatives SB-1, SB-7 and SB-8

The final hydraulic analysis of Alternatives SB-1, SB-7 and SB-8 was based on the same approach as the evaluation of the draft array of alternatives. However, refinements were made to the Wadsworth Canal model and Sutter Bypass and Feather River hydraulic model. The Wadsworth Canal model was refined to include four bridges. The Sutter Bypass and Feather River models were revised to include a diversion weir near Thermalito Afterbay. These refinements were found to have negligible impacts on computed water surface profiles and flood risk assessment.

2.7.3.1 Current Authorization and Requirement

The Authorized Design Water Surface (ADWS) is the 1957 design water surface (DWS). The Authorized Top of Levee (ATOL) is the 1957 ADWS plus 3-foot free board.

2.7.3.2 Design Analysis

Water surface profiles were developed for use in the design of seepage measures, estimation of project performance, and economic risk analysis. The top of levee was not based on a design water surface profile. As required by ER 1105-2-101 Risk Analysis for Flood Damage Reduction Studies, freeboard or similar buffers to account for hydrologic and geotechnical uncertainties are no longer used for levee planning and design. Project performance is to be described by annual exceedance probability (AEP) and long term risk rather than level of protection. A description of the levee performance is provided at key index points in the Flood Reduction Measures (FRM) performance section of the Hydraulics Appendix.

Water surface profiles along the project reach of Alternative SB-7 and Alternative SB-8 were computed using the Sutter Bypass and Feather River HEC-RAS unsteady one-dimensional flow model of the Sacramento River system. The model was calibrated to two historic flood events that occurred in January 1997 and December 2005 - January 2006. Calibration efforts were specifically focused on the Feather River, Sutter Bypass, and Wadsworth Canal. Detailed calibration for all of the other rivers and storage areas within the HEC-RAS model was considered outside of the scope of this study. Manning's roughness values range from 0.031 to 0.07 in the main channel and 0.05 to 0.10 in the overbanks.

Mean water surface profiles were simulated for 50% (1/2) ACE, 10% (1/10) ACE, 4% (1/25) ACE, 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE, and 0.2% (1/500) flood events.

2.7.3.3 Top of Levee

The levee height will be reconstructed to the existing top of levee elevation or the ATOL elevation (defined in Paragraph 2.7.3.1), whichever is higher. In no cases, will the levee height exceed these profiles. This height was selected through the plan formulation process. The selection of the levee height is described in the feasibility report and the economic appendix.

2.7.3.4 Erosion Protection/Levee Superiority and Resiliency

Levee superiority for a flood risk management system is the increment of levee height added in order to increase the likelihood that an event exceeding the design event will result in controlled flooding at the design overtopping section. To insure controlled flooding, erosion protection features are required in the reach where initial levee overtopping will most likely occur.

Based on hydraulic analysis of the levee crest and water surface profiles, erosion protections features (such as an articulated mat or anchored High Performance Turf Reinforced Mat (HPTRM) etc.) are needed for 1 location within reach 7, the first point of overtopping, and 1 location within reach 23, another initial point of overtopping (see Plate 2-2 for map of project reaches). For the purpose of this study, use of anchored HPTRM was assumed based on Sacramento District’s knowledge of its performance history and familiarity with its cost. Other products such as an articulated mat could also be considered. The purpose of these erosion protection features is to increase the resiliency of the initial overtopping sections. The design objective is to increase the flood warning and evacuation time prior to overtopping failure.

2.7.3.5 Interior Drainage

The levee construction, utility improvements and other relocations will temporarily disrupt the storm drain systems; however, it is anticipated that the temporary disruption will not cause any significant impacts to interior drainage of the basin since the levee construction is expected to be within normal construction season (April through October) during which the storm drain systems won’t be needed.

The project also includes removal or downsizing of six culverts for Alternative SB-8. Based on a site evaluation conducted by the local sponsors' engineers, it is estimated that interior drainage would not be impacted by the modification of these features. Further detailed analysis is recommended during preconstruction engineering and design (PED).

2.8 Geotechnical Design

2.8.1 General

This section describes general geotechnical considerations for the evaluation of the existing condition and describes the geotechnical design considerations for and recommendations resulting from the Class 4 and Class 3 analyses. Refer to the Geotechnical Design Appendix for further details.

2.8.2 Evaluation of the Existing Condition (Alternative SB-1)

The evaluation of the existing condition followed the conventional method for evaluating the without-project condition during the screening and selection of alternatives. Risk-based geotechnical analyses were performed to evaluate the existing levees. The first-order-second-moment (FOSM) method, as recommended in ETL 1110-2-556, "Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies" dated 28 May 1999, was followed during the evaluation. In this approach, the uncertainty in performance is taken to be a function of the uncertainty in model parameters. A set of conditional-probability-of-poor-performance versus floodwater-elevation graphs (also known as fragility curves) were developed for the existing levees as related to underseepage piping, stability and judgment. For all levee reaches in the study except one, the underseepage piping performance mode accounts for virtually all of the probability of poor performance, which agrees with the actual performance history of the levees.

The geotechnical analysis of the existing condition was also updated with additional information (e.g. new boring logs etc.) during the Final Analysis (Class 3).

2.8.3 Class 4 Analysis of Alternatives SB-2 through SB-8

The analysis of Alternatives SB-2 through SB-8 followed the parametric approach during the screening and selection of alternatives. The geotechnical recommendations for seepage and stability modification for fix-in-place alternatives and seepage controls for non-fix-in-place alternatives (e.g., new ring levees, setback levees, etc.) were developed based in large part using engineering judgment. The approach assumed that cutoff walls were the primary method for seepage control, and the design of the measures (e.g., length, depth, percentage of reach, etc) was selected using judgment and the principal of most likely minimum and maximum for each value. After identifying a range, an expected mean value was selected. Refer to Figures 2.1 and 2.9 of the Civil Design Appendix for templates of typical modification measures developed for the Class 4 analysis.

2.8.4 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

The Final Analysis (Class 3) of Alternatives SB-7 and SB-8 was based on the conventional design approach for development of feasibility level design (35%; Class 3) using existing subsurface explorations and deterministic seepage and stability analyses. The design considerations and recommendations for the final alternatives are listed below.

2.8.4.1 Current Authorization and Requirement

USACE guidance for levee design requires geotechnical analysis (for seepage and slope stability) to be performed at the 1957 Authorized Design Water Surface (1957 ADWS, defined in Paragraph 2.7.3.1) at a minimum. The Sacramento District's standard practice requires the analyses to also be performed with the water surface at the 1957 Authorized Top of Levee (1957 ATOL, defined in Paragraph 2.7.3.1).

2.8.4.2 Design Analysis

The geotechnical analysis (for seepage and slope stability) for the design of Alternatives SB-7 and SB-8 were based on the geotechnical analysis prepared for the SBFCA EIP (SBFCA EIP was defined in Paragraph 1.3). The geotechnical analysis for the SBFCA EIP was conducted at two water surfaces: (1) the SBFCA EIP's design water surface (not the 1957 ADWS), and (2) the hydraulic top of levee (HTOL).

The SBFCA EIP's design water surface (SBFCA EIP's DWS) is defined as:

- The 0.5% (1/200) ACE for the urban area upstream of station 461+00 (Reaches 5 – 41)
- The 1% (1/100) ACE for the rural area downstream of station 461+00 (Reaches 1 – 5).

The SBFCA EIP's HTOL (SBFCA EIP's HTOL) is defined as the lowest of:

- The SBFCA EIP's DWS plus 3 feet
- The 0.2% (1/500) ACE water surface
- The existing levee crest elevation

In addition, SBFCA's analysis added an extra foot to the EIP's design water surface (SBFCA EIP's DWS + 1 foot) and to the SBFCA EIP's HTOL profiles (SBFCA EIP's HTOL + 1 foot) for SBFCA EIP's geotechnical analysis of the design of modification measures. The additional foot, which originates in DWR's Urban Levee Criteria, increases confidence in the seepage and stability design.

The "SBFCA EIP's DWS + 1 foot" and "HTOL + 1 foot" profiles were determined to be comparable (within a foot) with the "1957 ADWS" and "1957 ATOL" profiles, respectively (see Plate 2-5). The highest of the water surfaces (SBFCA EIP versus authorized) varies by location along the Feather River. The SBFCA EIP geotechnical analysis showed seepage exit gradients and slope stability factors of safety well within USACE criteria; adding an extra foot of water would not change the recommended design modification measures. Therefore, for the purpose

of this Feasibility Study, the SBFCA EIP's geotechnical analysis was considered to be adequate for use as the USACE's final geotechnical analysis of Alternatives SB-7 and SB-8.

2.8.4.3 Modification Features

Where the existing levee meets the geotechnical analysis criteria, no modification is needed. Where modification is required, cutoff walls are the primary feature for addressing geotechnical deficiencies of the existing FRWL for the following reasons:

- Cutoff walls are highly effective when constructed correctly.
- Cutoff walls do not require the acquisition of additional permanent real estate.
- Cutoff walls do not require maintenance once constructed (except for monitoring activities).
- Cutoff walls constructed by the conventional open-trench method are cost-comparable to landside berms.
- Cutoff walls have minimal long-term environmental impact primarily due to their location within the existing levee footprint.

Two primary modification measures of the FRWL were evaluated. In general, the measures were a fully-penetrating soil-bentonite cutoff wall and a partially-penetrating soil bentonite cutoff wall combined with a seepage berm or relief wells. Both measures would include a partial levee degrade to obtain the needed working platform width. (A full levee degrade is proposed where the levee has a severe burrowing rodent infestation or to prevent having to use the more expensive deep soil mixing (DSM) method for cutoff wall construction due to depth). A reach-by-reach cost comparison between the two measures showed a fully-penetrating soil bentonite cutoff wall was the least-cost measure for most reaches. However, site conditions dictated selection of a different measure for some reaches or portions of reaches.

Jet grout cutoff walls are proposed at locations where it is not practical to construct a conventional soil bentonite cutoff wall (i.e. bridges, railroad crossings, and the Yuba City Water Treatment Plant). Seepage berms by themselves are proposed for the northernmost end of the FRWL because a conventional soil bentonite cutoff wall is not constructible through the cobble levee. Partially penetrating cutoff walls combined with seepage berms or relief wells are proposed for the southern end of the FRWL because fully-penetrating cutoff walls would be too deep to be cost-effective. A cutoff wall with levee relocation and a cutoff wall with Sutter Butte Main Canal (SBMC) relocation are proposed for some levee sections along the FRWL (north of Sunset Weir, where the Sutter Butte Main Canal is located adjacent to the landside levee toe) to obtain the required O&M corridors.

The recommended modification measures for Alternatives SB-7 and SB-8 are shown on Plate 2-3.

2.8.4.4 Minimum Levee Template

The minimum levee template criteria obtained from four sources (USACE EM 1110-2-1913, CESPK-ED-G-SOP-EDG-03 (SOP3), DWR Urban Levee Design Criteria, and the Code of

California Regulations (Title 23 Division 1) are shown on Plate 2-4. As a levee modification project, the Sacramento District allows a narrower crest width (not less than 15 ft) for existing levees that have improvements constructed to address seepage and stability concerns. The Sacramento District has adopted the following minimum levee template criteria:

- Crest width: 15 feet minimum.
- Landside slope: 2H:1V or flatter.
- Waterside slope: 3H:1V or flatter.
- Landside easement: 15 feet minimum.
- Waterside easement: 15 feet minimum.

2.8.4.5 Levee Fill and Borrow

Type 1, Type 2 and Random fill materials are needed for levee, cutoff wall and seepage berm constructions. Type 1 levee fill material will be used primarily as a clay core for the reconstructed levee above the cutoff wall and for the cutoff wall's soil-bentonite mix. Type 2 levee fill material will be used primarily for shells for the reconstructed levee above the cutoff wall. Random fill will be used primarily for the seepage berm.

Excavated materials from the levee degrade are expected to be reusable for Type 1 and Type 2 fills. Type 1 fill can be used as Type 2 and Random Fill. Type 2 fill can be used as Random fill. It is expected that borrow materials will be needed for construction of the project. The two primary types of borrow material for the levee and cutoff wall constructions are: Type 1 and Type 2. Source for borrow is discussed in Paragraph 2.6. Specifications for the two material types are as follows:

- Type 1 Levee Fill: USCS classification of CL, SC, or CH; maximum particle size of 2 inches; minimum 35% by weight passing the #200 sieve; maximum liquid limit of 60; plasticity index between 12 and 40.

- Type 2 Levee Fill: Maximum particle size of 2 inches; minimum 12% by weight passing the #200 sieve; maximum liquid limit of 45.

Based on preliminary geotechnical investigations and standard practice, an approximately 20% increase should be applied to the total demand (to account for all material swell, loss and shrinkage during excavation, transportation and placement, respectively) when estimating the borrow amount needed. The approximate percentages of levee degrade suitable for levee fill are shown in Table 2-2.

Table 2-2 Percentages of Levee Degrade Suitable for Levee Fill

Reach ID	Percentage for Levee Core (Type 1)	Fraction	Percentage for Levee Shell (Type 2)	Fraction
2A-North	5	0.05	95	0.95

2B	5	0.05	95	0.95
3	5	0.05	95	0.95
4	5	0.05	95	0.95
5	5	0.05	95	0.95
6	5	0.05	95	0.95
7	40	0.4	60	0.6
8	0	0	85	0.85
9	0	0	55	0.55
10	0	0	70	0.7
11	0	0	100	1
12	NA	NA	NA	NA
13	0	0	95	0.95
14	NA	NA	NA	NA
15	NA	NA	NA	NA
16	NA	NA	NA	NA
17	0	0	100	1
18	15	0.15	85	0.85
19	30	0.3	70	0.7
20	0	0	100	1
21	0	0	100	1
22	15	0.15	85	0.85
23	0	0	90	0.9
24	0	0	100	1
25	0	0	100	1
26	0	0	100	1
27	80	0.8	20	0.2
28	15	0.15	85	0.85
29	NA	NA	NA	NA
30	0	0	95	0.95
31	30	0.3	70	0.7
32	0	0	100	1
33	0	0	100	1
34	0	0	100	1
35	0	0	100	1
36	0	0	100	1

37	0	0	100	1
38	0	0	100	1
39	NA	NA	NA	NA
40	60	0.6	0	0
41	60	0.6	0	0

2.9 Civil Design

2.9.1 General

This section describes general civil design considerations for and recommendations resulting from the Class 4 and Class 3 analysis.

2.9.2 Class 4 Analysis of Alternatives SB-2 through SB-8

The Class 4 civil design analysis of Alternatives SB-2 through SB-8 followed the parametric approach in which site assessments were completed based on existing information and aerial photos, and quantity estimates were completed based on typical design templates from geotechnical design recommendations. Refer to the Civil Design Appendix for further details.

2.9.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

The final civil design analysis of Alternatives SB-7 and SB-8 was based on a conventional design approach for development of feasibility level design (35%; Class 3) with detailed site assessments and deterministic analyses for encroachment and utility improvements, and for quantity analysis. The design considerations are listed below. All civil design analysis was based on hydraulic and geotechnical design recommendations provided in Paragraphs 2.7 and 2.8.

2.9.3.1 Embankment Geometry

The primary feature of the project is a cutoff wall which requires reconstruction of the excavated levee embankment. The reconstructed embankment is required to meet the minimum levee template criteria or to match the existing levee prism, whichever is larger (see Paragraph 2.8.4.4). The degraded levee will be reconstructed to the existing top of levee elevation or the 1957 authorized top of levee elevation, whichever is higher (see Paragraph 2.7.3.3).

In general, the existing levee prism of the FRWL currently appears to be larger than the minimum levee template. At some locations, however, the landside slope was damaged and needs to be reconstructed to meet the minimum levee template criteria (see Paragraph 2.8.4.4). Plate G-2 shows the typical section for embankment reconstruction.

An active railroad embankment (Union Pacific Railroad) crosses the levee alignment at approximate station 1130+00. The railroad embankment is about 4 feet lower than the levee. A

stop log closure structure will be provided to meet the authorized levee height without causing impacts to the UPRR's operation. This structure will be closed during flood events.

There are three locations along the FRWL alignment, between station 1434+00 and station 1957+00, where the SBMC encroaches into the proposed right-of-way. The levee will be relocated toward the river at these locations (see Paragraph 2.9.3.3). The relocated levee is required to meet the minimum levee template criteria (see Paragraph 2.8.4.4) and levee height requirement (see Paragraph 2.7.4.3).

2.9.3.2 Right-Of-Way (ROW) Requirements

Currently, the existing FRWL's right-of-way (ROW) corridor includes O&M corridors which vary in width along the alignment and are discontinuous for a significant distance at some locations. The minimum levee template criteria require the project levee to have a 15 feet minimum O&M corridor on each side of the levee, along the levee toes (see Paragraph 2.8.4.4). The O&M corridors are necessary for O&M and flood fighting purposes. Therefore, for this feasibility study, additional real estate will be acquired to provide sufficient space for the O&M corridors. Acquiring additional real estate will result in relocation of physical structures (e.g., buildings, canals, etc.) along the alignment (see Paragraph 2.3). Where it is impractical to acquire the additional real estate, the levee will be relocated toward the river (see Paragraph 2.9.3.3).

There will be one exception in regards to the minimum requirement for O&M corridor. The exception covers the area between station 1904+00 and station 1957+00 where the SBMC is encroaching into the proposed 15ft minimum landside easement. For this area, an existing 10ft minimum natural berm, on the levee's landside slope, will be utilized for O&M purposes without any further actions (see Paragraph 2.9.3.3).

2.9.3.3 Relocations

To meet the minimum ROW requirements as stated above, acquisition of additional real estate is necessary and will require relocations of certain physical structures. Any physical structures falling within the ROW proposed will be considered potential relocations (except for the encroachment of the SBMC). These relocations will be studied in greater detail in the PED phase.

In the case of the SBMC, which encroaches into the proposed ROW at four locations along the FRWL alignment between stations 1430+00 and 1957+00 (Plate 2-3), there were four potential measures considered for each area to address the issue. The measures include: construction of retaining wall in the landside slope, construction of a flood wall, levee relocation, and canal relocation. Each measure was evaluated based on construction cost and impacts.

The proposed measures were also coordinated with the USFWS to obtain their inputs. The flood wall and retaining wall options were eliminated because these structures were deemed to create a substantial barrier for terrestrial wildlife species migration.

Levee relocation was deemed to have the least overall impact and was selected as the primary measure for addressing the issue. The relocated levee is required to meet the minimum levee template criteria (see Paragraph 2.8.4.4) and height requirement (see Paragraph 2.7.3.3). The cutoff wall will be constructed at the centerline of the relocated levee sections.

Canal relocation was selected for a small section along the alignment where the FRWL is too close to the Feather River's main channel to relocate the levee. This option was also selected for a small section of the SBMC near the Sunset Weir Pump Station, around station 1430+00, because it was deemed to be more cost effective than the levee relocation option which requires relocation of the pump station' electrical system.

At one of the four locations where the SBMC encroaches into the proposed ROW, specifically between station 1904+00 and station 1957+00, an existing 10ft minimum natural berm, on the levee's landside slope, will be utilized for O&M purposes without any further actions needed.

2.9.3.4 Encroachments

A comprehensive inventory of all encroachments (utilities, physical structures, and woody vegetation) was completed based on existing data and field investigations. The existing encroachment data came from multiple sources including the CVFPB encroachment list, the USACE Periodic Inspection report, and as-built drawings of various projects located along the FRWL alignment. Field investigations were conducted to validate and improve the existing inventories.

The final encroachment list (Table 4-3 for Alternative SB-7 and Table 5-3 for Alternative SB-8) shows numerous pipelines (both gravity and pressurized lines) and conduits (cables, electrical lines etc.) crossing the existing FRWL embankment. The record also indicates a number of utilities running parallel to the alignment (power poles, irrigation ditches, pipelines etc.), physical structures (public, residential and commercial buildings), and woody vegetation (mature trees) currently located within the proposed ROW. The encroachments were divided into 2 groups:

- Utilities and Physical Structures
- Woody Vegetations

The following Paragraphs outline the approach for addressing levee encroachment issues (see Plate 2-6 for the utility handle chart).

2.9.3.4.1 Utilities and Physical Structures

This group was subdivided into 2 categories: levee prism encroachments and ROW encroachments.

The levee prism encroachments are utility pipelines and conduits running perpendicular to the levee alignment. Most of these pipeline and conduit crossings are either dated and do not

comply with the current standard for levee encroachment or will be disrupted/otherwise impacted by levee construction. These pipelines and conduits, therefore, will be removed before the cutoff wall construction begins and replaced after the cutoff wall construction completes with proper pipe materials. Gravity lines (storm drain) will be replaced in-place. Pressurized lines (irrigation and drainage discharge lines, gas pipes, water and sewer lines etc.) and conduits (electrical and communication lines, cables etc.) will be relocated above the 1957 Water Surface Elevation (WSEL) profile or 0.5% (1/200) ACE WSEL profile north of station 461+00, whichever is greater and above the 1957 WSEL profile or 1% (1/100) ACE WSEL profile south of station 461+00, which ever greater. Where it is not feasible to relocate the pressurized pipelines above the intended WSEL (e.g. at Sunset Weir pump station), these pipelines will be replaced in-place. Pipes that are known to be recent installations will remain. All pipelines and conduits crossing the levee alignment will be modified to include positive closure devices and meet the USACE design criteria for levee penetrations in accordance with EM 1110-2-1913. Abandoned pipelines and conduits will be removed. Typical improvement plans for these utility encroachments were developed and shown in Plate G-3.

ROW Encroachments are the utilities and physical structures that are outside of the levee prism but fall within the limits of the proposed ROW (see Paragraph 2.9.3.2). These structures will be relocated outside of the proposed ROW prior to levee and seepage berm constructions.

Temporary bypass systems will be provided to minimize disruption to irrigation and other utility services during the farming season. The utility improvements and relocations will disrupt the storm drain systems; however, it is anticipated that the disruption will not cause any significant impacts to interior drainage of the basin since the levee construction is expected to be within normal construction season (April through October) during which the storm drain systems won’t be needed.

Tables 4-3 and 5-3 provide detailed descriptions of all utilities, encroachments and the proposed improvement for each site within the Alternatives SB-7 and SB-8, respectively.

2.9.3.4.2 Woody Vegetation on Levee

The FRWL currently has mature trees on the both the levee slopes and within 15 feet of both the landside and waterside levee toes, with the majority of the trees being within 15 feet of the toes in some locations. USACE Engineering Technical Letter (ETL) 1110-2-571 (Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures, 10 April 2009) establishes a vegetation-free zone to provide a reliable corridor of access to, and along, levees, floodwalls, embankment dams, and apparent structures, to assure adequate access by personnel and equipment for surveillance, inspection, maintenance, monitoring, and flood-fighting, and to prevent root penetration into the levee that could compromise its structural integrity. It is, therefore, required that the O&M corridors and levee embankment will be free of all woody vegetation in accordance with the Vegetation-Free Zone (VFZ) requirements in the ETL 1110-2-571.

The local sponsor, in their EIP, proposed allowing woody vegetation to temporarily remain within the EIP’s ROW and the adoption of a life cycle adaptive management approach to

address noncompliant vegetation removal overtime. The Sacramento District's PDT considered two options to address this issue. The first option was to require complete compliance with the ETL by removal of all woody vegetations within the VFZ. The second option was to require removal of all woody vegetation in the upper 2/3 of the waterside levee slope, the entire landside slope, within 15 feet of the landside toe and obtaining a vegetation variance for trees in the lower 1/3 of the waterside slope and within 15 feet of the waterside toe. The estimated cost differential of ETL 1110-2-571 compliance between the options appeared to be within the overall feasibility study cost contingency.

Because there is no significant cost differential, the first option, complete compliance with the ETL 1110-2-571, is the final recommendation (with exceptions to be considered on a case-by-case basis during the design phase).

2.9.3.5 Quantity Estimate

Quantity estimates were completed for levee construction and utility improvements in accordance with ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works and ER 1110-2-1302 Civil Works Cost Engineering.

The quantity estimates were completed on a reach by reach basis. The estimates for levee excavation and backfill took into account the swell and shrinkage factors, respectively, based on the geotechnical design recommendations (see Paragraph 2.8.4.5). The excavation quantities were estimated based on a degrade level placed at half of the levee height. The backfill quantities were estimated based on the recommended levee geometry (see Paragraph 2.9.3.1). Borrow quantities were estimated based on the total demand and the quantities of reusable levee degrade. A 20% increase was applied to the total demand, defined as the additional backfill quantities needed beyond the reusable levee degrade, to account for all material swell, loss and shrinkage during excavation, transportation and placement, respectively. The quantities of reusable levee degrade were estimated based on the recommended percentages of reusable material (see Paragraph 2.8.4.5). Cutoff wall quantities were estimated separately for each type of cutoff wall (soil bentonite cutoff wall, deep soil mix cutoff wall, and jet grouting cutoff wall).

2.10 Borrow Sites and Disposal Areas

2.10.1 General

This section describe general considerations for borrow and disposal areas for the Class 4 and Class 3 analyses. Refer to the Geotechnical and Civil Design Appendixes for further details.

2.10.2 Class 4 Analysis of Alternatives SB-2 through SB-8

Borrow sites and disposal areas were not specifically identified during the screening and selection of alternatives. For borrow, the general assumption was that suitable borrow materials could be typically found within the basin and that the borrow sites would be within 15-mile to 30-mile radius of the construction sites. It is assumed that borrow would likely become cost

prohibitive if not obtained within this distance, primarily due to air quality impacts. A conservative shrinkage factor of 15% was used for estimating borrow quantities.

2.10.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

Detailed analyses of borrow sites and disposal areas were completed for the final alternatives. The considerations are detailed below.

2.10.3.1 Borrow Sites

While some of the embankment material removed during levee degrading will be re-used to reconstruct the levee, it is anticipated that borrow materials will be needed to meet the levee fill material specifications. Two primary types of borrow material needed for levee and cutoff wall construction are: Type 1 levee fill, primarily used as a clay core for the reconstructed levee above the cutoff wall and for the soil-bentonite mix, and Type 2 levee fill, primarily used for shells for the reconstructed levee above the cutoff wall. Specifications for the two material types are discussed in Paragraph 2.8.4.5.

There were 13 sites identified as potential borrow areas, five of which were eliminated as a result of a preliminary screening process completed for each of the sites. The screening criteria, detailed in the EIS, include contamination level, and relative location to the levee/seepage berm. The design teams are currently in the process of sampling and testing the sites to ensure they meet material requirements. The borrow sites are shown on Plates 4-3 and 5-3 for Alternatives SB-7 and SB-8, respectively. Sampling and testing is ongoing for these potential borrow sites. It was estimated that the borrow sites can provide up to 1,349,900 cubic yards of Type 1 fill material, 459,800 cubic yards of Type 2 fill material, and 330,800 cubic yards of Random fill material materials.

Alternative SB-8 may require up to cubic yards of 629,850 Type 1fill material, 809,850 cubic yards of Type 2 fill material, and 179,550 cubic yards of Random fill material.

2.10.3.2 Solid Waste Disposal Areas

The nearest solid waste facilities to the project area are the Ostrom Landfill (located east of the project site, approximately 30 road miles south of the project Reach 2) and the Neal Road Landfill (located 25 miles north of the project Reach 40).

The 225 acre Class II Ostrum Landfill is permitted to accept the following types of waste: solid waste; waste water treatment sludge; construction debris; food and green waste; some types of contaminated soils; and non-friable asbestos. The landfill has a total maximum permitted capacity of 43,467,230 cubic yards. In 2007, the Ostrum Landfill was reported to have 39,223,000 cubic yards of remaining capacity (90% of total capacity).

The Neal Road Facility is permitted to accept the following types of waste: municipal solid waste, inert industrial waste, demolition materials, special wastes containing nonfriable

asbestos; and septage. The landfill has a total maximum permitted capacity of 25,271,900 cubic yards. In June 2011, the Neal Road Landfill was reported to have 20,396,081 cubic yards of remaining capacity (80% of total capacity).

Implementation of Alternative SB-8 may generate up to 813,000 cubic yards of solid waste that would require disposal. Sources of solid waste related to construction activities would include levee material, structural debris from removal of residences and agricultural structures, roadway pavements, and levee material deemed unsuitable for reuse.

2.11 Construction Access, Haul Routes and Staging Areas

2.11.1 General

This section describes general considerations for hauling and staging activities for the Class 4 and Class 3 analyses.

2.11.2 Class 4 Analysis of Alternatives SB-2 through SB-8

Haul routes and staging areas were not specifically identified during the screening and selection of alternatives. For cost estimating purposes, it was assumed that a typical 15-mile haul distance (30 miles round trip) would be sufficient for estimating hauling efforts from theconstruction sites to borrow sites and disposal areas. Refer to the Civil Design Appendix for further details.

2.11.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

A hauling and staging plan was developed for Alternatives SB-7 and SB-8 during the Final Analysis (Class 3). Plates 4-3 and 5-3 show the hauling and staging plans for the final two Alternatives SB-7 and SB-8. The plans were developed based on the following assumptions from historical/typical USACE cutoff wall construction projects:

- A 1.5-acre staging area is needed every 2,500 linear feet of levee construction.
- A 5-acre staging area is needed every 5 miles of levee construction to accommodate a job trailer and staff parking.
- The haul route will be mainly on existing public roads, from the center of the source (commercial/borrow source) to the center of the construction contract (see Plates 4-3 and 5-3).
- A 15 foot permanent road easement along the landside and water side edge of the project features (see Paragraph 2.8) is sufficient for movement of construction equipments within the construction site.
- The proposed staging areas are close to public roads for easy access and away from active farm lands, orchards and residential homes (where possible) to minimize impacts caused by construction activities.
- Permanent access to the existing levees will remain except where seepage berms are proposed. Access ramps will be constructed at the seepage berm locations to provide new maintenance access.

2.12 Real Estate Requirements

2.12.1 General

This section describes general real estate requirements determined during the Class 4 and Class 3 analyses. Additional details can be found in the Real Estate Appendix.

2.12.2 Class 4 Analysis of Alternatives SB-2 through SB-8

During the screening and selection of alternatives, the Sacramento District's Engineering Division delineated the project's footprint and identified properties impacted by the project (refer to the Civil Design Appendix for greater details). Based on this information, Real Estate Division completed the real estate cost estimate for the draft array of alternatives using the parametric approach in which the impacted properties were classified based on land use and each type of land use was given an empirical unit cost. The preliminary real estate requirements for the levee footprint, O&M corridor, and utility corridor were estimated as fee value only.

2.12.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

The real estate estimate for the Final Analysis (Class 3) of Alternatives SB-7 and SB-8 was developed based on the conventional approach for development of feasibility level design. During the Final Analysis, the Real Estate Plan was developed for Alternatives SB-7 and SB-8 in accordance with ER 405-1-12 and based on the footprints delineating project requirements developed by the Sacramento's Engineering Division. The general Land, Easements, Rights-of-way, Relocation and Disposal Areas (LERRD)'s requirements for the Real Estate Plan include: the acquisition of flood protection levee easement, permanent road easement, utility easement, drainage easement, temporary work area easement, borrow easement, and fee title. The basis for different types of acquisition is as follows:

- The flood protection levee easement is required for the construction and operation and maintenance of project features. The easement varies in width and is delineated by the toe of existing levee and seepage berms (within the project's limit), relocated levee segments and new seepage berms.
- A 15 foot permanent road easement along the landside and waterside edge of the flood protection levee easement, at a minimum, is needed for providing maintenance access to and for flood fighting purposes along the toe of the project features.
- Flood protection levee easement and permanent road easement together will be sufficient to cover the acquisition needed for the vegetation free zone and to allow for the movement of construction equipments within the construction site.
- Additional utility easement (approximately 20ft beyond the permanent road easement for O&M roads) may also be needed for obtaining utility corridors for relocation of utilities parallel to the project's alignment outside of the proposed ROW. This additional utility easement was not specifically identified for the SBFS and will be estimated as percentage of the total utility relocation costs.
- Drainage easement is required for the canal relocations.

- Temporary work area easement is required for acquiring staging areas along the 41 mile long alignment of the project.
- Borrow easement is required for potential borrow sites.
- Potential on-site mitigation areas will be acquired in fee title.

2.13 Environmental Considerations

2.13.1 General

This section describes environmental considerations for the draft and final arrays of alternatives. Refer to the main integrated report for further details.

2.13.2 Evaluation of the Existing Condition (Alternative SB-1)

An inventory and forecast of future without-project conditions was conducted for the study area using existing sources of information for the study area (e.g., county and city general plans, and prior NEPA and CEQA environmental documentation). The results are described in the Sutter Basin Feasibility Study Environmental Without-Project Conditions Report (ICF International, 2012). This report and the EIS/EIR prepared for the SBFCA EIP forms the basis for the "Affected Environment" and "No Action Alternative" sections of the Sutter Pilot Feasibility Study/EIS/EIR. (The SBFCA EIP was defined in Paragraph 1.3 of this report.)

2.13.3 Class 4 Analysis of Alternative SB-2 through SB-8

The screening of alternatives from an environmental standpoint focused on qualitatively assessing temporary and permanent impacts on the environment. The criteria include:

- Assessment of the potential for induced development in the floodplain.
- Minimization of land disturbance outside the existing levee footprint, loss of farmland, impacts to existing structures.
- Minimization and avoidance of adverse effects on air and water quality, sensitive habitat, and other resources.

Information from various data bases and existing reports was used in the evaluation. The primary sources were the Sutter Basin Feasibility Study Environmental Without-Project Conditions Report (ICF International, 2012) and the Environmental Constraints Analysis prepared for the SBFCA EIP (ICF International, August 2011). The results of public involvement, NEPA scoping, and coordination with the resource agencies were also used to assess alternatives.

2.13.4 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

For the Final Analysis (Class 3) of Alternatives SB-7 and SB-8, the study heavily relied on environmental surveys and the Draft EIS/EIR prepared for SBFCA EIP which was released for public review in December 2012. Extensive information developed for the SBFCA EIP's EIS/EIR aided the study in determining environmental impacts and developing mitigation cost estimates. The considerations are detailed below.

2.13.4.1 Significant Impacts

Alternatives SB-7 and SB-8 are anticipated to result in the following significant and unavoidable or potentially significant and unavoidable impacts. The main integrated report discusses these impacts in greater details.

1. **Air Quality Impacts**

Project construction would result in temporary construction-related emissions. These include:

- Exceedance of applicable thresholds for construction emissions

Emissions would be partially mitigated by reducing vehicle and equipment emissions and implementing a fugitive dust plan. Despite the mitigation measures, the temporary construction emissions are anticipated to be significant and unavoidable.

2. **Noise Impacts**

Implementation of any of the project alternatives would result in temporary but significant effects related to construction noise and vibration to sensitive receptors near construction areas. These might include:

- Exposure of Sensitive Receptors to Temporary Construction-Related Noise
- Exposure of Sensitive Receptors to Temporary Construction-Related Vibration

Noise-reducing mitigation measures and vibration-reducing construction practices may not be sufficient to reduce the exposure of sensitive receptors to temporary construction noise and vibration to less than significant.

3. **Vegetation Impacts**

Project construction is estimated to result in permanent impacts to riparian vegetation and wetlands. These might include:

- Disturbance or Removal of Riparian Trees
- Potential Loss of Special-Status Plant Populations Caused by Habitat Loss Resulting from Project Construction

Habitat compensation is proposed to mitigate losses with the goal of no net loss. Mitigation for significant habitat losses would take place at the Star Bend Conservation Area on about 28 acres. Mitigation needs not met at this site would occur at additional mitigation sites and/or mitigation banks. Mitigation for needs for Alternative SB-7 are estimated at 56 acres. Alternative SB-8 is estimated at 90 acres.

4. **Visual Resources**

Construction potentially could result in significant visual effects in reaches with sensitive viewers. These might include:

- Temporary Visual Effects from Construction.
- Adverse Affects to a Scenic Vista.
- Substantial degradation of the Existing Visual Character or Quality of the Site and its Surroundings.
- Creation of a New Source of Substantial Light or Glare that would Adversely Affect Day and Nighttime Public Views.

The effect mechanisms are primarily vegetation removal and replacement of agricultural and developed land use with seepage berms. Construction activities would also have temporary visual effects.

5. Cultural Resources

Cultural resources are known to exist throughout the planning area. Cultural resources could be disturbed and destroyed under any of the project alternatives. Impacts might include:

- Effects on Identified Archaeological Sites Resulting from Construction of Levee Improvements and Ancillary Features
- Potential to Disturb Unidentified Archaeological Sites
- Potential to Disturb Human Remains
- Direct and Indirect Effects on Identified Historic Architectural/Built Environment Resources Resulting from Construction Activities

While mitigation measures have been identified, the mitigation does not reduce effects to less than significant. The cultural site assessment (CSA) is discussed in greater detail in Paragraph 2.15 of this report.

6. Hazardous, Toxic and Radioactive Wastes (HTRW)

HTRW is discussed in detail in Paragraph 2.14 of this report.

2.13.4.2 Other Impacts

Other environmental impacts are expected due to construction of the proposed Alternatives SB-7 and SB-8. These include:

1. Flood Control and Geomorphic Conditions

Construction of any of the alternatives would be a flood control benefit in the planning area although existing drainage patterns could be altered. Effects on local interior drainage would be mitigated to less than significant by coordinating with owners and operators, preparing drainage studies, and remediating effects through project design.

2. Water Quality and Groundwater Resources

Dewatering of construction areas could result in the release of contaminants to surface or groundwater. This impact would be mitigated to less than significant by implementing provisions for dewatering effluent before it is discharged.

3. Geology, Soils, Seismicity and Mineral Resources

Construction activities associated with any of the alternatives would not result in any significant impacts to geology, soils, seismicity, and mineral resources.

4. Traffic, Transportation and Navigation

Temporary increases in construction-related traffic, temporary road closures, emergency response times, and other traffic, transportation and navigation effects from project implementation were determined to be less than significant under all action alternatives.

5. Climate Change and Greenhouse Gas

Construction activity would cause a temporary and less than significant increase in greenhouse gas emissions.

6. Wildlife

Construction activities could result in potential injury, mortality, or disturbance of special-status and common species, which could affect local populations. Implementation of mitigation measures would minimize or avoid these impacts and bring effects down to a less than a significant level.

7. Fish and Aquatic Resources

No in-water construction is proposed that could directly affect fishery resources. No loss of Shaded Riverine Aquatic cover and critical habitat would occur. Some loss of floodplain riparian vegetation would occur but mitigation is proposed to offset this loss. Thus, the project is not expected to significantly effect fish and aquatic resources.

8. Agriculture, Land Use and Socioeconomics

Project implementation would permanently convert farmland to nonagricultural use where construction extends beyond the existing levee footprint. Overall, the project is intended to preserve existing land use and socioeconomic conditions, especially for agriculture. Additionally, flood control activities are typically considered public uses, which are largely consistent with the land use policies and regulations governing the project area. Construction activities would temporarily increase employment and personal income in the local area.

9. Population, Housing and Environmental Justice

Project implementation of any of the alternatives will require displacement of existing housing units. Permanent acquisition, relocation, and compensation services will be conducted in compliance with Federal and State relocation laws. In cases where project construction is temporarily disruptive to nearby residents, assistance would be provided for residents to relocate temporarily during construction activities and provide compensation to residents for reasonable rent and living expenses incurred as a result of relocation.

The alternatives would not result in disproportionately high and adverse effects on minority populations and low-income populations from acquisition of homes because plenty of vacant homes exist within the affected area to serve as replacement housing.

10. Recreation

The alternatives would not have any permanent effects on recreation in the project area. Temporary access to recreational facilities along the Feather River would be an impact and addressed by providing notification of construction area closures to protect public safety.

11. Utilities and Public Services

Construction of the project may damage drainage and irrigation systems and public utility infrastructure, resulting in temporary disruptions to service. Coordination with drainage and irrigation systems users, consultation with service providers, and implementation of appropriate protection measures would minimize the possibility of any significant effects.

12. Public Health and Environmental Hazards

Project implementation has the potential to slightly increase risks to the public during construction through use of equipment and fuels, but the increased risk is temporary. These risks are minimized by implementation of a stormwater pollution prevention plan and the best management practices (BMPs) it contains to control accelerated erosion, sedimentation, and other pollutants during and after project construction.

2.13.4.3 Environmental Commitments

The following environmental commitments are proposed as part of the project to avoid and minimize construction-related effects.

- Avoidance measures for valley elderberry longhorn beetle.
- Avoidance measures for giant garter snake.
- Avoidance measures for Swainson’s hawk.
- Avoidance measures for raptors.
- Measures to minimize loss riparian vegetation.
- Invasive plant species prevention measures.
- Construction limitations near residences.

- Soil borrow site reclamation plan.
- Post-construction operations and maintenance.
- Stormwater pollution prevention plan.
- Bentonite slurry spill contingency plan spill prevention, control and counter-measure plan.
- Monitoring of turbidity in adjacent water bodies.

2.13.4.4 Fish and Wildlife Mitigation Facilities

The existing 49-acre Star Bend Conservation Area, located on the west levee of the Feather River, approximately 6 miles south of Yuba City, is proposed as a elderberry transplant site and riparian habitat compensation area for both Alternatives SB-7 and SB-8. In 2009, LD 1 of Sutter County proposed to construct the Feather River Setback Levee and Habitat Enhancement Project at Star Bend to replace a portion of existing levee that poses a high risk of failure in order to decrease the flood stage, velocity, and scour potential; increase and improve floodplain habitat; and improve habitat connectivity between the Abbot Lake and O'Connor Lakes Units of CDFW's Feather River Wildlife Area. The Star Bend project created approximately 55 acres of floodplain habitat, which included habitat enhancement and onsite mitigation for impacted elderberry and riparian habitat.

- Approximately 21 acres have been used to date for elderberry transplants and associated native plants. The remaining 28 acres are available at the conservation area for compensating for impacts on elderberry shrubs and riparian habitat from construction.

- Additional compensation needs will be addressed through purchase of credits from a mitigation bank.

- A mitigation and monitoring plan has been prepared and accompanies the integrated report.

2.14 Hazardous, Toxic and Radioactive Wastes (HTRW)

2.14.1 General

This section describes HTRW considerations during the Class 4 and Class 3 analyses for the project area.

2.14.2 Class 4 Analysis of Alternatives SB-1 through SB-8

The project area consists of urban, suburban, and rural areas. Potential sources of hazardous materials and waste may exist in the urbanized as well as agricultural areas adjacent to the levees. The following hazardous materials may be present in the project area in a variety of common contexts.

- Pesticides, herbicides, and fertilizers associated with agricultural lands.

- Petroleum hydrocarbons.
- Underground storage tanks.
- Contaminated debris including asbestos.
- Lead associated with paints and structures.
- Wastewater.
- Pits or ponds.
- Stormwater runoff structures.
- Transformers that may contain PCBs.

2.14.2.1 Preliminary Site Assessment

A Preliminary Environmental Site Assessment was conducted by USACE in June–July of 2009. The Preliminary Environmental Site Assessment was conducted to identify recognized environmental conditions, including presence or likely presence of any hazardous substance or petroleum products under conditions that indicate an existing release, a past release, or the material threat of a release into structures, the ground, groundwater, or surface waters of the property. As part of the assessment, a database record search was conducted to identify any known HTRW in the project area. Results of the Preliminary Environmental Site Assessment included:

- 51 registered underground storage tanks and 3 aboveground storage tanks.
- Five sources are listed as small and large generators of U.S. Environmental Protection Agency (EPA)-regulated hazardous waste.
- Five sites that had leaking underground storage tanks, two of which have or had affected public drinking water.
- Six known or potential hazardous substance sites under investigation or cleanup.
- Two waste discharge systems.
- Two landfills.
- 12 suspected drug labs.
- One pesticide-producing facility.

One additional site not included in the Preliminary Environmental Site Assessment was a SuperFund site (Onstott Dusters, Inc.). For the majority of the sources, no records were found to indicate that these potential sources have actually caused major contamination, although investigations are still on-going. Several areas of concern were revealed during the investigation. Most of these areas of concern involve registered underground storage tanks, hazardous waste generators, minor tank leaks, underground storage tank removal and remediation, and accidental releases.

During records research, no known contamination due to HTRW was confirmed within the construction zone. In conclusion, no evidence was found to indicate that any other potential sources of contamination would interfere with any planned construction of the levees. However, implementation of Alternatives SB-7 and SB-8 would potentially result in effects on public health and environmental hazards related to construction activity. These effects are judged to be insignificant when mitigated by various plans and measures to be implemented before construction including Stormwater Pollution and Prevention Plan, Phase I/Phase II

Environmental Site Assessment, Toxic Release Contingency Plan, Construction Site Safety Measures, and Emergency Response Plan.

2.14.2.2 Storm Water Pollution Prevention Plan (SWPPP)

Because ground disturbance for the project would be greater than 1 acre, coverage would be obtained under the EPA's National Pollutant Discharge Elimination System (NPDES) general construction activity stormwater permit. The Central Valley Regional Water Quality Control Board administers the NPDES storm water permit program in Sutter and Butte counties. Obtaining coverage under the NPDES general construction activity permit generally requires that the project applicant prepare a stormwater pollution prevention plan (SWPPP) that describes the best management practices that would be implemented to control accelerated erosion, sedimentation, and other pollutants during and after project construction. The SWPPP would be prepared prior to commencing earth-moving construction activities.

The specific best management practice that would be incorporated into the erosion and sediment control plan and SWPPP would be site-specific and would be prepared by the construction contractor in accordance with the Central Valley Regional Water Quality Control Board Field Manual. However, the plan likely would include one or more of the following standard erosion and sediment control best management practices.

- **Timing of construction**. The construction contractor would conduct all construction activities during the typical construction season to avoid ground disturbance during the rainy season.
- **Staging of construction equipment and materials**. To the extent possible, equipment and materials would be staged in areas that have already been disturbed.
- **Minimize soil and vegetation disturbance**. The construction contractor would minimize ground disturbance and the disturbance/destruction of existing vegetation. This would be accomplished in part through the establishment of designated equipment staging areas, ingress and egress corridors, and equipment exclusion zones prior to the commencement of any grading operations.
- **Stabilize grading spoils**. Grading spoils generated during construction would be temporarily stockpiled in staging areas. Silt fences, fiber rolls, or similar devices would be installed around the base of the temporary stockpiles to intercept runoff and sediment during storm events. If necessary, temporary stockpiles may be covered with an appropriate geotextile to increase protection from wind and water erosion.
- **Install sediment barriers**. The construction contractor may install silt fences, fiber rolls, or similar devices to prevent sediment-laden runoff from leaving the construction area.
- **Stormwater drain inlet protection**. The construction contractor may install silt fences, drop inlet sediment traps, sandbag barriers, and/or other similar devices.
- **Permanent site stabilization**. The construction contractor would install structural and vegetative methods to permanently stabilize all graded or otherwise disturbed areas once construction is complete. Structural methods may include the installation of biodegradable fiber rolls and erosion control blankets. Vegetative methods may involve the application of organic mulch and tackifier and/or the application of an erosion control seed mix. Implementation of a SWPPP would substantially minimize the potential for project-related erosion and associated adverse effects on water quality.

2.14.2.3 Discovery of Potential HTRW Sites During Construction

If any evidence of potential HTRW is found during construction, all work would cease, and USACE would be notified by the contractor for further evaluation of the potential contamination. Any unanticipated hazardous materials encountered during construction would be handled according to applicable Federal, State, and local regulations. USACE would require that a contingency plan that outlines steps to be taken before and during construction activities to document soil conditions, as well as procedures to be followed if unexpected conditions are encountered, be prepared by the contractor. The non-Federal sponsor is responsible for 100 percent of the cost to develop the clean-up procedures (remedial action plan) and to treat the contamination in place or relocate the material (ER 1110-2-1150).

2.14.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

The HTRW considerations from the screening and selection of alternatives apply to the Final Analysis (Class 3) of Alternatives of SB-7 and SB-8. A Phase I Environmental Site Assessment of HTRW for Alternative SB-7 or Alternative SB-8 would be complete in PED.

2.15 Cultural Impact Assessment

2.15.1 General

This section describes the CSA during the Class 4 and Class 3 analyses. Refer to the EIS for further details.

2.15.2 Class 4 Analysis of Alternatives SB-1 through SB-8

The cultural resources impacted by the proposed conceptual alternatives were not specifically identified during the screening and selection of alternatives. A statutory level set aside of 1% of the federal share of construction costs (set by the Archeological and Historical Preservation Act of 1974, Public Law 93-271) was applied and used as the cost estimate for the draft array of Alternatives SB-1 through SB-8.

2.15.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

The construction of Alternative SB-8 would result in impacts to the levee itself, the Sutter Butte Canal, historic buildings and neighborhoods in Yuba City, other built environment resources identified in the FRWLP EIS/EIR, and several known prehistoric archaeological sites (CA-SUT-5, CA-SUT-10, CA-SUT-20, CA-SUT-77, CA-BUT-52, CA-BUT-53, CA-BUT-496, CA-BUT-1123, and the unnamed site identified by UAIC). The geographically smaller Alternative SB-7 would result in similar impacts, but would avoid the known prehistoric sites in Butte County (CA-BUT-52, CA-BUT-53, CA-BUT-496, CA-BUT-1123).

Additional impacts may be identified as cultural resources inventories are completed, including the borrow areas and utility relocations. These could result in further costs that would be included in the cost estimate developed during PED.

In light of this analysis, USACE will continue to use the 1% of the federal share of construction costs set aside for data recovery of impacted cultural resources as a gross means of estimating cost. USACE would only cost-share the project up to the cost of Alternative SB-7, the Federal costs associated with both alternatives would be the same. Increased cultural resources costs associated with the larger Alternative SB-8 including data-recovery investigations, would be borne by the local sponsor.

2.16 Operation and Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)

2.16.1 General

This section describes the OMRR&R considerations during the Class 4 and Class 3 analyses.

2.16.2 Class 4 Analysis of Alternatives SB-2 through SB-8

OMRR&R related activities were not specifically identified during the screening and selection of alternatives. A brief investigation of OMRR&R costs was done by the local sponsor by soliciting information from various levee districts (LDs) and State maintenance agencies (MAs) within the Sutter Basin. The costs reflect a ratio of base costs to the summation of yearly OMRR&R budgets for the various LDs and MAs. For estimating purposes, the assumed 8.5% of construction cost for OMRR&R related activities for each of the alternatives were deemed to be reasonable.

2.16.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

The OMRR&R requirements, activities and costs were identified during the Final Analysis (Class 3) of Alternatives SB-7 and SB-8.

2.16.3.1 General Requirements

The non-Federal sponsors (CVFPB and SBFCA) will be responsible for all OMRR&R related activities upon transfer of the project which will in turn be delegated to the individual levee maintenance authorities. The OMRR&R costs represent average cost to maintain the project improvements throughout the project life. The OMRR&R for flood control features would be performed in accordance with provisions of Title 33, Flood Control Regulation, Maintenance and Operation of Flood Control Work, approved by Secretary of the Army , 9 August 1944, published 17 August 1944, Federal Register. The general intent of the regulations is expressed as follows: “The structures and facilities constructed by the United States for flood protection shall be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits.”

USACE’s resident engineer schedules and conducts joint acceptance inspections, monitors correction of deficiencies, schedules and monitors OMRR&R training, ensures that all as-built drawings are complete and accurate, and provides information/support for USACE to prepare and distribute property transfer documentation.

Prior to final acceptance of the project or an increment of the project, pre-final inspections will be conducted on an area-by-area basis or may be conducted on a functional basis. The purpose of these inspections is to ensure transfer of a complete, functional and maintainable project, constructed fully in accordance with contract specifications and drawings. Upon final acceptance of an area or the project, USACE will prepare and transfer an amended OMRR&R manual for the project features and the non-Federal sponsor will assume OMRR&R.

2.16.3.2 Typical OMRR&R Activities

Typical OMRR&R activities both with and without project are considered to be::

- Vegetation removal and control in compliance with Corps of Engineers ETL 1110-2-571, 10 April 2009.
- Rodent control and repair of rodent damage.
- Slope re-grading and reseeding.
- Repair of waterside erosion.
- Maintenance of relief wells and collection ditches.
- Maintenance and repair of flap gates to minimize internal drainage.
- Patrol road/ramp maintenance.
- Inspection/patrolling including participation in Federal and State inspection programs, routine patrolling to identify maintenance needs and to assure flood worthiness, and continuous patrolling during high water conditions.
- Flood fighting
- Closure of the gap in the levee crown for passage of the railroad during high water conditions to prevent flooding of Yuba City and vicinity.

Project implementation will likely result in increased cost /effort for some of these activities and decreased cost/effort for others. Net change in OMRR&R cost/effort is considered to be minimal.

A comparison of the estimated without project O&MRR&R and with project costs in 2012 dollars for the levees to be repaired under Alternatives SB-7 and SB-8 is shown in Table 2-3

Table 2-3 OMRR&R Cost Estimates

Alternative	W/O Project	With Project	Difference (Increase)
SB-7	$ 264,000	$ 277,000	$ 13,000
SB-8	$ 432,000	$ 454,000	$ 22,000

2.16.3.3 Vegetation

The without-project maintenance requirements for vegetation within the project area are not altered by the USACE ETL 1110-2-571. The requirements remain as identified in the Sacramento River Flood Control Project standard manual which states: “clearing of bushes, trees, and other wild growth from the levee crown and slopes. Bushes and small trees may be

retained on the waterside slope where desirable for the prevention of erosion and wave wash. Where practicable, measures shall be taken to retard bank erosion by the planting of willows or other suitable growths on areas riverward of the levees."

Under USACE policy, it is expected that any potential levee project will be required to fully comply with the USACE ETL 1110-2-571, unless a variance is obtained. The USACE ETL 1110-2-571 requires that no vegetation (with the exception of grasses) be allowed to grow within the Vegetation-Free Zone (VFZ), defined in Paragraph 2.9.3.4.2) to assure adequate access by personnel and equipment for surveillance, inspection, maintenance, monitoring, and flood-fighting, and to prevent root penetration into the levee that could compromise its structural integrity.

USACE guidance defines a variance as "alternative vegetation management standards to be applied to a levee system or portion thereof that provide for the same levee functionality as intended in ETL 1110–2–571" (Federal Register, February 17, 2012). Variances may only be granted to allow the preservation of waterside vegetation below the upper third of the waterside slope. Per the draft variance request procedure published in the Federal Register (February 17, 2012), no variance requests will be approved for noncompliant landside vegetation.

For the case of the Sutter Basin project, it is anticipated that the local sponsor will be seeking a vegetation variance. However, attempting to obtain a variance during the feasibility phase would require substantial time and cost and would be inconsistent with the USACE SMART planning modernization effort. Therefore, the issue of ETL variance will be addressed during the PED phase. Also during the PED phase, further consideration can be given to avoiding and minimizing the removal of vegetation that provides significant habitat for endangered species and other wildlife. Levee design modifications (overbuilding, etc) may be implemented to avoid the loss of trees that are determined regionally significant, such as heritage oak trees. Vegetation outside the construction footprint would be retained if it conforms to established USACE vegetation policy at the time of PED, during detailed design and preparation of construction plans and specifications. Vegetation removal requirements would be based on full compliance with vegetation management guidelines in ETL 1110-2-571, or another approach approved by USACE.

2.17 Cost Engineering

2.17.1 General

This section describes general considerations for the development of the cost estimates during the Class 4 and Class 3 analyses. Refer to the Cost Engineering Appendix for further details.

2.17.2 Class 4 Analysis of Alternatives SB-2 through SB-8

During the screening and selection of alternatives, the cost estimate for Alternatives SB-2 through SB-8 was developed using the parametric approach in which historical and unit costs

were employed. The Parametric Cost Estimating MII Toolbox (spreadsheet format) was used to prepare the cost estimate.

2.17.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

The cost estimate, prepared by the Sacramento District's Cost Engineering Section, for the final feasibility design of Alternatives SB-7 and SB-8 followed the conventional approach for developing cost estimates for feasibility level design (35%; Class 3). The cost estimate was prepared in accordance with ER 1110-2-1302 and ETL 1110-2-573 for Cost Estimating. The cost estimate was based on the quantity estimates provided by the Sacramento District's Engineering Division (see Paragraph 2.9.3.5 for quantity development). The construction contracts for each of Alternatives, SB-7 and SB-8, were sequenced based on the approximated funding availability and appropriation (see Tables 4-4 and 5-4).

2.18 Value Engineering

2.18.1 General

A combined Value Engineering (VE) Study and Planning Charette was held from 31 October to 4 November 2011. The VE methodology was incorporated into the planning process at an early stage of the study to compare, refine, and optimize alternatives based on multiple criteria. This process also provided an opportunity to validate the array of preliminary alternatives and to ensure that significant alternatives had not been overlooked. The VE Study/Charette was attended by the PDT and non-Federal sponsors, the SPK VE Officer and SPD VE Program Manager, the SPD Plan Formulation Lead, and representatives from the National Pilot Program 17+1 Team.

2.18.2 Methodology

The team reviewed initial alternative evaluation criteria and expanded these criteria based on inputs from the group.The following are the final criteria that were used to assess each alternative in combination with the conceptual level cost estimates for each alternative.

- Life Safety
- Flood Damage Benefits
- Critical Infrastructure Impacts
- Design Capacity Exceedance
- Wise Use of Floodplain
- Sustainability
- Ecosystem Functionality
- Environmental Impacts

Based on the discussions during the combined VE Study and Planning Charette, the team identified alternatives with very similar functions as well as alternatives with little probability of implementation. This resulted in combining and eliminating some of the alternatives as well as

refining and optimizing those that were retained by adding or removing measures in order to ensure a robust array. A draft array of potential alternatives was identified for further evaluation.

2.18.3 Results

Following is a summary of the recommendations for the draft array of 8 alternatives to be carried forward for further evaluation.

- Alternative SB-1 – No action alternative (i.e. existing condition)
- Alternative SB-2 – Minimal fix-in-place Feather River Levees, Sunset Weir to Star Bend
- Alternative SB-3 – Yuba City ring levee
- Alternative SB-4 – Little "J" levee, Thermalito Afterbay to South of Yuba City
- Alternative SB-5 – Fix-in –place Feather River Levees: Thermalito Afterbay to Star Bend
- Alternative SB-6 – Fix-in –place Feather River, Sutter Bypass, and Wadsworth Canal Levees

The VE Study and Planning Charette Report, which includes details on the relative ratings of each of the original alternatives and the evaluation process, is included in Appendix B of the Sutter Basin, CA Pilot Study, Progress Document#1 (30 May 2012).

Following the VE study, through additional plan formulation, two additional alternatives were added to the draft array (because the economic net benefit analysis determined that extending the fix-in-place reach further south increased the net benefits), these include:

- Alternative SB-7 – Fix-in-place Feather River Levees: Sunset Weir to Laurel Avenue
- Alternative SB-8 – Fix-in-place Feather River Levees: Thermalito Afterbay to Laurel Avenue

CHAPTER 3 – EXISTING CONDITION

3.1 General

The purpose of this chapter is to provide an overview of the existing levee system delineating the perimeter of the Sutter Basin. The discussion will focus on describing the existing features. Hydraulic and geotechnical analyses of the existing condition and performance of the levee system are discussed in Paragraphs 2.3 and 2.4 of this report. Refer to the Hydraulic and Geotechnical Appendixes for greater details.

3.2 Existing Sutter Basin Levee System

The existing Sutter Basin Levee System (SBLS) consists of four mainline levees which are Feather River West Levee (FRWL), Sutter Bypass East Levee (SBEL), Wadsworth Canal East Levee (WCEL) and Cherokee Canal East Levee (CCEL) surrounding the communities of

Yuba City, Live Oak, Gridley, Biggs and other smaller towns in Sutter and Butte Counties, California.

These Local Maintenance Authority (LMA) entities include Levee District (LD) 1 of Sutter County, LD 9 of Sutter County, and California Department of Water Resources Maintenance Areas (MA 3, 7, 13, 16, Wadsworth Canal, and Sutter Bypass). These entities maintain all levees within the study area. Plate 1-1 shows the existing SBLS and LMAs. The levee segments in the study area are as follows:

- Feather River West Levee – MA 3: Right levee (on the west bank) of the Feather River from Project Levee Mile (PLM) 0.00 at the Sutter Bypass confluence upstream to PLM 5.19 at the downstream boundary of the LD 1 segment.

- FRWL – LD 1: Right levee (on the west bank) of the Feather River from PLM 0.00 at the boundary of MA 3 upstream to PLM 16.65 at the downstream boundary of the LD 9 segment.

- FRWL – LD 9: Right levee (on the west bank) of the Feather River from PLM 0.00 at the LD 1 boundary upstream to PLM 6.24 at the downstream boundary of the MA16 segment

- FRWL – MA 16: Right levee (on the west bank) of the Feather River from PLM 0.00 at the LD 9 boundary upstream to PLM 4.09 at the downstream boundary of the MA 7 segment.

- FRWL – MA 7: Right levee (on the west bank) of the Feather River from PLM 0.00 at the MA 16 boundary upstream to PLM 12.07 at the downstream boundary of the Hamilton Bend segment.

- FRWL – Hamilton Bend Area: Right levee (on the west bank) of the Feather River from PLM 0.00 at the MA 7 boundary upstream to PLM 1.20 at the Thermalito Afterbay outlet channel.

- SBEL – Downstream of Wadsworth Canal: Left levee (on the east bank) of the Sutter Bypass from the confluence with the Wadsworth Canal at PLM 4.40 downstream boundary to PLM 22.11 at the confluence with the Feather River.

- SBEL –Upstream of Wadsworth Canal: Left Levee (on the east bank) of the Sutter Bypass from the confluence with the Wadsworth Canal at PLM 4.40 downstream boundary to PLM 0.00.

- WCEL: Left levee (on the south east bank) of the Wadsworth Canal from PLM 0.00 at the confluence with the Sutter Bypass upstream to PLM 4.66 at the East Interceptor Canal.

- WCEL: Right levee (on the north west bank) of the Wadsworth Canal from PLM 0.00 at the Sutter Bypass confluence upstream to PLM 4.66 at the West Interceptor Canal

- CCEL – MA 13: Left levee (on the south east bank) of the Cherokee Canal from PLM 9.90 at the Southern Pacific Railroad Bridge upstream to PLM 6.10 at the Western Canal crossing (this partial segment is not part of the ULE program).

The following Paragraphs provide more details for reach of these levee segments.

3.2.1 Feather River West Levee – MA3

The MA 3 levee segment extends north (upstream) along the right bank of the Feather River from PLM 0.00 at the Sutter Bypass left bank levee to PLM 5.19.

The levee crest elevation varies between 52 feet NAVD88 at the downstream end to 66 feet about half a mile downstream of the upstream end of the segment. The levee height varies between 18 and 26 feet, with an average height of 22 feet. The crest width varies between 20 and 30 feet. The waterside slope varies between 1.6H:1V and 2.5H:1V. The landside slope varies between 1.5H:1V and 3H:1V.

The levee soils consist mostly of alternating layers of silty sand and silt, with lesser amounts of lean clay and sandy clay. The foundation consists of a sandy clay/clay/sandy silt blanket 1 to 50 feet thick. In general, the blanket layer thickness decreases moving upstream along the segment. There is no hardpan within the blanket layer. The underlying pervious layer consists of sand, silty sand, and gravel.

After the 1997 flood, pervious toe drains with overlying stability berms were constructed by USACE between PLM 2.28 and 2.43 (Sacramento River Flood Control Project Phase II Levee Reconstruction, Site 11) and between PLM 3.46 and 3.83 (PL84-99 rehabilitation).

3.2.2 Feather River West Levee – LD 1

The LD 1 segment of the Feather River extends north (upstream) along the right bank of the Feather River from PLM 0.00 at the upstream end of the MA 3 segment to PLM 16.65 at the downstream end of the LD 9 segment. Yuba City is adjacent to the upstream 6 miles of this segment.

The crest elevation varies between 62 feet NAVD88 at the downstream end and 88 feet NAVD88 about 200 feet downstream of the upstream end of the segment. The levee height varies between 19 and 25 feet, with an average height of 22 feet. The crest width varies between 15 and 22 feet. The waterside slope varies between 2H:1V and 3.5H:1V. The landside slope varies between 1.8H:1V and 3.1H:1V. The waterside bench between the levee toe and the riverbank varies from about 30 to 4,500 feet wide.

The levee soils consist of sandy silt, sandy clay, and clay with occasional zones of silty sand downstream of Star Bend (PLM 0.00 to 5.7) and sand, silty sand, and clayey sand with some zones of sandy silt and sandy clay upstream of Star Bend. The foundation soils are highly

variable and consist of a clay, sandy clay and sandy silt blanket between 2 and 62 feet in thickness. Occasional, discontinuous zones of the blanket are cemented into hardpan. The blanket layer overlies a sand and gravel pervious layer that is up to 45 feet thick.

Relief wells were installed by USACE in 1955-1957. The City of Yuba City installed additional relief wells between the old relief wells in the southern portion of the relief well area in 1991. USACE installed new relief wells between the original relief wells in the northern portion of the relief well area in 2000. The Shanghai Bend setback levee with a 25-foot deep cutoff wall through the foundation was constructed by USACE after the 1997 flood under a PL84-99 action. A permanent stability berm was constructed by LD 1 after the 1986 flood (approximate PLM 14.00 to 15.5). After the 1997 flood USACE constructed a cutoff wall 40 to 55 feet deep between PLM 12.76 and 14.54. Riprap protection was installed near the Fifth Street Bridge in Yuba City (PLM 14.27 to 14.57) after the 1997 flood. USACE installed relief wells just north of Star Bend (PLM 4.56 to 5.42) after the 1997 flood. LD 1 constructed a setback levee with a 40 to 65-foot deep soil-bentonite cutoff wall through the foundation in 2008 at Star Bend (PLM 3.76 to 4.58). The without–project-condition assumes Star Bend setback levee was not constructed. At PLM 1.5, USACE constructed a stability berm under a PL84-99 rehabilitation action after the 1997 flood.

3.2.3 Feather River West Levee – LD 9

The LD 9 segment extends north (upstream) along the right bank of the Feather River from PLM 0.00 at the upstream end of the LD 1 segment to PLM 6.24 at the downstream end of the MA 16 segment.

The levee crest elevation varies between 83 feet NAVD88 at the downstream end and 91 feet NAVD88 near the upstream end of the segment. The levee height varies between 11 and 21 feet, with an average height of 19 feet. The crest width varies between 16 and 25 feet. The waterside slope varies between 1.9H:1V and 3H:1V. The landside slope varies between 1.4H:1V and 2.6H:1V. The SBMC (about 30 feet wide at the bottom and between 5 and 8 feet deep) is adjacent to the landside levee toe over a portion of this segment. Smaller, localized drainage ditches are at the landside levee toe in some areas where the SBMC is not adjacent to the toe. Width of the waterside bench between the levee toe and the riverbank varies between 5 and 3,800 feet.

The levee soils consist of silt, sandy silt, and sandy lean clay with occasional silty sand. The clay soils predominate at the downstream end of the segment and the silty and sandy soils predominate towards the upstream end of the segment. The foundation soils consist of a sandy clay/sandy silt blanket of variable thickness (average thickness 12 feet), sometimes cemented into a hardpan, overlying a sand/silty sand pervious layer. The pervious layer has some gravel lenses in the downstream half of the segment.

An active railroad embankment crosses the levee alignment at the LD1/LD 9 boundary. The railroad embankment is about 4 feet lower than the levee. This opening is sandbagged during flood events. Trench drains were placed at the landside levee toe between PLM 3.0 and 3.83 and between PLM 4.33 and 4.9 by LD 9 in 1992. The trenches were 4-5 feet deep and 2 feet

wide and consisted of a geotextile lining around drain rock, with a perforated PVC pipe near the bottom of the trench. USACE constructed a toe drain with a concrete V-ditch collector between PLM 2.43 and 2.59 in 1998.

3.2.4 Feather River West Levee – MA 16

The MA 16 segment extends north (upstream) along the right bank of the Feather River from PLM 0.00 at the upstream end of the LD 9 segment to PLM 4.09 at the downstream end of the MA 7 segment.

The levee crest elevation varies between 91 feet NAVD88 at the downstream end to 96 feet NAVD at the upstream end. The levee height varies between 7 and 14 feet, with an average height of 10 feet. The crest width varies between 15 and 25 feet. The waterside slope varies between 1.9H:1V and 3.2H:1V. The landside slope varies between 1.3H:1V and 3H:1V. The SBMC is adjacent to the landside levee toe over a portion of this segment. The waterside bench between the levee toe and the riverbank varies between 30 and 3,100 feet wide.

The levee soils consist mostly of sandy silt, with some zones of sandy clay. The foundation consists of a clay/sandy silt blanket, at some locations cemented into hardpan, between 0 and 50 feet thick (average thickness about 20 feet) overlying a pervious sand layer. The pervious layer contains gravel in the upstream half of the segment.

3.2.5 Feather River West Levee – MA 7

The MA 7 segment extends north (upstream) along the right bank of the Feather River from PLM 0.00 at the upstream end of the MA 16 segment to PLM 12.07 at the downstream end of the Hamilton Bend segment.

The levee crest elevation varies between 96 feet NAVD88 at the downstream end and 135 feet NAVD88 at the upstream end. The levee height varies between 5 and 22 feet, with an average height of 15 feet. The crest width varies between 15 and 25 feet. The waterside slope varies between 1.9H:1V and 3.2H:1V. The landside slope varies between 1.3H:1V and 3H:1V. The SBMC is adjacent to the landside levee toe over a portion of this segment. The waterside bench between the levee toe and the riverbank varies between 5 and 4,800 feet wide.

The levee soils consist mostly of sandy silt, with some zones of sandy clay and occasional lenses of sand. The foundation consists of a blanket of clay/sandy clay in the southern portion of the segment and silt/silty sand in the northern portion of the segment. Thickness of the blanket varies between 0 and greater than 80 feet; the average thickness is about 15 feet, and in general the thickness decreases moving upstream along the segment. The pervious layer consists of sand and gravel. The pervious layer is almost entirely gravel upstream of PLM 3.2. Dredge tailings, consisting primarily of cobbles and gravel, have been placed on the waterside bench over the upstream 4 miles of the segment.

USACE constructed a 50-foot deep cutoff wall between PLM 2.68 and 2.82 after the 1986 flood.

3.2.6 Feather River West Levee – Hamilton Bend Area

The Hamilton Bend segment extends north (upstream) along the right bank of the Feather River from PLM 0.00 at the upstream end of the MA 7 segment to PLM 1.20 at the Thermalito Afterbay outlet channel.

The levee crest elevation varies between 134 feet NAVD88 at the downstream end and 139 feet NAVD88 at the upstream end. The levee height varies between 3 and 24 feet, with an average height of 14 feet. The crest width is 15-20 feet upstream of the headgate structure and 60-70 feet downstream of the headgate structure. The waterside slope varies between 2H:1V and 2.5H:1V. The landside slope varies between 1.5H:1V and 3H:1V. The waterside bench between the levee toe and the riverbank varies between 50 and 1,100 feet wide.

The levee is constructed of clay upstream of the headgate structure and silty sand, gravel, and cobbles (dredge tailings) downstream of the headgate structure. There is a thin clay blanket underlying less than half of this levee segment. The pervious layer consists of silty sand, gravel, and cobbles (dredge tailings) about 80 feet thick. The downstream 0.8 miles of the segment was built through dredge tailings piles. The dredge tailings consist of silty sand, gravel, and cobbles and are higher than the levee crest elevation at some locations.

The SBMC crosses the levee alignment at PLM 1.05-1.06. A concrete headgate structure was built across the canal alignment. The headgate structure is 36 feet tall, 50 feet long, and 13.5 feet wide. The headgate structure was abandoned after construction of the upstream Oroville Dam in 1968. The SBMC headgate structure's crest elevation is lower than the crest elevation of the adjacent levee.

3.2.7 Sutter Bypass East Levee

3.2.7.1 Downstream of Wadsworth Canal

The Sutter Bypass levee extends from the confluence with the Wadsworth Canal left bank levee at PLM 4.4 to the south (downstream) along the left bank of the Sutter Bypass to the confluence with the Feather River right bank levee at PLM 22.12.

The levee crest elevation varies from 52 feet NAVD88 at the downstream end to 60 feet NAVD88 at the upstream end. The levee height varies between 14 and 22 feet with an average height of 19 feet. The crest width varies between 17 and 30 feet. The waterside slope varies between 3H:1V and 4H:1V and the landside slope varies between 2.7H:1V and 4H:1V.

The levee soils consist mostly of lean and fat clays with occasional lenses of silt, sand, and silty sand up to 4 feet thick. Subsurface soil conditions are variable over the Bypass alignment, due to the geomorphology of the levee alignment cutting across numerous historic small drainage channels at approximately 90 degree angles. The foundation consists of a clay blanket 10-60 feet thick, with the layer thickness generally lower towards the downstream end of the segment. A portion of the clay blanket is cemented at some locations, locally called

"hardpan". There are pockets of sand and silty sand within the clay blanket, varying between 4 and 20 feet thick. The top of some of these pockets is 6 feet below the top of the impervious blanket layer. A widespread sand, silty sand, and gravel layer is underneath the clay blanket.

There is a 1-foot high, 50-foot wide berm at the landside levee toe, with a drainage ditch located at the toe of the berm over most of this segment. In addition, in this area USACE has previously constructed:

- A 2-foot wide, 15-foot deep toe drain trench between PLM 5.4 and 13 (McClatchy Road to Gilsizer Slough) after the 1958 flood.
- A pervious toe drain and overlying stability berm between PLM 12.7 and 14.6 (Gilsizer Slough to Everglade Road) after the 1986 flood.
- A toe drain trench and berm between PLM 4.4 and 5.4 (Wadsworth Canal to McClatchy Road) after the 1997 flood.
- A 2-foot wide, 5-foot deep pervious toe trench with an overlying stability berm at PLM 17.6 in 2001.
- A pervious vertical drain in an abandoned railroad embankment on the landside of the levee between PLM 21.88 and 22.07 (Feather River confluence to 1,000 feet upstream) in 2001.

3.2.7.2 Upstream of Wadsworth Canal

This levee segment extends along the right bank of the Sutter Bypass from PLM 0.00 at high ground at the Sutter Buttes to the southeast (downstream) to the confluence of the right bank levee of the Wadsworth Canal at PLM 4.31.

The levee height varies between 15 feet at the upstream end and 23 feet at the downstream end. The crest width is 20 feet. The waterside slope varies between 3.5H:1V and 4H:1V and the landside slope varies between 2.5H:1V to 3H:1V.

There are no existing soil explorations on this levee segment

A project pump plant at PLM 2.7 pumps interior drainage water over the levee into the Bypass There is also a drainage canal on the landside of the levee. The canal is located 15 to 50 feet from the landside toe and is about 5 feet deep and 12 feet wide at the bottom. USACE constructed a pervious toe drain and overlying stability berm between PLM 3.7 to 4.3 after the 1997 flood.

3.2.8 Wadsworth Canal Levees

3.2.8.1 East (Left) Levee

The left levee of the Wadsworth Canal extends to the northeast (upstream) from PLM 0.00 at the confluence with the Sutter Bypass to PLM 4.66 at the East Interceptor Canal.

The levee crest elevation varies between 60 feet NAVD88 at the downstream end to 65 feet NAVD88 at the upstream end. The levee height varies between 6 feet at the upstream end and 26 feet at the downstream end. The crest width varies between 12 feet at the upstream end and 27 feet at the downstream end. The waterside slope varies between 3H:1V and 3.5H:1V. The landside slope varies between 2H:1V and 2.5H:1V. There is a relatively flat bench 10 to 35 feet wide between the waterside levee toe and the excavated canal sideslopes.

The levee soils consist of interbedded lean clay, fat clay, sand, and silty sand. Sand and silty sand are the dominant soils over the downstream 1.4 miles of the levee segment. Clay soils dominate in the upstream 3.3 miles of the levee. The levee is founded on Basin deposits, generally 4 to 9 feet thick, consisting mostly of lean and fat clay with occasional lenses of silt and sand. The Modesto Formation underlies the Basin deposits. The upper contact of the Modesto Formation is characterized by very stiff to hard clays, called “hardpan” locally. Below the hardpan, the Modesto Formation consists of silt, lean clay, and fat clay, with 1 to 9 foot thick layers of sand and silty sand.

USACE constructed a soil-cement-bentonite cutoff wall between PLM 0.00 and PLM 0.57 in 2008. The depth of the cutoff wall varied between 42 and 63 feet.

3.2.8.2 West (Right) Levee

This levee segment extends from PLM 0.00 at the confluence with the right bank levee of the Sutter Bypass to the northeast (upstream) along the right bank of the Wadsworth Canal to PLM 4.66 at the West Interceptor Canal.

The levee height varies between 20 feet at the downstream end to 5 feet at the upstream end. The crest width is 10-20 feet. The waterside slope varies between 3H:1V and 3.5H:1V. The landside slope varies between 2H:1V and 2.5H:1V.

There are no known soil explorations in this levee segment. Since the canal is fairly small (about 300 feet from levee crest centerline to levee crest centerline), it is anticipated that soil conditions along the west bank levee would be similar to the left bank levee of the Wadsworth Canal.

A small drainage canal is located at the landside levee toe over most of this segment.

3.2.9 Cherokee Canal East Levee – MA 13

The Cherokee Canal is located in the northwest portion of the project area. The Canal discharges water into the Butte Sink, a low-lying area between the Sacramento River and the Sutter Buttes. The entire canal is 23.1 miles long. The SBFS only includes the left bank levee from PLM 9.90 at the Southern Pacific Railroad bridge to the northeast (upstream) to PLM 6.10 at the Western Canal confluence.

The levee height is 6-10 feet and the crest width is 10-20 feet. The waterside slope varies between 3H:1V and 3.5H:1V and the landside slope varies between 2.5H:1V and 3H:1V.

The levee is constructed of lean and fat clay, silt, and elastic silt. The foundation soils consist of a silt and sandy silt blanket between 3 and 19 feet thick, overlying a pervious layer of silty sand, clayey sand, and clean sand. Where the pervious layer consists of clean sand, it generally contains silt lenses that are 2-4 feet thick.

An irrigation ditch is present at the landside toe.

CHAPTER 4 – ALTERNATIVE SB-7

4.1 General

Alternative SB-7 includes 21 reaches (2A-North to 21) along the FRWL alignment, beginning at station 180+00 (approximately 2,000 feet south of Laurel Avenue) and ending at station 1433+83 (Sunset Weir/Pumping Plant). The levee reaches are shown on Table 4-2 and Plates 2-2 (for Alternative SB-7).

The following Paragraphs describe the project features and measures proposed for this alternative. The proposed project features and measures for this alternative include:

- Soil-Bentonite Cutoff Walls
- Deep Soil Mix Cutoff Walls
- Jet Grouting Cutoff Walls
- Seepage Berms
- Levee Relocations
- Canal Relocations
- Embankment Reconstruction/Landside Toe Fill
- Seepage Interceptor System (Relief Wells, Drain Ditch and Pump Station)
- Erosion Protections
- Closure Structure
- Utility Improvements
- Utility Relocations
- Structural Relocations

These proposed features and measures will rehabilitate, replace, or tie in and function in junction with the existing system. The existing system (see Chapter 3) includes the following features:

- Existing Embankment
- Existing Cutoff Walls
- Existing Stability Berms
- Existing Seepage Interceptor System (Relief Wells, Drain Ditch and Pump Station)

- Existing Relief Wells
- Existing Closure Structures
- Existing Toe Drains

Table 4-1A and 4-1B and Plate 2-3 summarize different combinations of the existing and proposed features for Alternative SB8 along its alignment. See the Engineering Plan drawings for more details.

Table 4-1 Summary of Project Features for Alternative SB-7

	Feature Description	Quantity
Alternative SB7 Reach 2A-North to 21 180+00 to 1433+83 2017 - 2021	No Modification Required	16,230LF
	Cutoff Wall Only	84,700LF
	Jet Grouting Cutoff Wall Only	560LF
	Seepage Berm Only	350LF
	Cutoff Wall with Full Levee Degrade and Existing Relief Wells	5,300LF
	Cutoff Wall with Full Levee Degrade	N/A
	Cutoff Wall with Existing Relief Wells	5,930LF
	Cutoff Wall with New Relief Wells (22 Wells)	2,500LF
	Cutoff Wall with Seepage Berm	7,670LF
	Cutoff Wall with Levee Relocation	N/A
	Cutoff Wall with Sutter Butte Canal Relocation	370LF
	Cutoff Wall with Landside Toe Fill	1,870LF
	DSM Cutoff Wall (subpart of the Cutoff Wall Only area)	7,030LF
	Erosion Protection	5,760LF
	Utilities and Encroachments (Total)	269
	Utilities and Encroachments (To be modified)	123
	Land Acquisition	2,110AC
	Impacted parcels	292
	Potential structural demolitions	27
	Closure Structures (stop logs)	1

4.2 Feature Description

This section provides general descriptions for each of the combinations listed in Table 4-1. Refer to Table 4-2 and Plates G-1 and G-2 for levee improvements. Refer to Table 4-3 and Plate G-3 for utility improvements.

4.2.1 No Modification Required

There are 4 levee sections along the FRWL alignment in SB-7 where modification is not required. These sections are between: (1) 831+50 and 844+50, (2) 923+75 and 1006+24, (3) 1007+70 and 1024+00, and (4) 1027+50 and 1078+00, approximately (see Table 4-2 for more details). Existing cutoff walls (30 to 50 feet in depth) are present within the first four levee sections.

4.2.2 Cutoff Wall Only

There are 7 levee sections along the FRWL alignment in SB7 where cutoff wall is the only modification feature required. These sections are between: (1) 231+00 and 453+00, (2) 478+68 and 512+00, (3) 570+00 and 831+50, (4) 1078+00 and 1096+00, (5) 1098+10 and 1107+00, (6) 1125+70 and 1129+99, and (7) 1130+20 and 1429+00, approximately (see Table 4-2 for more details).

4.2.3 Jet Grouting Cutoff Wall Only

There are 3 levee sections along the FRWL alignment in Alternative SB-7 where jet grouting cutoff wall is the only modification feature required. These levee sections are between: (1) 1006+04 and 1007+90, (2) 1095+80 and 1098+30, and (3) 1129+50 and 1130+67, approximately (see Table 4-2 for more details).

4.2.4 Seepage Berm Only

There is 1 levee section along the FRWL alignment in Alternative SB-7 where seepage berm is the only modification feature required. These levee sections are between: (1) 1024+00 and 1027+50, approximately (see Table 4-2 for more details).

4.2.5 Cutoff Wall with Full Levee Degrade and Relief Wells

The levee section between 844+50 and 897+50 along the FRWL alignment will be fully degraded and reconstructed with a cutoff wall along the levee centerline. The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 52 relief wells, drain ditch and pump stations).

4.2.6 Cutoff Wall with Relief Wells

A cutoff wall is required for the area between station 512+00 and station 570+00. The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 24 relief wells, A drainage ditch, and pump stations) between station 512+00 and station 545+00. New seepage collector system (including 22 relief wells and a 2,500-foot long concrete lined V-ditch) will be installed between station 545+00 and station 570+00 at 120-foot interval. The new seepage interceptor system will be tied in with the existing one at station 545+00.

A cutoff wall is also required for the area between station 897+50 and station 923+75. The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 24 relief wells, drain ditch and pump stations).

4.2.7 Cutoff Wall with Seepage Berm

There are 2 levee sections where both a cutoff wall and a seepage berm are required. These levee sections are approximately between: (1) 180+00 and 231+00, and (2) 453+00 and 478+68 (see Table 4-2 for more details).

4.2.8 Cutoff Wall with Levee Relocation

None of the levee sections within the limit of Alternative SB-7 requires levee relocation.

4.2.9 Cutoff Wall with Canal Relocation

The SBMC will be relocated away from the existing levee toe between 1429+00 and 1432+70. The existing canal section will be backfilled. A cutoff wall is required at this location and will be constructed along the levee centerline.

4.2.10 Cutoff Wall with Landside Toe Fill

Cutoff wall is required for the area between 1107+00 and 1125+70. The landside toe depression in this area will be filled.

4.2.11 Soil- Bentonite versus Deep Soil Mix (DSM) Cutoff Wall

The proposed cutoff walls vary in depth along the project alignment. At locations where a cutoff wall is required (except for the jet grouting sites), the cutoff wall will be: soil bentonite cutoff wall (if the wall is less than 75 feet in depth) or DSM cutoff wall (if the wall is greater than 75 feet in depth). There are 4 levee sections along the FRWL alignment where DSM cutoff walls are required. These sections are between: (1) 230+00 and 250+00, (2) 1125+00 and 1129+99, (3) 1130+20 and 1151+50, and (4) 1224+00 and 1248+00, approximately (see Table 4-2 for more details). The wall's depth at these locations varies between 75 and 120 feet. Between 844+50 and 897+50, an 85-foot deep soil bentonite cutoff wall is considered adequate for this area.

4.2.12 Erosion Protection

An anchored HPTRM is required on the landside slope for the initial overtopping section located in reach 7 between 547+00 and 604+60 in order to increase the sections resiliency and enhance flood warning and evacuation time prior to overtopping failure from events that exceed the design event.

4.2.13 Closure Structure

Stop log closure structure or equivalent is required at station 1130+00, where the UPRR crosses the FRWL alignment.

4.2.14 Modification of Existing Utilities and Encroachments

Table 4-4B summarizes the number of utilities and encroachments to be modified by construction of Alternative SB-7. A total of 123 utility/encroachment items will be removed, modified (to meet the USACE standard for levee penetrations) or relocated outside of the proposed ROW. Refer to Table 4-3 for more detailed descriptions.

4.3 Environmental Mitigation Measures

For direct effects on woody riparian trees that cannot be avoided, compensation will be provided for the loss of riparian habitat to ensure no net loss of habitat functions and values. Compensation ratios will be based on site-specific information and determined through coordination with the appropriate State and Federal agencies during the permitting process. Compensation will be provided based on the ratio determined (e.g., 2:1 = 2 acres restored/created/enhanced or credits purchased for every 1 acre removed). Compensation may be a combination of offsite restoration or mitigation credits.

For elderberry shrubs and riparian habitat, 35 acres of mitigation acreage are available at Star Bend. For Alternative SB-7 an estimated 56 acres would be required. Acreage in excess of the 35 acres will require additional mitigation sites and/or mitigation banks.

For elderberry shrubs and riparian habitat, USACE will develop a restoration and monitoring plan that describes how this habitat will be enhanced or recreated and monitored over a minimum period of time, as determined by the appropriate State and Federal agencies.

The revegetation plan will be prepared by a qualified restoration ecologist and reviewed by the appropriate agencies. The revegetation plan will specify the planting stock appropriate for each riparian land cover type and each mitigation site, ensuring the use of genetic stock from the project area. The plan will employ the most successful techniques available at the time of planting. Success criteria will be established as part of the plan and will include a minimum of 80% revegetation success at the end of 5 years, 70% revegetation success after 3 year, and 75% vegetative coverage after 5 years. USACE will monitor and maintain the plantings as necessary for 3 years, including weed removal, irrigation, and plant protection. SBFCA will then assume monitoring and maintenance responsibilities after year 3 and submit annual monitoring reports of survival to the regulatory agencies issuing permits related to habitat effects, including DFG, USACE, National Marine Fisheries Service, and USFWS. Replanting will be necessary if success criteria are not met, and replacement plants subsequently will be monitored and maintained to meet the success criteria. The riparian habitat mitigation will be considered successful when the sapling trees established meet the success criteria, the habitat no longer requires active management, and vegetation is arranged in groups that, when mature, replicate the area, natural structure, and species composition of similar riparian habitats in the region.

4.4 Cultural Mitigation Measures

USACE negotiated a programmatic agreement (PA) with the California State Historic Preservation Officer (SHPO) that outlines the specific processes that USACE will follow to identify and treat cultural resources. The PA took effect after it was signed by USACE and the

SHPO on June 8, 2012, and was subsequently transmitted to the Advisory Council on Historic Preservation.

Following the terms of the PA, before construction begins, the following will occur:

- USACE and the SHPO would formally agree upon a final area of potential effect (APE) for the project. The APE comprises the entirety of the area where cultural resources could potentially be affected by the project.
- USACE, in consultation with the SHPO, would fully inventory the APE for cultural resources. This inventory would include both the pedestrian survey efforts conducted to date by ICF, as well as subsurface prospection efforts.
- In consultation with the SHPO, USACE would evaluate all cultural resources in the APE for their eligibility for listing in the National Register of Historic Places (NRHP). Work necessary for these evaluations may include detailed recordation, background research, and test excavation.
- USACE; in consultation with the SHPO, the public, interested Native American Tribes, or other identified stakeholders; would provide adequate mitigation to resolve any adverse effects to NRHP eligible cultural resources (historic properties).

Alternative SB-7 is a subset of Alternative SB-8 and would impact fewer cultural resources. Based on available information, it is possible to anticipate that construction of Alternative SB-7 could affect known cultural resources including the levee, the historic buildings and neighborhoods in Yuba City, other built environment resources identified in the FRWLP 408 EIS/EIR, and several prehistoric archaeological sites (CA-SUT-5, CA-SUT-10, CA-SUT-20, CA-SUT-77, and the unnamed site identified by UAIC). USACE would follow the processes outlined in the PA to resolve adverse effects to these resources.

Proposed borrow areas have not yet been surveyed. The records and literature search indicates that one of the proposed borrow locations at Star Bend would impact a fourth prehistoric archaeological site, CA-BUT-17. Inventories of the remaining borrow sites, and other sites that may be defined in the future, could result in the identification of more impacts.

Any unknown cultural resources found in the course of further inventory work would be evaluated for NR eligibility, and effects to those resources would be resolved as necessary, following the processes outlined in the PA.

4.5 Borrow, Borrow Sites and Disposal Areas

Type 1, Type 2 and Random fill materials are needed for levee, cutoff wall and seepage berm constructions. Type 1 levee fill material will be used primarily as a clay core for the reconstructed levee above the cutoff wall and for the cutoff wall's soil-bentonite mix. Type 2 levee fill material will be used primarily for shells for the reconstructed levee above the cutoff wall. Random fill is used primarily for seepage berms.

Excavated materials from levee degrade are expected to be reusable for Type 1 and Type 2 fills. Type 1 fill can be used as Type 2 and Random Fill. Type 2 fill can be used as Random fill. It is expected that borrow materials will be needed for construction of the project.

The two primary types of borrow material for the levee and cutoff wall constructions are: Type 1 and Type 2. Specifications for the two material types are as follows:

- Type 1 Levee Fill: USCS classification of CL, SC, or CH; maximum particle size of 2 inches; minimum 35% by weight passing the #200 sieve; maximum liquid limit of 60; plasticity index between 12 and 40.

- Type 2 Levee Fill: Maximum particle size of 2 inches; minimum 12% by weight passing the #200 sieve; maximum liquid limit of 45.

The borrow areas are sites 5, 7, 8 and 12 shown in Plate 4-3. The source for borrow is discussed in Paragraph 2.10.3.1. A material balance analysis was completed for borrow quantities based on the preliminary information and the results are shown cubic yards (cy) in Tables 4-5 and 4-6.

Table 4-5 Borrow Sites and Usage for SB-7	**Volume of Material (Potential)**		
Borrow Sites and Usage	Type 1 (cy)	Type 2 (cy)	Random (cy)
2 - CDFG (OWA - Cobble Borrow)			330,800
3 - Live Oak Detention Basin	150,000		
4 - Lanza 235 Borrow	250,000		
5 - Nevis Property	250,000		
Left over after borrow for C2 - as type 1	197,900		
Left over after borrow for C2 - as type 2	184,400		
Left over after using borrow for C1 - as type 1	66,445		
Left over after using borrow for C1 - as type 2	53,102		
7 - Lanza 620 Acres Property	119,932	359,796	
Left over after using borrow for A - as type 1	948	19,986	
Left over after using borrow for A - as type 2			
8 - Huston Property	330,000		
Left over after using borrow for B - as type 1	199,279		
Left over after using borrow for B - as type 2	33,687		
11 - Silver Live Oak Property	250,000		
12 - Silver Yuba City Property		100,000	
Left over after borrow for SBFIP - as type 2		53,200	
Total Potential	1,349,932	459,796	330,800

Table 4-6 Borrow Demand for SB-7	**Volume of Material (Demand)**		
Borrow Sites and Usage	Type 1 (cy)	Type 2 (cy)	Random (cy)
CONTRACT A	118,984	339,810	
7 - Lanza 620 Acres Property	118,984	339,810	
CONTRACT STAR BEND (SBFIP)		46,800	

12 - Silver Yuba City Property		46,800	
CONTRACT B	130,721	165,592	
8 - Huston Property	130,721	165,592	
CONTRACT C1	117,955	13,343	
5 - Nevis Property	117,955	13,343	
CONTRACT C2	52,100	13,500	
5 - Nevis Property	52,100	13,500	
Total Demand	419,760	579,045	0

Implementation of Alternative SB-7/SB-8 may generate up to 813,000 cubic yards of solid waste that would require disposal. Sources of solid waste related to construction activities would include levee material, structural debris from removal of residences and agricultural structures, roadway pavements, and levee material deemed unsuitable for reuse.

The nearest solid waste facilities to the project area are the Ostrom Landfill (located east of the project site, approximately 30 road miles from the southern end of the project at Reach 2) and the Neal Road Landfill (located 25 miles north of the project Reach 40).

Assuming all of the estimated 813,000 cubic yards of waste material would require permanent disposal, Alternative SB7/SB8 implementation would represent 2% of the Ostrom Road Landfill and 4% of the Neal Road Landfill remaining capacities. However, the option of beneficial reuse is likely to reduce the cubic yards of soil that require permanent disposal.

4.6 Construction Access, Haul Routes and Staging Areas

Haul route will be mainly on existing public roads (see Plate 4-3).

4.7 Real Estate Requirements

A total of 27 physical structures fall within the proposed ROW and, therefore, will be demolished for construction of this alternative. All of these structures are within reach 16 (Yuba City).

Approximately 2,110 acres will be acquired and 292 parcels will be impacted (refer to the Real Estate Appendix for more details).

4.8 Operation and Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)

4.8.1 Flood Damage Reduction Features

OMRR&R activities for flood control works are generally the same with and without the project. However the cost and effort associated with each activity may increase or decrease as a result of the project. These increases or decreases are considered to be roughly offsetting and net

change in overall OMRR&R effort is judged to be insignificant. Expected impacts of the project on these activities are as follows:

1. Construction activities including reconstruction of the upper half of the levee, regarding of side slopes vegetation removal, rodent disruption and crown road reestablishment will reduce maintenance costs in the short term.

2. Vegetation removal/control. For the purpose of this feasibility study it is assumed that, absent the project, the State will gradually bring levees into compliance with USACE ETL 1110-2-571 using a life cycle approach to vegetation management. Under this assumption, the immediate compliance with the ETL required by the project will result in an interim increase in cost and effort required for vegetation removal and control which will be offset initially by clearing during construction. Net increase in OMRR&R cost is anticipated.

3. Rodent control/damage repair. Increase in embankment volume resulting from the addition of seepage and stability berms could result in a slight increase in rodent related maintenance activity.

4. Slope maintenance. Reduction in OMRR&R will occur due to reduction in seepage. The VFZ required by USACE ETL 1110-2-571 the project area will reduce the need for periodic levee toe regrading previously caused by farming operations.

5. Repair of waterside erosion. No additions or significant changes to erosion are anticipated.

6. Maintenance of relief wells and collection ditches. Relief wells north of Shanghai Bend will be converted to observation wells due to slurry wall taking over seepage control function. These actions result in a net reduction in OMRR&R effort.

7. Maintenance and repair of flap gates and closure structures to minimize internal drainage. A stop log closure structure for the railroad crossing at SBFCA station 1130+47, reach 17 is a project feature added to prevent over topping at this location. This accomplished without the project by sandbagging. The stop log structure will significantly reduce the effort to close this gap. However, it remains a flood control feature that requires human intervention to implement. This structure must remain functional to prevent flooding of Yuba City and vicinity.

8. Encroachments. Wet penetration encroachments will be improved or eliminated all along the length of the project. Dry encroachments, such as power poles and vegetation will be reduced. Result will be a decrease in OMRR&R costs.

9. Road/ramp maintenance. The addition of an O&M road at the toe of the levee for the entire length of the levee in addition to the existing road on the levee crown will essentially double the cost and effort associated with road maintenance. However, the added road will enhance the efficacy of virtually all OMRR&R activities including inspections, patrolling and flood fighting.

10. Inspection/patrolling including participation in Federal and State inspection programs, routine patrolling to identify maintenance needs and to assure flood worthiness, and continuous patrolling during high water conditions. The added landside O&M toe road will significantly enhance inspection and patrolling activities.

11. Flood fighting. The project flood control features (seepage berms, stability berms, and cutoff walls) are intended to eliminate seepage and stability issues during high water. The added O&M road at the landside levee toe should dramatically improve identification of any issues that may develop during high water and facilitate their rapid repair.

4.8.2 Mitigation Features

For Alternative SB-7 an estimated 56 acres are designated for mitigation of habitat loss due to project construction. An estimated 35 acres are available at the Star Bend mitigation site. Additional mitigation needs will be accomplished with additional mitigation sites and/or mitigation bank credits. USACE will enter into a contract to preserve the plantings for a term of three years following completion of construction. At the end of this term the areas will be turned over to the local sponsor who will maintain the areas to accomplish predetermined levels of re-vegetation success targeted for 5 years from planting.

4.8.3 Estimated Annual OMRR&R Cost

The estimated cost of OMRR&R for Alternative SB-7 in 2012 dollars is $ 277,000 as compared to $ 264,000 for the same levee reaches without the project.

4.9 Cost Estimate and Construction Schedule

The project is divided into 5 construction contracts: A, B, C1, C2 and Star Bend Fix-in-place (SBFIP). Table 4-4 summarizes the extent, year of construction and project features for each of the construction contracts. For more information on construction contracts and their sequencing, refer to the Cost Engineering Appendix.

CHAPTER 5 – ALTERNATIVE SB-8

5.1 General

Alternative SB-8 includes 41 reaches (2A-North to 41) along the FRWL alignment, beginning at station 180+00 (approximately 2,000 feet south of Laurel Avenue) and ending at station 2368+00 (Thermalito Afterbay). The levee reaches are shown on Table 5-2 and Plate 2-2 (for Alternative SB-8).

The following Paragraphs describe the project features and measures proposed for this alternative. The proposed project features and measures for this alternative include:

- Soil-Bentonite Cutoff Walls
- Deep Soil Mix Cutoff Walls

- Jet Grouting Cutoff Walls
- Seepage Berms
- Levee Relocations
- Canal Relocations
- Embankment Reconstruction/Landside Toe Fill
- Seepage Interceptor System (Relief Wells, Drain Ditch and Pump Station)
- Erosion Protections
- Closure Structure
- Utility Improvements
- Utility Relocations
- Structural Relocations

These proposed features and measures will rehabilitate, replace, or tie in and function in junction with the existing system. The existing system (see chapter 3) includes the following features:

- Existing Embankment
- Existing Cutoff Walls
- Existing Stability Berms
- Existing Seepage Interceptor System (Relief Wells, Drain Ditch and Pump Station)
- Existing Relief Wells
- Existing Closure Structures
- Existing Toe Drains

Table 5-1A and 5-1B and Plate 2-3 summarize different combinations of the existing and proposed features for Alternative SB-8 along its alignment. See the engineering plan drawings for more details.

Table 5-1A Summary of Project Features for SB8

	Feature Description	Quantity
Alternative SB8 Reach 2A-North to 41 180+00 to 2688+00 2017 - 2023	No Modification Required	28,220LF
	Cutoff Wall Only	147,570LF
	Jet Grouting Cutoff Wall Only	960LF
	Seepage Berm Only	5,350LF
	Cutoff Wall with Full Levee Degrade and Existing Relief Wells	5,300LF
	Cutoff Wall with Full Levee Degrade	600LF
	Cutoff Wall with Existing Relief Wells	5,930LF
	Cutoff Wall with New Relief Wells (22 Wells)	2,500LF
	Cutoff Wall with Seepage Berm	7,670LF
	Cutoff Wall with Levee Relocation	11,610LF
	Cutoff Wall with Sutter Butte Canal Relocation	1,540LF
	Cutoff Wall with Landside Toe Fill	1,870LF
	DSM Cutoff Wall (subpart of the Cutoff Wall Only area)	19,790LF
	Erosion Protection	7,660LF
	Utilities and Encroachments (Total)	451

	Utilities and Encroachments (To be modified)	223
	Land Acquisition	2,196AC
	Impacted Parcel	468
	Potential Structural Demolition	34
	Closure structures (stop logs)	1

5.2 Feature Descriptions

This section provides general descriptions for each of the combinations listed in Table 5-1. Refer to Table 5-2 and Plates G-1 and G-2 for levee improvements. Refer to Table 5-3 and Plate G-3 for utility improvements.

5.2.1 No Modification Required

There are 7 levee sections along the FRWL alignment where modification is not required. These sections are between: (1) 831+50 and 844+50, (2) 923+75 and 1006+24, (3) 1007+70 and 1024+00, (4) 1027+50 and 1078+00, (5) 1625+00 and 1673+00, (6) 1769+40 and 1813+30, and (7) 2303+00 and 2331+00, approximately (see Table 5-2 for more details). Existing cutoff walls (30 to 50 feet in depth) are present within the first four levee sections.

5.2.2 Cutoff Wall Only

There are 14 levee sections along the FRWL alignment where cutoff wall is the only modification feature required. These sections are between: (1) 231+00 and 453+00, (2) 478+68 and 512+00, (3) 570+00 and 831+50, (4) 1078+00 and 1096+00, (5) 1098+10 and 1107+00, (6) 1125+70 and 1129+99, (7) 1130+20 and 1429+00, (8) 1451+50 and 1455+00, (9) 1461+00 and 1608+50, (10) 1624+70 and 1625+00, (11) 1673+00 and 1673+30, (12) 1766+00 and 1769+40, (13) 1813+30 and 1900+50, and (14) 1903+50 and 2290+00, approximately (see Table 5-2 for more details).

5.2.3 Jet Grouting Cutoff Wall Only

There are 4 levee sections along the FRWL alignment where jet grouting cutoff wall is the only modification feature required. These levee sections are between: (1) 1006+04 and 1007+90, (2) 1095+80 and 1098+30, (3) 1129+50 and 1130+67, and (4) 1900+00 and 1904+00 approximately (see Table 5-2 for more details).

5.2.4 Seepage Berm Only

There are 3 levee sections along the FRWL alignment where seepage berm is the only modification feature required. These levee sections are between: (1) 1024+00 and 1027+50, (2) 2290+00 and 2303+00, and (3) 2331+00 and 2368+00, approximately (see Table 5-2 for more details).

5.2.5 Cutoff Wall with Full Levee Degrade and Relief Wells

There are 2 levee sections along the FRWL alignment where the levee will be fully degraded and reconstructed with a cutoff wall along the levee centerline These levee sections area between: (1) 844+50 and 897+50, and (2) 1455+00 and 1461+00.

The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 52 relief wells, a drainage ditch and pump stations) between station 844+50 and station 897+50.

5.2.6 Cutoff Wall with Relief Wells

Cutoff wall is required for the area between station 512+00 and station 570+00. The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 24 relief wells, a drainage ditch and pump stations) between station 512+00 and station 545+00. A new seepage collector system (including 22 relief wells and a 2,500-foot long concrete lined V-ditch) will be installed between station 545+00 and station 570+00 at 120-foot interval. The new seepage interceptor system will be tied in with the existing one at station 545+00.

A cutoff wall is also required for the area between station 897+50 and station 923+75. The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 24 relief wells, drain ditch and pump stations).

5.2.7 Cutoff Wall with Seepage Berm

There are 2 levee sections where both a cutoff wall and a seepage berm are required. These levee sections are between: (1) 180+00 and 231+00, and (2) 453+00 and 478+68, approximately (see Table 5-2 for more details).

5.2.8 Cutoff Wall with Levee Relocation

The existing levee will be relocated 20 feet toward the river at three locations, between: (1) 1432+70 and 1451+50, (2) 1608+50 and 1624+70, and (3) 1673+30 and 1754+30. A cutoff wall is required at these locations and will be constructed along the relocated levee alignment.

5.2.9 Cutoff Wall with Canal Relocation

The SBMC will be relocated away from the existing levee toe at two locations: (1) between 1429+00 and 1432+70, and (2) between 1754+30 and 1766+00. The existing canal sections will be backfilled. A cutoff wall is required at these locations and will be constructed along the levee centerline.

5.2.10 Cutoff Wall with Landside Toe Fill

A cutoff wall is required for the area between 1107+00 and 1125+70. The landside toe depression in this area will be filled.

5.2.11 Soil- Bentonite versus Deep Soil Mix (DSM) Cutoff Wall

The proposed cutoff walls vary in depth along the project alignment. At locations where a cutoff wall is the required (except for the jet grouting sites), the cutoff wall will be: soil bentonite cutoff wall (if the wall is less than 75 feet in depth) or DSM cutoff wall (if the wall is greater than 75 feet in depth). There are 10 levee sections along the FRWL alignment where DSM cutoff walls are required. These sections are between: (1) 230+00 and 250+00, (2) 1125+00 and 1129+99, (3) 1130+20 and 1151+50, (4) 1224+00 and 1248+00, (5) 1987+25 and 2002+00, (6) 2016+75 and 2036+75, (7) 2067+00 and 2088+00, (8) 2137+00 and 2148+00, (9) 2182+00 and 2196+50, (10) 2245+75 and 2292+00, approximately (see Table 5-2 for more details). The wall's depth at these locations will vary between 75 and 120 feet. Between 844+50 and 897+50, an 85-foot deep soil bentonite cutoff wall is considered adequate for this area.

5.2.12 Erosion Protection

An anchored HPTRM is required on the landside slope for two initial overtopping levee sections located in reaches 7 and 23 between: (1) 547+00 and 604+60, and (2) 1582+00 and 1601+00 to increase the sections' resiliency and enhance flood warning and evacuation time prior to overtopping failure from events that exceed the design event.

5.2.13 Closure Structure

A stop log closure structure or equivalent is required at station 1130+00, where the UPRR crosses the FRWL alignment.

5.2.14 Modification of Existing Utilities and Encroachments

Table 5-4B summarizes the number of utilities and encroachments to be modified by construction of Alternative SB-8. A total of 223 utility/encroachment items will be removed, modified (to meet the USACE standard for levee penetrations) or relocated outside of the proposed ROW. Refer to able 5-3 for more detailed descriptions.

5.3 Environmental Mitigation Measures

For direct effects on woody riparian trees that cannot be avoided, compensation will be provided for the loss of riparian habitat to ensure no net loss of habitat functions and values. Compensation ratios will be based on site-specific information and determined through coordination with the appropriate State and Federal agencies during the permitting process. Compensation will be provided based on the ratio determined (e.g., 2:1 = 2 acres restored/created/enhanced or credits purchased for every 1 acre removed). Compensation may be a combination of offsite restoration or mitigation credits.

For elderberry shrubs and riparian habitat, 35 acres of mitigation acreage are available at Star Bend. For Alternative SB-8,an estimated 90 acres would be required. Acreage in excess of the 35 acres will require additional mitigation sites and/or mitigation banks

For elderberry shrubs and riparian habitat, USACE will develop a restoration and monitoring plan that describes how this habitat will be enhanced or recreated and monitored over a minimum period of time, as determined by the appropriate State and Federal agencies.

The revegetation plan will be prepared by a qualified restoration ecologist and reviewed by the appropriate agencies. The revegetation plan will specify the planting stock appropriate for each riparian land cover type and each mitigation site, ensuring the use of genetic stock from the project area. The plan will employ the most successful techniques available at the time of planting. Success criteria will be established as part of the plan and will include a minimum of 80% revegetation success at the end of 5 years, 70% revegetation success after 3 year, and 75% vegetative coverage after 5 years. USACE will monitor and maintain the plantings as necessary for 3 years, including weed removal, irrigation, and plant protection. SBFCA will then assume monitoring and maintenance responsibilities after year 3 and submit annual monitoring reports of survival to the regulatory agencies issuing permits related to habitat effects, including DFG, USACE, National Marine Fisheries Service, and USFWS. Replanting will be necessary if success criteria are not met, and replacement plants subsequently will be monitored and maintained to meet the success criteria. The riparian habitat mitigation will be considered successful when the sapling trees established meet the success criteria, the habitat no longer requires active management, and vegetation is arranged in groups that, when mature, replicate the area, natural structure, and species composition of similar riparian habitats in the region.

5.4 Cultural Mitigation Measures

USACE negotiated a programmatic agreement (PA) with the California State Historic Preservation Officer (SHPO) that outlines the specific processes that USACE will follow to identify and treat cultural resources. The PA took effect after it was signed by USACE and the SHPO on June 8, 2012, and was subsequently transmitted to the Advisory Council on Historic Preservation.

Following the terms of the PA, before construction begins, the following will occur:

- USACE and the SHPO would formally agree upon a final area APE for the project. The APE comprises the entirety of the area where cultural resources could potentially be affected by the project.
- USACE, in consultation with the SHPO, would fully inventory the APE for cultural resources. This inventory would include both the pedestrian survey efforts conducted to date by ICF, as well as subsurface prospection efforts.
- In consultation with the SHPO, USACE would evaluate all cultural resources in the APE for their eligibility for listing in the National Register of Historic Places (NRHP). Work necessary for these evaluations may include detailed recordation, background research, and subsurface test excavations.
- USACE; in consultation with the SHPO, the public, interested Native American Tribes, or other identified stakeholders; would provide adequate mitigation to resolve any unavoidable adverse effects to NRHP eligible cultural resources (historic properties).

Alternative SB-8 could result in impacts to the levee itself, the Sutter Butte Canal, historic buildings and neighborhoods in Yuba City, other built environment resources identified in the FRWLP EIS/EIR, and several known prehistoric archaeological sites (CA-SUT-5, CA-SUT-10, CA-SUT-20, CA-SUT-77, CA-BUT-52, CA-BUT-53, CA-BUT-496, CA-BUT-1123, and the unnamed site identified by UAIC). USACE would follow the processes outlined in the PA to resolve adverse effects to these resources.

Proposed borrow areas have not yet been surveyed. Inventories of the borrow sites, utility relocations, and other sites that may be defined in the future, could result in the identification of more impacts.

Any unknown cultural resources found in the course of further inventory work or during construction would be evaluated for NR eligibility, and effects to those resources would be resolved as necessary, following the processes outlined in the PA.

5.5 Fill, Borrow, Borrow Sites and Disposal Areas

Type 1, Type 2 and Random fill materials are needed for levee, cutoff wall and seepage berm constructions. Type 1 levee fill material will be used primarily as a clay core for the reconstructed levee above the cutoff wall and for the cutoff wall's soil-bentonite mix. Type 2 levee fill material will be used primarily for shells for the reconstructed levee above the cutoff wall. Random fill is used primarily for seepage berms.

Excavated materials from levee degrade are expected to be reusable for Type 1 and Type 2 fills. Type 1 fill can be used as Type 2 and Random Fill. Type 2 fill can be used as Random fill. It is expected that borrow materials will be needed for construction of the project.

The two primary types of borrow material for the levee and cutoff wall constructions are: Type 1 and Type 2. Specifications for the two material types (see Paragraph 2.4.4.3) are as follows:

- Type 1 Levee Fill: USCS classification of CL, SC, or CH; maximum particle size of 2 inches; minimum 35% by weight passing the #200 sieve; maximum liquid limit of 60; plasticity index between 12 and 40.

- Type 2 Levee Fill: Maximum particle size of 2 inches; minimum 12% by weight passing the #200 sieve; maximum liquid limit of 45.

The borrow areas are sites 2 to 5, 7, 8, 11 and 12 shown in Plate 5-3. Source for borrow is discussed in Paragraph 2.6. A material balance analysis was completed for borrow quantities based on the preliminary information and the results are show in Tables 5-5 and 5-6.

Table 5-5 Borrow Sites and Usage for SB-8	**Volume of Material (Potential)**		
Borrow Sites and Usage	Type 1 (cy)	Type 2 (cy)	Random (cy)
2 - CDFG (OWA - Cobble Borrow)			330,800
Leftover after using borrow for D2			151,280

3 - Live Oak Detention Basin	150,000		
Leftover after using borrow for D2 - as Type 1	92,150		
Leftover after using borrow for D1 - as Type 1	0		
4 - Lanza 235 Borrow	250,000		
Leftover after using borrow for D1 - as Type 1	233,250		
Leftover after using borrow for D1 - as Type 2	62,850		
Leftover after using borrow for C2 - as Type 1	0		
5 - Nevis Property	250,000		
Leftover after using borrow for C2 - as Type 1	217,450		
Leftover after using borrow for C2 - as Type 2	143,550		
Leftover after using borrow for C1 - as Type 1	25,595		
Leftover after using borrow for C1 - as Type 2	12,252		
7 - Lanza 620 Acres Property	119,932	359,796	
Leftover after using borrow for A - as Type 1	948		
Leftover after using borrow for A - as Type 2		19,986	
8 - Huston Property	330,000		
Leftover after using borrow for B - as Type 1	199,279		
Leftover after using borrow for B - as Type 2	33,687		
11 - Siller Live Oak Property	250,000		
12 - Siller Yuba City Property		100,000	
Leftover after using borrow for SBFIP - as Type 2		53,200	
Total Potential	1,349,932	459,796	330,800

Table 5-6 Borrow Demand for SB-8	**Volume of Material (Demand)**		
Construction Contracts and Usage	Type 1 (cy)	Type 2 (cy)	Random (cy)
CONTRACT A	118,984	339,810	
Unknown (7 or within vicinity R of the contract)	118,984	339,810	
CONTRACT STAR BEND (SBFIP)		46,800	
12 - Siller Yuba City Property		46,800	
CONTRACT B	130,721	165,592	
8 - Huston Property	130,721	165,592	
CONTRACT C1	117,955	13,343	
5 - Nevis Property	117,955	13,343	
CONTRACT C2	95,400	73,900	
4 - Lanza 235 Borrow	62,850		
5 - Nevis Property	32,550	73,900	
CONTRACT D1	108,900	170,400	
3 - Live Oak Detention Basin	92,150		
4 - Lanza 235 Borrow	16,750	170,400	

CONTRACT D2	57,850		179,520
2 - CDFG (OWA - Cobble Borrow)			179,520
3 - Live Oak Detention Basin	57,850		
Total Demand	629,810	809,845	179,520

Implementation of Alternative SB-7/SB-8 may generate up to 813,000 cubic yards of solid waste that would require disposal. Sources of solid waste related to construction activities would include levee material, structural debris from removal of residences and agricultural structures, roadway pavements, and levee material deemed unsuitable for reuse.

The nearest solid waste facilities to the project area are the Ostrom Landfill (located east of the project site, approximately 30 road miles from the southern end of the project at Reach 2) and the Neal Road Landfill (located 25 miles north of the project Reach 40).

Assuming all of the estimated 813,000 cubic yards of waste material would require permanent disposal, Alternative SB7/SB8 implementation would represent 2% of the Ostrom Road Landfill and 4% of the Neal Road Landfill remaining capacities. However, the option of beneficial reuse is likely to reduce the cubic yards of soil that require permanent disposal.

5.6 Construction Access, Haul Routes and Staging Areas

Haul route will be mainly on existing public roads (see Plate 5-3).

5.7 Real Estate Requirements

A total of 34 physical structures fall within the proposed ROW and, therefore, will be demolished for construction of this alternative. 27 of these structures are within reach 16 (Yuba City). The remaining structures are in reaches 26 to 31.

Approximately 2,196 acres will be acquired and 468 parcels will be impacted (refer to Real Estate Appendix for more details).

5.8 Operation and Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)

5.8.1 Flood Damage Reduction Features

OMRR&R Activities for flood control works are generally the same with and without the project. However the cost and effort associated with each activity may increase or decrease as a result of the project. These increases or decreases are considered to be roughly offsetting and net change in overall OMRR&R effort is judged to be insignificant. Expected impacts of the project on these activities are as follows:

1. Construction activities including reconstruction of the upper half of the levee, regrading of side slopes vegetation removal, rodent disruption and crown road reestablishment will reduce maintenance costs in the short term.

2. Vegetation removal/control. For the purpose of this feasibility study it is assumed that, absent the project, the State will gradually bring levees into compliance with USACE ETL 1110-2-571 using a life cycle approach to vegetation management. Under this assumption, the immediate compliance with the ETL required by the project will result in an interim increase in cost and effort required for vegetation removal and control (Offset initially by clearing during construction). Net increase in OMRR&R cost anticipated.

3. Rodent control/damage repair. Increase in embankment volume resulting from the addition of seepage and stability berms could result in a slight increase in rodent related maintenance activity.

4. Slope maintenance. Reduction in OMRR&R will occur due to reduction in seepage. The VFZ required by USACE ETL 1110-2-571 for the project area will reduce the need for periodic levee toe regrading previously caused by farming operations.

5. Repair of waterside erosion. No additions. No significant change.

6. Encroachments. Wet penetration encroachments will be improved or eliminated throughout the length of the project. Dry encroachments, such as power poles and vegetation will be reduced. The result will be a decrease in OMRR&R costs.

7. Road/ramp maintenance. The addition of an O&M road at the toe of the levee for the entire length of the levee in addition to the existing road on the levee crown will essentially double the cost and effort associated with road maintenance. However, the added road will enhance the efficacy of virtually all OMRR&R activities including inspections, patrolling and flood fighting.

8. Encroachments. Wet penetration encroachments will be improved or eliminated all along the length of the project. Dry encroachments, such as power poles and vegetation will be reduced. Result will be decrease in OMRR&R costs.

9. Road/ramp maintenance. The addition of an O&M road at the toe of the levee for the entire length of the levee in addition to the existing road on the levee crown will essentially double the cost and effort associated with road maintenance. However, the added road will enhance the efficacy of virtually all OMRR&R activities including inspections, patrolling and flood fighting.

10. Inspection/patrolling including participation in Federal and State inspection programs, routine patrolling to identify maintenance needs and to assure flood worthiness, and continuous patrolling during high water conditions. The added landside O&M toe road will significantly enhance inspection and patrolling activities.

11. Flood fighting. The project flood control features (seepage berms, stability berms, and cutoff walls) are intended to eliminate seepage and stability issues during high water. The added O&M road at the landside levee toe should dramatically improve identification of any issues that may develop during high water and facilitate their rapid repair.

5.8.2 Mitigation Features

For Alternative SB-8 an estimated 90 acres are designated for mitigation of habitat loss due to project construction. An estimated 35 acres are available at the Star Bend mitigation site. Additional mitigation needs will be accomplished with additional mitigation sites and/or mitigation bank credits. USACE will enter into a contract to preserve the plantings for a term of three years following completion of construction. At the end of this term the areas will be turned over to the local sponsor who will maintain the areas to accomplish predetermined levels of re-vegetation success targeted for 5 years from planting.

5.8.3 Estimated Annual OMRR&R Cost

The estimated cost of OMRR&R for Alternative SB-8 in 2012 dollars is $ 454,000 as compared to $ 432,000 for the same levee reaches without the Project.

5.9 Cost Estimate and Construction Schedule

The project is divided into 7 construction contracts those are A, B, C1, C2, D1, D2 and Star Bend Fix-in-place (SBFIP). Table 5-4 summarizes the extent, year of construction and project features for each of the construction contracts. For more information on construction contracts and their sequencing, refer to the Cost Engineering Appendix.

Tables

Table 4-1B Summary of Project Features for Alternative SB7

Engineering Appendix Paragraph	Measure	Typical Section (Plate)	Segment	Contract	Beg. STA of Measure	End. STA of Measure	Length per Segment (LF)	Length per Contract (LF)	Length per Measure (LF)
4.2.1	No Rehabilitation Required	-	1	B	831+50	844+50	1,300	1,300	
	No Rehabilitation Required	-	2	C1	923+75	1006+24	8,249		
	No Rehabilitation Required	-	3	C1	1007+70	1024+00	1,630		
	No Rehabilitation Required	-	4	C1	1027+50	1078+00	5,050	14,930	16,230
4.2.2	Cutoff Wall Only	G-2A	1	A	231+00	453+00	22,200	22,200	
	Cutoff Wall Only	G-2A	2	SBFIP	478+68	512+00	3,332	3,340	
	Cutoff Wall Only	G-2A	3	B	570+00	831+50	26,150	26,150	
	Cutoff Wall Only	G-2A	4	C1	1078+00	1096+00	1,800		
	Cutoff Wall Only	G-2A	5	C1	1098+10	1107+00	890		
	Cutoff Wall Only	G-2A	6	C1	1125+70	1129+99	429		
	Cutoff Wall Only	G-2A	7	C1	1130+20	1213+85	8,365	11,490	
	Cutoff Wall Only	G-2A	7	C2	1213+85	1429+00	21,515	21,520	84,700
4.2.3	Jet Grouting Cutoff Wall Only	G-2A	1	C1	1006+04	1007+90	186		
	Jet Grouting Cutoff Wall Only	G-2A	2	C1	1095+80	1098+30	250		
	Jet Grouting Cutoff Wall Only	G-2A	3	C1	1129+50	1130+67	117	560	560
4.2.4	Seepage Berm Only	G-2B	1	C1	1024+00	1027+50	350	350	350
4.2.5	Cutoff Wall with Full Levee Degrade and Existing Relief Wells	G-2D	1	C1	844+50	897+50	5,300	5,300	5,300
4.2.5	Cutoff Wall with Full Levee Degrade	G-2D	-	-	0+00	0+00	0	0	0
4.2.6	Cutoff Wall with Existing Relief Wells	G-2C	1	B	512+00	545+00	3,300	3,300	
	Cutoff Wall with Existing Relief Wells	G-2C	3	C1	897+50	923+75	2,625	2,630	5,930
4.2.6	Cutoff Wall with New Relief Wells	G-2C	2	B	545+00	570+00	2,500	2,500	2,500
4.2.7	Cutoff Wall with Seepage Berm	G-2C	1	A	180+00	231+00	5,100		
	Cutoff Wall with Seepage Berm	G-2C	2	A	453+00	478+68	2,568	7,670	7,670
4.2.8	Cutoff Wall with Levee Relocation	G-2E	-	-	0+00	0+00	0	0	0
4.2.9	Cutoff Wall with Sutter Butte Canal Relocation	G-2F	1	C2	1429+00	1432+70	370	370	370
4.2.10	Cutoff Wall with Landside Toe Fill	G-2G	1	C1	1107+00	1125+70	1,870	1,870	1,870
4.2.11	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	1	A	230+00	250+00	2,000	2,000	
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	2	C1	1125+00	1129+99	499		
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	3	C1	1130+20	1151+50	2,130	2,630	
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	4	C2	1224+00	1248+00	2,400	2,400	7,030
4.2.12	Erosion Protection	-	1	B	547+00	604+60	5,760	5,760	5,760
4.2.13	Closure Structure (Stop Log)	-	1	C1	1130+00	1130+00	-	-	-

Table 4-2 Summary of Project Features for Alternative SB7

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
2A North	180+00 to 202+50	2,250	Cutoff wall with undrained seepage berm	180+00 to 202+50: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 180+00 to 202+50: Cutoff wall extending to an elevation of 25 ft.	
2B	202+50 to 218+66	1,616	Cutoff wall with undrained seepage berm	180+00 to 218+66: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 202+50 to 218+66: Cutoff wall extending to an elevation of 25 ft.	
3	218+66 to 300+66	8,200	Cutoff wall Cutoff wall with undrained seepage berm	218+66 to 231+00: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 218+66 to 230+00: Cutoff wall extending to an elevation of 25 ft. with 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 230+00 to 250+00: Cutoff wall extending to an elevation of -35 ft. 250+00 to 289+00: Cutoff wall extending to an elevation of -20 ft. 289+00 to 300+66: Cutoff wall extending to an elevation of -12 ft.	
4	300+66 to 410+67	11,001	Cutoff wall	300+66 to 312+00: Cutoff wall extending to an elevation of -12 ft. 312+00 to 349+00: Cutoff wall extending to an elevation of 15 ft. 349+00 to 368+00: Cutoff wall extending to an elevation of 10 ft. 368+00 to 410+67: Cutoff wall extending to an elevation of 20 ft.	

Table 4-2 Summary of Project Features for Alternative SB7

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
5	410+67 to 478+68	6,801	Cutoff wall Cutoff wall with undrained seepage berm	453+00 to 478+00: 300 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 410+67 to 417+00: Cutoff wall extending to an elevation of 20 ft. 417+00 to 425+00: Cutoff wall extending to an elevation of 10 ft. 425+00 to 456+00: Cutoff wall extending to an elevation of 15 ft. 456+00 to 475+35: Cutoff wall extending to an elevation of 15 ft. 475+35 to 478+68: Cutoff wall extending to an elevation of 15 ft.	
6 FIP	478+68 to 512+00	3,332	Cutoff wall	478+68 to 512+00: 65ft deep (from degrade line) cutoff wall.	
7	512+00 to 596+00	8,563	Cutoff wall Cutoff wall with existing and new relief wells Erosion Protection	512+00 to 514+00: 65ft deep (from degrade line) cutoff wall. 514+00 to 526+00: Cutoff wall tip elevation +15 feet 526+00 to 570+00: Cutoff wall tip elevation -5 feet 545+00 to 570+00: 22 new relief wells at 120 feet spacing and 50 feet depth (including new concrete lined V-ditch). 570+00 to 575+00: Cutoff wall tip elevation -5 feet 575+00 to 595+00: Cutoff wall tip elevation -10 feet 595+00 to 596+00: Cutoff wall tip elevation +15 feet 547+00 to 596+00: High Performance Turf Reinforce Mat (HPTRM)	512+00 to 545+00: existing seepage interceptor system (24 relief wells, ditch and pump station) are to remain.
8	596+00 to 654+75	5,875	Cutoff wall Erosion Protection	596+00 to 654+75: Cutoff wall tip elevation +15 feet 596+00 to 604+60: High Performance Turf Reinforce Mat (HPTRM)	

Table 4-2 Summary of Project Features for Alternative SB7

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
9	654+75 to 706+50	5,175	Cutoff wall	654+75 to 670+00: Cutoff wall tip elevation +15 feet 670+00 to 697+00: Cutoff wall tip elevation +20 feet 697+00 to 706+50: Cutoff wall tip elevation -10 feet	
10	706+50 to 774+00	6750	Cutoff wall	706+50 to 726+00: Cutoff wall tip elevation -10 feet 726+00 to 746+00: Cutoff wall tip elevation -5 feet 746+00 to 754+50: Cutoff wall tip elevation +5 feet 754+50 to 774+00: Cutoff wall tip elevation +25 feet	
11	774+00 to 830+00	5,600	Cutoff wall	774+00 to 784+50: Cutoff wall tip elevation +25 feet 784+50 to 827+50: Cutoff wall tip elevation -5 feet 827+50 to 830+00: Cutoff wall tip elevation +25 feet	
12	830+00 to 845+00	1,500	No proposed rehabilitation measure with exception below Cutoff wall (transition only, at both ends of this reach)	830+00 to 831+50: Cutoff wall tip elevation +25 feet (transition only) 844+50 to 845+00: Cutoff wall tip elevation -26 feet (transition only)	829+85 to 845+25: existing cutoff wall (23.5ft deep, tip elevation 30.5)
13	845+00 to 927+00	8,200	Cutoff wall Cutoff wall with full levee degrade and existing relief wells	844+50 to 897+50: Full levee degrade and re-construction 844+50 to 849+00: Cutoff wall tip elevation -20’ to -29’ 848+00 to 863+00: Cutoff wall tip elevation -29’ 863+00 to 877+00: Cutoff wall tip elevation -30’ 877+00 to 887+00: Cutoff wall tip elevation -31’ 887+00 to 893+00: Cutoff wall tip elevation -30’ 893+00 to 897+50: Cutoff wall tip elevation -29’ 897+50 to 923+75: Cutoff wall tip elevation +25’	844+50 to 897+50: Existing seepage interceptor system (52 relief wells, ditch and pump stations) are to remain. 897+50 to 923+75: Existing seepage interceptor system (29 relief wells, ditch and pump stations) are to remain. 923+23 to 927+00: existing cutoff wall (32.5ft deep, tip elevation 42.5)

Table 4-2 Summary of Project Features for Alternative SB7

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
14	927+00 to 954+40	2,740	No proposed rehabilitation measure	---	927+00 to 954+40: existing cutoff wall (32.5ft deep, tip elevation 42.5) No as-built drawing available for the existing cutoff wall.
15	954+40 to 968+50	1,410	No proposed rehabilitation measure	---	954+40 to 968+50: existing cutoff wall (32.5ft deep, tip elevation 42.5) No as-built drawing available for the existing cutoff wall.

Table 4-2 Summary of Project Features for Alternative SB7

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
16	968+50 to 1080+00	11,150	Jet grouting cutoff wall at 5th Street bridge crossing. Toe berm at 10th Street bridge crossing. Cutoff wall (transition only, at the end of Reach 16 to overlap existing cutoff wall).	1006+04 to 1007+90 (5th Street bridge crossing): Jet grouting cutoff wall tip elevation +40 feet 1023+90 to 1027+50 (10th Street bridge crossing): Toe berm, 23 feet wide, approximately 7 feet thick at the levee toe, 4H:1V slope at toe berm. 1077+85 to 1080+00: Cutoff wall tip elevation +30 feet and backfill landside toe depression (transition only).	968+50 to 983+23: existing cutoff wall (32.5ft deep, tip elevation 42.5) 983+23 to 996+23: existing cutoff wall (22.5ft deep, tip elevation 52.5) 996+23 to 1006+24: existing cutoff wall (32.5ft deep, tip elevation 42.5) 1007+90 to 1015+70: existing cutoff wall (32.5ft deep, tip elevation 42.5) 1015+70 to 1024+42: existing cutoff wall (43ft deep, tip elevation 35) 1026+99 to 1079+66: existing cutoff wall (39ft deep, tip elevation 38)

Table 4-2 Summary of Project Features for Alternative SB7

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
17	1080+00 to 1130+86	5,086	Cutoff wall Jet grouting cutoff wall at Yuba city water treatment plant Jet grouting cutoff wall at Railroad North of Yuba City Landside toe depression filled Closure Structure	1107+00 to 1125+70: Backfill landside toe depression 1080+00 to 1089+00: Cutoff wall tip elevation +30 feet 1089+00 to 1096+00: Cutoff wall tip elevation +35 feet 1095+80 to 1098+30: Jet grouting cutoff wall tip elevation +35 feet 1098+10 to 1125+00: Cutoff wall tip elevation +35 feet 1125+00 to 1129+99: Cutoff wall tip elevation +0 feet 1129+50 to 1130+67: Jet grouting cutoff wall tip elevation +0 feet 1130+20 to 1130+86: Cutoff wall tip elevation +0 feet 1130+00: Stoplog closure structure or equivalence	
18	1130+86 to 1213+85	8,299	Cutoff wall	1130+86 to 1151+50: Cutoff wall tip elevation +0 feet 1151+50 to 1159+50: Cutoff wall tip elevation +30 feet 1159+50 to 1169+50: Cutoff wall tip elevation +25 feet 1169+50 to 1189+50: Cutoff wall tip elevation +30 feet 1189+50 to 1209+50: Cutoff wall tip elevation +40 feet 1209+50 to 1213+85: Cutoff wall tip elevation +35 feet	
19	1213+85 to 1297+83	8,398	Cutoff wall	1213+85 to 1219+75: Cutoff wall tip elevation +35 feet 1219+75 to 1224+00: Cutoff wall tip elevation +5 feet 1224+00 to 1238+00: Cutoff wall tip elevation -28 feet 1238+00 to 1248+00: Cutoff wall tip elevation -42 feet 1248+00 to 1268+75: Cutoff wall tip elevation +3 feet 1268+75 to 1297+83: Cutoff wall tip elevation +35 feet	
20	1297+83 to 1374+33	7,650	Cutoff wall	1297+83 to 1298+75: Cutoff wall tip elevation +35 feet 1298+75 to 1359+00: Cutoff wall tip elevation +50 feet 1359+00 to 1369+00: Cutoff wall tip elevation +40 feet 1369+00 to 1374+33: Cutoff wall tip elevation +32 feet	

Table 4-2 Summary of Project Features for Alternative SB7

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
21	1374+33 to 1433+83	5,950	Cutoff wall Levee relocation with cutoff wall (transition only) Canal relocation	1374+33 to 1386+50: Cutoff wall tip elevation +32 feet 1386+50 to 1408+50: Cutoff wall tip elevation +55 feet 1408+50 to 1433+83: Cutoff wall tip elevation +40 feet 1429+00 to 1433+83 Sutter Butte Main Canal relocation.	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
183	21	1430+55	2,216,425.27	6,664,383.06	Sunset Pump Station owned an operated by Sutter Extension Main Pump Station. There is a 60 Inch steel pipe through the levee. Pump end has gate valves on structure. Automatic drainage gates on the landside end.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	15.6
184	21	1430+47	2,216,417.64	6,664,382.64	Sunset Pump Station owned an operated by Sutter Extension Main Pump Station. There is a 60 Inch steel pipe through the levee. Pump end has gate valves on structure. Automatic drainage gates on the landside end.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	15.6
185	21	1430+40	2,216,410.86	6,664,382.27	Sunset Pump Station owned an operated by Sutter Extension Main Pump Station. There is a 36 Inch steel pipe through the levee. Pump end has gate valves on structure. Automatic drainage gates on the landside end.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	15.6
186	21	1430+40			To construct and operate a vertical-perforated plate fish screen with a power operated brush on the right bank of Feather River. Located at Sunset Pump Plant.	Cutoff wall with Sutter Butte canal relocation		IR	
187	21	1430+00			36" CM pipe crossing through levee. The O&M manual indicates this pipeline is located 50 feet south of Sunset Pump Station but it appears this pipeline is the same pipeline addressed in Permit 4556 and 4719 located at Station 1465+50. The pipeline at Station 1465+50 was a 36 inch CMP installed in 1913 and removed in 1964. It should have shown on the O&M manual.	Cutoff wall with Sutter Butte canal relocation	There is no documenation of proper abandonment of the pipeline. We believe this pipeline was actually located at 1465+50 and removed per permit 4719. The type and size appear to match the Reclamation Board Permit. **Replace in accordance with USACE Standard.**	IR (G)	
188	21	1429+98	2,216,368.25	6,664,376.98	12 KV OH Power	Cutoff wall with Sutter Butte canal relocation		EL	OH
189	21	1429+68	2,216,338.71	6,664,376.58	12 KV OH Power	Cutoff wall with Sutter Butte canal relocation		EL	OH
190	21	1429+50			Existing rubble coffer dam constructed with Reclamation Board Permit 3610. Repair coffer dam.	Cutoff wall with Sutter Butte canal relocation		IR	
191	21	1428+50			Sutter Butte Main Canal Begin (Station 1428+50 to 1433+83) -Main Irrigation Canal approx 420 cfs	Cutoff Wall	**Recommended Relocation between station 1429+00 to 1433+83**	IR	
192	21				To construct a 12 KV pole line extension adjacent to the levee and across the floodway of the Feather River. The pole line will be located 30 feet from the waterside toe of the levee and will parallel the levee for a distance of 792 feet, thence across the floodway for a distance of 834 feet. The pole line extension will consists of three 264 foot spans and three 278 foot spans.	Cutoff Wall		EL	OH
193	21	1399+27	2,213,450.77	6,664,966.80	To install a 12 kv pole line across and along the right bank levee of the Feather River.	Cutoff Wall		EL	OH
194	21				To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. End Seepage Interceptor Trench	Cutoff Wall	No work proposed and the seepage drain can remain.	struc	
195	21				Plant 9 acres of Kiwi plants on waterside of levee between Bridgeford and Hermanson Avenues	Cutoff Wall		Trees	
196	21				Plant 14 acres of Kiwi plants on waterside of levee upstream of Hermanson Avenue	Cutoff Wall		Trees	
197	21				To construct a well and septic tanks for 2 mobile homes and to extend electrical service to well on right bank overflow area of Feather River	Cutoff Wall		Struc	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
198	21				To plant 8 acres of kiwi plants, a submersible pump, and underground sprinkler system on the right bank overflow area of the Feather River	Cutoff Wall		Trees	
199	~~21~~				~~To pump storm water from landward drainage ditch over the right bank levee of the Feather River from one separate location for approximately size at the end of Hermansen Road.~~ ~~**Pipe has been removed**~~	~~Cutoff Wall~~		~~SD(P)~~	
200	21	1391+96	2,212,767.43	6,665,226.86	To extend a 12 kv pole line out into the right bank levee and overflow area of the Feather River	Cutoff Wall		EL	OH
201	21	1375+35	2,211,296.56	6,665,998.34	Sutter Extension Sunset Lateral Begin (Station 1375+35 to 1428+50) Open irrigation ditch 15 feet from landside toe	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	Struc	
202	21	1374+94	2,211,260.36	6,666,016.66	To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. Begin Seepage Interceptor Trench	Cutoff Wall		Struc	
203	21	1375+00			To level and plant 13 acres Peach Orchard on the right bank overflow area of the Feather River	Cutoff Wall		Trees	
	20/21	1374+33			Reach 20/21 Transition				
204	20	1350+00			To plant peach trees and to establish two wells and install pumping plants in right bank overflow of the Feather River	Cutoff Wall		struc	
205	20	1350+00			To extend 12 kv pole line parallel to the water ward toe of levee for a distance of approximately 1,500 feet north from Koch Lane, on the right bank overflow area of the Feather River/	Cutoff Wall		EL	OH
206	20				Excavation into toe of levee from 1 to 3 feet high and ground is tilled adajcent to the landside toe. The CVFPB sent an encroachment violation notice on August 17, 2011 to Julie M. Filter-Correll.	Cutoff Wall		Struc	
207	20	1347+37	2,208,612.74	6,666,676.45	To install a 60 foot pole 86 feet from the landward toe of the levee, a 60 foot pole 10 feet from the water ward toe of the levee and 6 additional poles on the right bank overflow of the Feather River. The 12kv electrical service will be extend across the levee to serve a pump installed under Permit 6380. The span across the levee will be 234 feet. The clearance between the overhead wires and the top of the levee will be 31 feet.	Cutoff Wall		EL	OH
208	20	1347+00	2,208,582.82	6,666,680.19	Missile Communication Cable System. Installation of an underground cable at a minimum depth of 3 feet, a corrugated metal cutoff wall is located on each cable, from Beale Air Force Base to the vicinity of Chico Airport, crossing several channels in Butte, Placer, Sutter, and Yuba Counties. In 1968 the USACE requested approval to abandon the cable in-place and cut	Cutoff Wall	The cable does not meet title 23 requirements. According to email from US Government to WR, the cable is no longer in use and can be disposed. **Replace in accordance with USACE standard**	TL	4.0
209	20	1345+00			To plant prune orchard on the right bank overflow area of the Feather River, downstream from Koch Road	Cutoff Wall		Trees	
210	20	1345+00			To retain walnut orchard on the right bank overflow area of the Feather River, downstream from Koch Road	Cutoff Wall		Trees	
211	~~20~~	~~1328+10~~			~~To install 3 temporary discharge pipelines across the right bank levee of the Feather River. The proposed pipeline will be in installed in three separate locations at LM 3.53, 3.72, and 3.78. The pipelines will be exposed on the levee slopes and will have a pad constructed over them across the levee crown.~~ ~~**Pipe has been removed.**~~	Cutoff Wall		~~SD(P)~~	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
212	20	1328+00			To construct a 12 kv aerial power line on the right bank overflow area of the Feather River	Cutoff Wall		EL	OH
213	20	1327+00	2,206,597.56	6,666,928.33	12KV overhead power line crossing	Cutoff Wall		EL	OH
~~214~~	~~20~~	~~1317+15~~			~~To install 3 temporary discharge pipelines across the right bank levee of the Feather River. The proposed pipeline will be in installed in three separate locations at LM 3.53, 3.72, and 3.78. The pipelines will be exposed on the levee slopes and will have a pad constructed over them across the levee crown.~~ ~~**Pipe has been removed.**~~	~~Cutoff Wall~~		~~SD(P)~~	
215	20	1315+03	2,205,398.45	6,666,943.63	To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. End Seepage Interceptor Trench	Cutoff Wall		Struc	
216	20	1314+80	2,205,375.80	6,666,944.25	Micheli Storm Drainage Pump Station. To install a pump with 20 Inch steel discharge pipe through the right bank of the Feather River for the removal of stormwater.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(P)	2.0
217	20	1312+08			To plant an orchard and grade the land on the right bank overflow area of the Feather River. The project is located north of Yuba City approximately 5.5miles.	Cutoff Wall		Trees	
~~218~~	~~20~~	~~1305+30~~			~~To pump storm water from landward drainage ditch over the right bank levee of the Feather River from one separate location for approximately size at the end of Hermansen Road.~~ ~~**Pipe has been removed**~~	~~Cutoff Wall~~		~~SD(P)~~	
	19/20	1297+83			Reach 19/20 Transition				
219	19	1295+00			To plant an orchard and grade the land on the right bank overflow area of the Feather River. The project is located north of Yuba City approximately 1.3 miles upstream (north) of the intersection of Eager Road and Live Oak Boulevard.	Cutoff Wall		Trees	
220	19	1293+66	2,203,266.22	6,666,867.99	End Concrete Lined Ditch on landside toe of levee	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	struc	
221	19	1293+66	2,203,266.22	6,666,867.99	12 KV Overhead Power line crossing of levee. One pole 6 foot from levee toe.	Cutoff Wall		EL	OH
222	19				To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. Begin Seepage Interceptor Trench	Cutoff Wall		struc	
223	19	1284+91	2,202,406.27	6,666,705.08	Begin Concrete Lined Ditch on landside toe of levee	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	struc	
224	19	1266+71	2,200,600.09	6,666,626.50	12KV overhead power line crossing	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
225	19	1265+59	2,200,487.69	6,666,648.86	Sullivan Pump Station. 18 inch steel pipe through the levee. Pump and Gate valve in pump house on the channel bank. Concrete well on the bank. Siphon breaker in CMP riser on landside slope. (Sullivan Pump Station)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and anti-siphon device on waterside hinge of levee. The pipe line is pressurized and need to be installed above the design water surface. The current installation is at-grade. **Replace in accordance with Title 23**	IR(P)	18.3

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
226	19	1229+41	2,197,325.05	6,668,184.53	Kewal Singh IR PS. A 16 inch steel pipe through levee. Pump in pump house on channel bank. Gate valve on the waterside end. Concrete standpipe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and anti-siphon device on waterside hinge of levee. The pipeline is pressurized and will need to be installed about the design water surface. **Replace in accordance with USACE standard**	IR(P)	3.0 or deeper through levee?
227	19	1226+06	2,197,092.42	6,668,425.95	12 KV power pole located in landside slope	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
	18/19	1213+85			Reach 18/19 Transition				
228	18				Excavation into the toe of levee on waterside 0.5 to 3 feet high with near vertical slope. CFPB sent an encroachment violation notice on July 27, 2011 to Kewall Singh.	Cutoff Wall		struc	
229	18	1201+00			Wilbur Ranch Irrigation Water Well located within 50 feet of levee toe. Underconstruction as of March 6, 2012.	Cutoff Wall		well	
230	18	1200+69	2,194,694.58	6,669,169.33	Wilbur Ranch Irrigation Water Well located within 10 feet of levee toe. There is also a service pole and electrical panel.	Cutoff Wall	The water well does not meet Title 23 since too cloase to levee. The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
~~231~~	~~18~~	~~1200+69~~	~~2,194,694.58~~	~~6,669,169.33~~	~~Abandoned 10 inch steel pipe through levee. Waterside end open. Steel Plate welded on landward end. Pump and Standpipe at the landside end.~~	~~Cutoff Wall~~	~~Not sure if the abandonment meets title 23 requirements. Pipe may need to be properly abandoned or completely removed.~~	~~IR(P)~~	~~2.8~~
232	18	1195+20			12 KV power line in overflow and levee crossing north of Rednall Road	Cutoff Wall		EL	OH
~~233~~	~~18~~	~~1182+75~~			~~20 Inch steel pipeline through levee **(not installed)** - Plans prepared by MHM Job No. 78-158~~	~~Cutoff Wall~~	~~Pipe eas never installed. No work.~~	~~IR(A)~~	~~3.0~~
234	18	1181+50			Abandoned 8 inch steel pipe through levee. Pipe plugged on the waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(A)	4.0
235	18	1180+98	2,192,727.96	6,669,163.92	3 inch steel pipe through levee crown	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	1.0
236	18	1180+50			One 12 inch steel pipe through levee. Pipe exposed on landside slope	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	1.0
237	18	1180+00			To construct a 15 inch diameter corrugated metal drain pipeline across the overflow area and through the right bank of the Feather River. The proposed pipeline will be 625 feet in length and have 15 feet of cover.	Cutoff Wall		SD(G)	
~~238~~	~~18~~	~~1182+75~~			~~To install an irrigation pump and a buried pipeline landward over the right bank levee of the Feather River, upstream Rednall Road. **Not install per Reclamation Board**~~	~~Cutoff Wall~~		~~IR(P)~~	
239	18	1174+05	2,192,034.01	6,669,096.85	Water Well and Pump 20 feet from Landside toe	Cutoff Wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
240	18	1170+04	2,191,638.99	6,669,057.61	12KV overhead power line crossing	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
241	18	1152+55	2,189,899.09	6,668,879.71	Twin 110 KV Tower line across Feather River	Cutoff Wall		EL	OH
242	18	1138+22	2,188,574.27	6,668,732.99	12 KV and 40/60 KV power pole located in landside slope	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	EL	OH

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
243	18	1135+31	2,188,188.41	6,668,676.43	16 inch gas line through the levee. Marker post on the waterside shoulder	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.5
244	18	1133+00			To construct 1,180 feet of 12 kv line in the right bank overflow area of the Feather River	Cutoff wall		EL	OH
	18	1132+61			Levee District No. 1 Levees /Levee District No. 9 Transition				
245	18	1132+09	2,187,967.19	6,668,647.98	8-5/8" steel pipeline within railroad right-of-way parallel to tracks	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	
246	18	1131+82	2,187,840.25	6,668,647.20	Fiber optic cable	Cutoff wall	The cable does not meet title 23 requirements. **Replace in accordance with USACE standard**	TL	
	17/18	1130+86			Reach 17/18 Transition				
247	17	1130+47	2,187,705.38	6,668,643.93	Union Pacific Railroad Crossing. There is no stop log structure.	Jet Grouting		RR	6.0
248	17	1128+00			To construct a ramp on the waterside slope of the right bank levee on the Feather River adjacent to the SPRR.	Cutoff wall		Struc	
249	17	1127+48	2,187,405.84	6,668,629.29	Village Green Trailer Park - To install a 10 inch outfall pipe through the right bank levee of the Feather River to provide storm drainage for a mobile home park.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	
250	17	1125+00			An existing irrigation well in the right bank overflow area of the Feather River.	Cutoff wall with landside toe fill		Well	
251	17	1111+46	2,185,808.02	6,668,723.59	West Onstott Frontage Road Pump Station and Clark Avenue Pump Station Drainage Area. 16 Inch welded steel 7 GA asphalt coated storm drain discharge pipe over levee connected to 24 inch pipe in overflow area, outfall ditch, and pipes in floodway (Source: City of Yuba City Pump Station No. 4 and City of Yuba City Pump Station No. 2)	Cutoff wall with landside toe fill	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	1.1
252	17	1107+82	2,185,444.63	6,668,754.75	12 KV crossing & power pole located in landside slope	Cutoff wall with landside toe fill	**Relocate outside of of the proposed right-of-way.**	EL	OH
253	17				To install an intertie to an existing waste water line and abandon approximately 40 feet of 24 inch diameter pipe on the right bank of the Feather River.	Cutoff wall		RW(P)	4.0
254	17	1096+81	2,184,421.28	6,669,119.50	Yuba City Water Treatment Plant 28" (29 25/32" OD) 7 GA welded steel waterline pipe crossing of levee. New permit included installation of automatic drainage gates on pipelines. (copy of record drawings)	Jet Grouting	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	RW(P)	5.0
255	17	1096+71	2,184,412.72	6,669,124.71	Yuba City Water Treatment Plant 24" 7 GA welded steel waterline pipe crossing of levee. New permit included installation of automatic drainage gates on pipelines. (copy of record drawings)	Jet Grouting	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	RW(P)	4.7
256	17	1096+62	2,184,404.80	6,669,129.53	Yuba City Water Treatment Plant 42"cement mortar lined and coated welded steel pipe waterline crossing of levee (copy of record drawings)	Jet Grouting	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	RW(P)	2.5
257	17	1096+50	to be installed	to be installed	Yuba City Water Treatment Plant 48"cement mortar lined and coated welded steel pipe waterline crossing of levee (to be installed and requested by the City of Yuba City)	Jet Grouting	This is a new pipelines that will meet Title 23 and USACE requirements except as noted in variance column. **Replace in accordance with USACE standard**	RW(P)	2.0

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
258	17	1096+74	2,184,416.62	6,669,124.90	To install a 12 kv aerial pole line extension across the right bank levee of the Feather River. The pole line shall serve the Yuba City Water treatment Plant intake pump station	Jet Grouting		EL	OH
259	17	1093+12			Telephone Call box on landside hinge point	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	TL	
260	17	1086+33			Construction of an 80 foot high Monopole for a Cell Tower. The work includes a 32' x 83' compound, PG&E 100 KVA transformer box, 600 AMP PG&E Electrical Meter Service.	Cutoff wall		Cell	
	16/17	1080+00			Reach 16/17 Transition				
261	16	1079+91	2,183,133.99	6,670,212.82	8 inch Gas Line	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.5
262	16	1073+41	2,182,671.85	6,670,670.15	16 inch Gas Line (PG&E Map shows the gas main as 12 inch)	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.5
263	16				Excavation into the levee on the waterside approximately 0.5 to 2 feet, near vertical in some places. Minor rutting, ponding, and depressions in the levee toe road. CVFPB sent a encroachment violation notice on August 16, 2011 to City of Yuba City.	No Rehabilitation Required		struc	
264	16	1054+75	2,181,074.23	6,671,588.96	Telephone Call box on landside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	
265	16	1043+52	not verified		Abandon 36 inch pipe	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SS(G)	
266	16	1043+52	2,180,149.57	6,672,223.24	Abandoned 27 inch Centrifugal Spun Concrete Pipe. City of Yuba City Drawing 214-D per 1949 plans	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SS(G)	38.6
267	16	1043+45	2,180,137.11	6,672,230.51	To install a 36 Inch discharge pipe through right bank of Feather River.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	5.0
268	16	1043+27	2,180,126.23	6,672,235.13	To install a 24 inch wrapped steel pipe through the right bank levee of the Feather River	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	2.0

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
269	16	1043+22	2,180,121.72	6,672,237.88	To construct a 24 inch steel pipe storm drainage discharge pipe crossing the west levee of the Feather River	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	4.0
270	16	1043+03	2,180,106.36	6,672,244.70	Gilsizer Slough Storm Drain Facilities. A 16 inch welded steel discharge pipe crossing of levee. (copy of record drawings)	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	1.3
271	16	1037+50	Not Verified		Abandoned 8 inch gas line through levee. Removed per Permit 1445A	No Rehabilitation Required	Not sure if the abandonment meets title 23 requirements. Pipe may need to be properly abandoned or completely removed.	GL	
272	16				To construct approximately 4,400 lineal feet of filter trench adjacent to the right bank levee of the Feather River. The proposed trench will be located at the landward levee toe, be 3 feet wide and 4 feet deep.	No Rehabilitation Required			
273	16	1028+11	2,178,636.47	6,672,461.02	Power pole in waterside slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	
274	16	1029+10	2,179,608.80	6,672,356.03	To bury existing two submarine telephone cables into two parallel trenches 100 feet apart in the channel of the Feather River. Both cables were installed per Permit 1334 in September 15, 1948. The permit stated the cable will be buried to a depth of five feet in the levees.	No Rehabilitation Required	The conduit may not meet title 23 requirements. **Replace in accordance with USACE standard**	TL	5.0
275	16	1028+10	2,179,506.59	6,672,370.16	To bury existing two submarine telephone cables into two parallel trenches 100 feet apart in the channel of the Feather River. Both cables were installed per Permit 1334 in September 15, 1948. The permit stated the cable will be buried to a depth of five feet in the levees.	No Rehabilitation Required	The conduit may not meet title 23 requirements. **Replace in accordance with USACE standard**	TL	2.0
276	16	1026+71	21,784,783.54	6,672,514.29	10" overside Drain line on the water side levee slope for bridge area drainage	Seepage berm	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	TL	
277	~~16~~	~~1026+70~~			~~To place a 10 Inch diameter conduit containing fiber optic cables across and under (bored) the channel and through the right bank of the Feather River. The permit was withdrawn on 9-6-00 according to the CVFPB file.~~	Seepage berm		TL	
278	16	1026+58	2,178,488.35	6,672,429.49	40 foot long retaining wall landside of levee just upstream of the Feather River Bridge	Seepage berm		Road	
279	16	1026+22	2,178,451.96	6,672,425.20	Feather River Bridge (SR 20) upstream side	Seepage berm		Bridge	
280	16	1025+32	2,178,375.92	6,672,443.76	Feather River Bridge (SR 20) downstream side	Seepage berm		Bridge	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
281	16	1025+32	2,178,375.92	6,672,443.76	Seismic Retro of Feather River Bridge and bike paths on both sides of bridge	Seepage berm		Bridge	
282	16	1024+95	2,178,319.03	6,672,456.34	12 kv power line across levee	Seepage berm	**Relocate outside of of the proposed right-of-way.**	EL	OH
283	16	1024+70			Backfill Community Swimming Pool located near the base of the Feather River Bridge (10th Street Bridge)	Seepage berm		struc	
284	16	1024+48	2,178,296.55	6,672,470.53	40 foot long retaining wall landside of levee just downstream of the Feather River Bridge	Seepage berm		Road	
285	16	1021+95	2,178,044.07	6,672,487.29	12 kv power line across levee	No Rehabilitation Required		EL	OH
286	16	1021+00			Telephone line on river slope of levee 260 feet downstream of Feather River Bridge (10th Street Bridge)	No Rehabilitation Required		TL	
287	16	1020+85			Abandon 4 inch pipe	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(G)	1.3
288	16	1020+30	2,177,879.35	6,672,496.38	Telephone Call box on waterside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	
289	16	1019+82	2,177,832.15	6,672,504.71	Power pole in waterside slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
290	16	1013+00			To place approximately 4,000 feet of blanket drain and filter trench on the right bank of levee of the Feather River upstream and downstream of the SR 20 Bridge	No Rehabilitation Required		Struc	
291	16	1010+75	2,176,773.87	6,672,930.97	Install Guy within in landside slope of levee, 12 kV overhead electric	No Rehabilitation Required		EL	
292	16	1008+38	2,176,779.63	6,672,929.15	12 kv power line across levee	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
293	16	1007+50			To construct approximately 1,300 feet of 12 foot wide bicycle trail on the crown of the right bank levee of the Feather River. The Project is located in Yuba City between the 5th Street Bridge and the easterly extension of Teagarden Avenue.	Jet Grouting		Struc	
294	16	1007+50			4' by 3' deep erosion pocket. 4 foot vertical bank under Twin Cities Memorial Bridge	Jet Grouting		struc	
295	16	1007+50			To construct a bicycle trail for approximately 3.5 miles on the right bank levee other the Feather River from Shanghai Bend Road to Northgate Boulevard	Jet Grouting		Road	
296	16	1007+50			Bike Path below Twin Cities Memorial Bridge	Jet Grouting		Road	
297	16	1007+51	2,176,709.34	6,672,981.09	Twin Cities Memorial Bridge upstream side	Jet Grouting		Bridge	
298	16	1007+46	2,176,706.50	6,672,984.37	Light pole in water side levee slope	Jet Grouting	**Relocate outside of of the proposed right-of-way.**	EL	OH
299	16	1007+06	2,176,671.72	6,673,005.93	Twin Cities Memorial Bridge downstream side	Jet Grouting		Bridge	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
300	16	1006+93	2,176,642.84	6,672,995.25	Power line and Anchor in Levee (actual location)	Jet Grouting		EL	
301	16	1006+60	2,176,647.27	6,673,046.63	Sacramento Northern Railroad	Jet Grouting		RR	
302	16	1006+07	2,176,610.55	6,673,084.90	Power Pole and anchor in slope of levee. 100 feet south of the SNRR bridge w/ service power overhead	Jet Grouting		EL	OH
303	16	1006+00			City of Yuba City. To replace the existing retaining wall with an 8 foot high, 76 foot long concrete retaining wall on the landside of the right (east) bank levee of Feather River.	Jet Grouting		struc	
304	16	1005+80			Concrete steps and 4 inch diameter PVC pipe on the landward slope and a pump house within 10 feet of the landward toe.	No Rehabilitation Required		struc/IR (P)	
305	16	1003+72	2,176,461.52	6,673,266.98	Power Pole and anchor in slope of levee. 300 feet south of the SNRR bridge	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
306	16	1000+50			A 3-wire barded wire fence with a gate within 5 feet of the levee toe and two mature trees at the landward toe. The project is located on Keyser Street	No Rehabilitation Required		struc	
307	16	999+90			A 120 foot long building at the landward toe	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
308	16	995+50			Authorize a 3-wire barded wire fence and two mature trees at the landward toe. The project is located at 563??? Second Street	No Rehabilitation Required		struc	
~~309~~	~~16~~	~~995+50~~			~~To excavate 25 feet into landward side of the right bank of the Feather River and construct a concrete retaining wall to provide parking lot space. The project is located at 463 2nd Street behind the Sutter County Administration Building/~~	~~No Rehabilitation Required~~		~~struc~~	
~~310~~	~~16~~	~~993+56~~			~~To install approximately 1,010 feet of 8 foot high chain link fence on the waterside side of the right bank levee of the Feather River.~~	~~No Rehabilitation Required~~		~~struc~~	
311	16	993+25			A building near the landward toe of the levee.	No Rehabilitation Required		struc	
312	16	992+00			A shed, concrete wall, and chain-link fence with gate at landward toe. The permit also covers two steel posts on the shoulder and seventeen mature trees on the landward slope	No Rehabilitation Required		struc	
313	16	991+00			A shed at the landward toe	No Rehabilitation Required		struc	
314	16	992+00			A two-story garage and shop building at the landward toe and six mature trees on the landward slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
315	16	989+75			A building at the landward toe and 21 mature trees and sprinkler system on the landward slope.	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
316	16	988+05	2,175,065.02	6,673,942.87	3 inch steel pipe, does not appear to cross levee anymore	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	
317	16	989+20			A garage and a shed at the landward toe	No Rehabilitation Required		struc	
318	16	988+50			Authorize a small building, a chain-link fence, four mature trees at the landward toe, and five clumps of oleanders on the landward slope.	No Rehabilitation Required		struc	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
319	16	987+60			Authorize a small building and a chain link fence on an existing retaining wall at the landward toe, concrete stairs, a steel pipe frame, and two large mature trees on the landward slope. A hose bib on the landward shoulder of the right bank of levee.	No Rehabilitation Required	**Recommended Relocation**	struc	
320	16	986+75			A see-through fence on a 5 foot retaining wall, steps, and nine mature trees on the landward slope.	No Rehabilitation Required		struc	
321	16	986+00			Concrete steps with railing and pomegranate bush on landward slope. The permit also covers a concrete retaining wall at the landward toe.	No Rehabilitation Required		struc	
322	16	985+30			Chain Link fence with gate, three oleander trees, and steps within the landward slope.	No Rehabilitation Required		struc	
323	16	984+50			Chain Link fence with gate, three oleander trees, and steps within the landward slope.	No Rehabilitation Required		struc	
324	16	983+20			A building, barbed wire fence, and ten trees at landward toe	No Rehabilitation Required		struc	
325	16	981+25			A 60 foot long see-through board fence and 75 foot long clothesline and landward toe. A shed 5 feet from landward toe and a mature oak tree on the landward slope	No Rehabilitation Required		struc	
326	16	980+15			A chain-link fence with gate within 10 feet of landward toe	No Rehabilitation Required		struc	
327	16	979+90			A see-through fence and storage shed within 10 feet of the landward toe. The project is located at 265 Second Street, Yuba City, CA	No Rehabilitation Required		struc	
328	16	979+40			A see-through fence and storage shed within 5 feet of the landward toe. The project is located at 261 Second Street, Yuba City, CA	No Rehabilitation Required		struc	
329	16	978+80			A Chain Link fence with gate within 5 feet of landward toe, a cedar tree at the landward toe, and stone steps on the landward slope. This project is located at 255 Second Street.	No Rehabilitation Required		struc	
330	16	976+10			A shed and three trees at the landward toe of the right bank levee of the Feather River. The project is located at 225 Second Street, Yuba City, CA 95591	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
331	16	975+40			A 6 foot high chain link fence and gate at the right bank levee of the Feather River	No Rehabilitation Required		struc	
332	16	974+25			A residence within 5 feet of the landward toe	No Rehabilitation Required		struc	
333	16	973+30			A residence at landward toe and oak on the landward slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
334	16	975+00			To construct a restroom facility with septic tank and leach lines at the Yuba City Boat Ramp on the right bank of the Feather River.	No Rehabilitation Required		struc	
335	16	972+29			2 Inch Domestic Water Line serving the Yuba City Boat Dock.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with Title 23**	W(P)	
336	16	972+00			To construct improvement for the boat launching ramp and related facilities on the right bank of the Feather River.	No Rehabilitation Required		struc	
337	16	972+00			To construct improvement for the Yuba City Boat Ramp consisting of a paved parking area, restroom facilities, floating boat dock and extension of concrete boat ramp on the right bank of the Feather River.	No Rehabilitation Required		struc	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
338	16	972+00			To reconstruct an existing access road to the Yuba-Sutter Boat Ramp on the right bank of the Feather River	No Rehabilitation Required		struc	
339	16	972+00			To maintain and operate existing boat dock for public use for boating, fishing, and a campground with related facilities including a mobile home on the right bank of the Feather River.	No Rehabilitation Required		struc	
	15/16	968+50			Reach 15/16 Transition	No Rehabilitation Required			
340	15	968+00			To construct 120 lineal feet of sheet piles retaining wall, and nine 10 x 10 foot boat docks supported by seven 12 inc diameter steel piles to an existing 30 foot wide ramp (Yuba City Boat Ramp)	No Rehabilitation Required	Located within floodway. Does not affect levee project.	struc	
341	15	964+78			Telephone Call box on waterside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	
	14/15	954+40			Reach 14/15 Transition	No Rehabilitation Required			
342	14	952+00			12 kv cable	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	UG
	13/14	927+00			Reach 13/14 Transition	No Rehabilitation Required			
343	13	925+16			Telephone Call box on waterside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	
344	13	925+00			To construct access ramps	No Rehabilitation Required	Located within floodway. Does not affect levee project.	struc	
345	~~13~~	~~920+00~~			~~Consolidated Area Housing Authority of Sutter County. Strom Drainage Pipe Crossings. The size and location of the pipe is unknown. They have retention pond located at southwest corner of the airport. The Airport Business Park proposed crossing but application never filed.~~	~~Cutoff Wall~~	~~The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed.~~ ~~**Replace in accordance with Title 23**~~	~~SD (P)~~	
346	13	913+19	2,168,046.21	6,673,496.81	Two 16 inch gas lines. (PG&E map shows the gas lines as 2-12 inch)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.0
347	13	894+23	2,166,221.70	6,673,147.49	To install a 12kv buried power cable through the right bank levee and across the right bank overflow of the Feather River, a total distance of 896 feet. Poles will be installed near the top of the banks of the low water channel and aerial cable will be placed between the two poles which will be connected to the underground cable.	Cutoff Wall	The cable appears to meet title 23 requirements but the cutoff wall will remove improvements. **Replace in accordance with USACE standard**	EL	UG
348	13	893+84	2,166,181.41	6,673,142.43	Garden Highway Industrial Park. To install a 12 inch steel storm drain pipeline through the right bank levee of the Feather River (Source: City of Yuba City Pump Station No. 1)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	3.3
349	13	893+78	2,166,175.45	6,673,142.43	Burns Drive Storm Water Pump Station. 16 inch steel storm drain discharge pipe through levee. (Source: City of Yuba City Pump Station No. 1)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	2.7
350	13	881+40	2,164,942.19	6,673,036.13	Levee District No. 1 Relief Well Pump Station 6" pipes located just southeast of the Waste Water Treatment Plant. The waterside outlet structure has cobbles and the flap gate is damaged or plugged. CVFPB sent a notice of encroachment violation on August 16, 2011 to Sutter County.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Recommended Removal**	RW(P)	5.1

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
351	13	881+43	2,164,944.70	6,673,036.17	Levee District No. 1 Relief Well Pump Station 14" pipes located just southeast of the Waste Water Treatment Plant. The waterside outlet structure has cobbles and the flap gate is damaged or plugged. CVFPB sent a notice of encroachment violation on August 16, 2011 to Sutter County.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Recommended Removal**	RW(P)	5.1
352	13	856+23	2,162,702.52	6,674,085.34	South Yuba City Seepage Interceptor Pump Station 24 inch 7 GA Steel Pipe asphalt coated and wrapped with asphalt saturated felt discharge pipe (Source: City of Yuba City Pump Station No. ?)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Recommended Removal**	SD(P)	5.2
353	13	856+08	2,162,689.81	6,674,093.30	South Yuba City Storm Drainage Pump Station 24 inch 7 GA Steel Pipe asphalt coated and wrapped with asphalt saturated felt discharge pipe (Source: City of Yuba City Pump Station No. 3)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	5.2
354	13				Seepage Interceptor Trench and additional relief wells. The improvements were adjacent to the River Oaks subdivision between the wastewater treatment plant and Shanghai Road. All work on landside of levee.	Cutoff wall		struc	
355	13	849+85			Telephone Call box on waterside hinge point	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	TL	
356	13				Bike Path below Twin Cities Memorial Bridge	Cutoff wall		struc	
	12/13	845+00			Reach 12/13 Transition				
~~357~~	~~12~~				~~Shanghai Bend Road Setback levee project~~	No Rehabilitation Required		~~struc~~	
358	12	832+24	to be installed	to be installed	City of Yuba City Sewer 24 inch welded steel pipe mortar lined and coated pipe discharge pipe. This pipeline shall replace the existing 24 inch located at Station 828+55. The existing pipeline will be removed and disposed.	No Rehabilitation Required	This is a new pipelines that will meet Title 23 and USACE requirements except as noted in variance column.	SS(P)	2.0
359	12	832+17	to be installed	to be installed	City of Yuba City Sewer 2-24 inch welded steel pipe mortar lined and coated pipe discharge pipe. This is a new pipeline requested by the City of Yuba City.	No Rehabilitation Required	This is a new pipelines that will meet Title 23 and USACE requirements except as noted in variance column.	SS(P)	2.0
	11/12	830+00			Reach 11/12 Transition				
360	11	828+55	2,160,267.77	6,675,134.01	City of Yuba City Sewer 24 inch welded steel pipe mortar lined and coated pipe (wall thickness 0.188" min) Discharge Pipe to river diffuser	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SS(P)	2.3
~~361~~	~~11~~				~~To place an 18 inch storm drain pipeline through the levee on the right bank of the Feather River **(project was not completed - no pipeline installed)**~~	~~Cutoff Wall~~		~~SD(P)~~	
	10/11	774+00			Reach 10/11 Transition	Cutoff Wall			
362	10	771+30			Construct a gaging station approximately 150 feet downstream form the present gaging station, known as Feather River below Shanghai Bend. It is proposed to install an 8 foot high by 5 foot 4 inch square recorder house on the right bank berm approximately 155 feet from centerline of levee.	Cutoff Wall		struc	
363	10	750+40	2,152,869.21	6,673,338.66	115 kv steel tower transmission line crossing of levee	Cutoff Wall		EL	OH
364	10	750+10	2,152,823.05	6,673,332.24	12 kv power line crossing of levee	Cutoff Wall		EL	OH
	9/10	706+50			Reach 9/10 Transition	Cutoff Wall			

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
365	9	692+00			To construct 140 lineal feet of sheet piles retaining wall, and nine 10 x 20 foot boat docks supported by seven 12 inch diameter steel piles to an existing 30 foot wide ramp (Boyd Pump Boat Ramp)	Cutoff Wall	Located within floodway. Does not affect levee project.	struc	
366	9	692+00			To improve the existing Boyd Pump Boat Launching Facility by widening the existing ramp to 30 feet with 4 foot walkways on each side, paving existing access road, and expanding parking area by 25 spaces, and placing riprap on the right bank of the Feather River.	Cutoff Wall		Struc	
367	9	692+00			To construct boat launching ramp, well, pump, pressure system, and sanitary facilities on the right bank overflow of the Feather River	Cutoff Wall		Struc	
368	9	689+09	2,146,949.33	6,672,031.04	Oswald Mutual Water Company (Boyd's Pump) 18 inch epoxy coated mortar lined steel pipe through existing 24 inch concrete pipe crossing of levee	Cutoff Wall	The pipeline does not meet title 23 requirements. The facility will need to go up and over the levee and will need a positive shut-off structure installed and anti-siphon device. **Replace in accordance with USACE standard**	IR(P)	27.6
369	9	689+00	2,146,953.52	6,672,029.11	To replace an existing pole line with a new pole line across the right bank levee of the Feather River. A new pole will be placed 10 feet landward of the landward toe of the levee and another pole will be placed 24 feet water ward of the water ward toe of the levee.	Cutoff Wall		EL	OH
370	9	689+00	2,146,953.52	6,672,029.11	To place a service line on a PG&E pole crossing the right bank levee of the Feather River	Cutoff Wall		TL	OH
371	9	688+90			Irrigation Production Well (located 25 foot west of landside levee toe)	Cutoff Wall		well	
372	9	669+20			Sierra Gold Nursery. Service Pole, Electrical Panel, Meter, and Irrigation Production Well 30 feet from landside levee toe.	Cutoff Wall		well	
373	9	664+07	2,144,450.88	6,672,127.42	Sierra Gold Nursery. An 8 inch steel pipe through levee. This pipe was pressure checked and in 1984 as part of permit 13980 to connect to existing pipe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	SD(P)	3.6
374	9	664+20			To reconstruct and pave a 12 foot wide, approximately 1370 feet long road on the landside toe of the right bank levee of the Feather River	Cutoff Wall		struc	4.0
375	9	655+50			Service Pole, Electrical Panel, Water Well, Pump, and irrigation facilities	Cutoff Wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
	8/9	654+75			Reach 8/9 Transition				
376	8	649+11	2,142,954.74	6,672,128.18	Construct #3/4 ACSR 12kv pole line across the right bank levee of the Feather River, approximately 1900 feet southerly from Messick Road extended easterly to the river. Extension to serve 50 HP agricultural pump for C.E. Sullivan	Cutoff Wall		EL	OH
377	8	647+74	2,142,830.08	6,672,119.48	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.6
378	8	647+70	2,142,826.16	6,672,118.89	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.3

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
379	8	647+66	2,142,822.01	6,672,118.27	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.4
380	8	647+61	2,142,817.52	6,672,117.60	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.3
381	8	638+20			Service Pole, Electrical Panel, Water Well, Pump, Sand Seperator, Concrete Pad, and irrigation facilities (20 feet west of levee toe)	Cutoff Wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
382	8	622+79			Stand pipe, Service Pole, Electrical Panel, and Pump House, Water Well, and Pump at landside levee toe	Cutoff Wall	The water well does not meet Title 23 since too cloase to levee. The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
383	8	622+79	2,140,350.59	6,671,955.66	Installation of a 12kv power line crossing of the right bank of the Feather River.	Cutoff wall		EL	OH
384	8	603+50			Service Pole, Electrical Panel, Water Well, Pump, Sand Seperator, Concrete Pad, and irrigation facilities (40 feet west of levee toe)	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	well	
	7/8	596+00			Reach 7/8 Transition	Cutoff wall			
385	7	592+67	2,137,447.24	6,671,791.94	12 kv power line across levee	Cutoff wall		EL	OH
386	7	587+00	2,136,925.70	6,671,619.94	Spur Levee upstream of Abbott Lake	Cutoff wall		struc	
387	7				WS Slope varies from 3:1 near crown to 2:1 to 1:1 at toe. Sloughing and caving toe. Along slope I is hummocky; possibly from local slumping.	Cutoff wall		struc	
388	7				caving and slumping at toe. Rip rap berm toe. Diffcult to evaluate due to vegetation growth.	Cutoff wall		struc	
389	7	560+00			To fill in approximately one mile of an existing irrigation ditch at the waterside toe of the right bank of the Feather River.	Cutoff wall with existing relief wells	**Relocate outside of of the proposed right-of-way.**	Struc	
390	7				Bank caving 3 to 4 feet high, intermittent repair with rip rap berm at base of over steepened slope	Cutoff wall with existing relief wells		struc	
391	7	560+00			To construct a water well with a 14 inch casing in the right bank overflow of the Feather River at Abbott Lake	Cutoff wall with existing relief wells		well	
392	7	560+00			To extend approximately 2,500 of 12kv electric service line in the right bank overflow area of the Feather River near Abbott Lake to serve 25 HP Ag Pump for A.S. Cozzolino.	Cutoff wall with existing relief wells		EL	OH
393	7	557+00			Service Pole, Electrical Panel, Water Well, Pump, Sand Seperator, Concrete Pad, and irrigation facilities (50 feet west of levee toe)	Cutoff wall with existing relief wells	**Relocate outside of of the proposed right-of-way.**	well	
394	7	545+41	2,132,940.57	6,672,317.26	Crushed CMP Riser in Land Side Slope. Possible location of 8 inch steel pipe.	Cutoff wall with existing relief wells	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(A)	3.1
395	7	536+73	2,132,153.19	6,672,681.57	Existing 10 inch steel pipe. Removed in 1964 by Levee District No. 1 as part of permit 4775	Cutoff Wall		IR(?)	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
396	7	536+64	2,132,149.73	6,672,692.81	5 inch steel drainage pipe	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(P)	2.0
397	7	532+00 to 596+00			Taylor Brothers. 15 Inch Irrigation Main located within 15 feet of landside toe	Cutoff Wall	The pipeline is within twenty (20) feet of the levee toe and does not meet Title 23. **Relocate outside of of the proposed right-of-way.**	IR (G)	
398	7	529+47	2,131,549.40	6,673,081.12	Abandon 6 inch pipe	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(A)	4.0
399	7	515+00			Seepage Interceptor Trench for Star Bend Relief Well Pumps	Cutoff Wall		struc	
400	7	512+08	2,130,379.55	6,674,329.99	Corp of Engineers Star Bend Road Relief Well Pump Station north 15" Steel Discharge Pipe Crossings	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed. **Replace in accordance with USACE standard**	SD(P)	3.8
401	7	512+04	2,130,375.66	6,674,332.71	Corp of Engineers Star Bend Road Relief Well Pump Station south 15" Steel Discharge Pipe Crossings	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed. **Replace in accordance with USACE standard**	SD(P)	3.7
402	7	510+97	2,130,288.81	6,674,393.77	12 kv power line crossing of levee	Cutoff Wall		EL	OH
	6/7	510+37			Reach 6/7 Transition	Cutoff Wall			
403	6	510+50			To retain a 12 kv overhead service line and four power poles in the right bank overflow area of the Feather River.	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
404	6	510+36	2,130,239.19	6,674,428.41	Volcano Vista Farms 18 inch steel irrigation discharge pipe crossing of levee	Cutoff Wall		IR(P)	4.0
405	6	510+30			To install 20 hp irrigation pump and to retain an existing walnut orchard (35 acres) all on the right bank of the Feather. Now owned by Volcano Vista Farms and located on Tudor Mutual Pump Station (relocated pipeline part of permit 18438)	Cutoff Wall		IR(P)	
406	6	510+25	2,130,230.41	6,674,434.54	Tudor Mutual Water Company North 30 inch steel irrigation discharge pipes crossing of levee	Cutoff Wall		IR(P)	4.2
407	6	510+20	2,130,222.24	6,674,437.45	Tudor Mutual Water Company South 30 inch steel irrigation discharge pipes crossing of levee	Cutoff Wall		IR(P)	4.1
408	6				12 inch steel pipe through levee	Cutoff Wall	The conduit may meet title 23 requirements but will need to be replaced during cutoff wall construction. **Replace in accordance with USACE standard**		
409	6				12 kv power line crossing of levee	Cutoff Wall			
410	6				12 kv power line crossing including 9 power poles and 3 anchors (appears to cover permit 2502 and 5072)	Cutoff Wall			
411	6				Abandon 14 inch pipe (this pipeline removed as part of 2009 setback levee project). Listed as 10" Steel in original 1955 O&M manual.	Cutoff Wall	**Recommended Removal**	IR(P)	4.1

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
412	6	509+00			To construct approximately 1,400 lineal feet of filter trench adjacent to the right bank levee of the Feather River	Cutoff Wall		Struc	
413	6	508+00			To clear, level, and plant a peach orchard on approximately 170 acres on the right bank of the Feather River.	Cutoff Wall		Trees	
414	6				Fix in-place the existing levee with 65ft deep cutoff wall between station 478+68 and station 512+00	Cutoff Wall		struc	
	5/6	478+68			Reach 5/6 Transition	Cutoff wall with seepage berm			
415	5	475+00			To plant walnut orchard in the right overflow area of the Feather River downstream from Star Bend	Cutoff wall with seepage berm		Trees	
	5	461+00			Urban (200 year) North - Nonurban (100 year) South Transition	Cutoff wall with seepage berm			
416	5	460+11	2,125,845.57	6,676,268.36	Abandon 8" steel drainpipe. The CVFPB sent an encroachment violation notice on August 16, 2011 to Dan Stephens Trust.	Cutoff wall with seepage berm	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(P)	4.1
417	5	442+80	2,124,212.69	6676803.8	Abandon 8" steel drainpipe	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(P)	4.1
418	5	433+50	2,123,304.56	6,677,004.67	Power line across levee to service pole with meter on waterside slope of levee	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
419	5	409+00 to 424+00			Taylor Brothers. 15 Inch Irrigation Main located within 15 feet of landside toe	Cutoff wall	The pipeline is within twenty (20) feet of the levee toe and does not meet Title 23. **Relocate outside of of the proposed right-of-way.**	IR (G)	
420	~~5~~	~~417+66~~	~~Not Verified~~		~~Abandon Existing 24 inch pipe through levee. The permit was revised to removal of 24 inch via 4666A so there should not be any pipe.~~	~~Cutoff wall~~		~~SD(G)~~	
	4/5	410+67			Reach 4/5 Transition	Cutoff wall			
421	4	410+53	2,121,173.09	66,776,661.21	Power line crossing to Feather Water District Pumps	Cutoff wall		EL	OH
422	4	409+84	2,121,105.29	6,677,660.77	To install a 2 inch electrical conduit through the levee. The conduit will be buried in the levee slopes and through the crown with one foot of cover. The conduit will provide electrical service to an existing pumping plant in the floodway of the Feather River.	Cutoff wall	The conduit may meet title 23 requirements but will need to be replaced during cutoff wall construction. **Replace in accordance with USACE standard**	EL	2.0
423	4	409+66	2,121,086.77	6,677,660.88	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	0.8
424	4	409+62	2,121,082.47	6,677,660.77	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	0.9
425	4	409+58	2,121,078.48	6,677,660.82	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	0.8
426	4	409+55	2,121,075.08	6,677,660.80	Taylor Brothers Farm Irrigation Pump Station. A inclined pump located on the waterside slope of levee with 14 Inch Pipeline through levee	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.4
427	4	409+50	2,121,069.88	6,677,660.77	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.7

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
428	4	407+72	2,120,892.86	6,677,656.42	Abandoned pipe and structure at landside toe, pipe is 8 inch, but the headwall appears that it is ran through a larger older pipe possibly and old drainage pipe.	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	21.8
429	4	407+72	2,120,892.86	6,677,656.42	Taylor Brothers Production Water Well (facilities located at levee toe).	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	well	
430	4	396+32	2,119,752.28	6,677,651.86	8 inch pipe crossing. Headwall at land toe, art on land side of crown, and cut pipe near water side toe. CVFPB sent a notice of violation notice on October 4, 2011.	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(P)	4.1
431	4	396+50 to 409+00			Taylor Brothers. 15 Inch Irrigation Main located within 15 feet of landside toe	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	IR (G)	
432	4	396+50 to 409+00			Feather Water District. 42 Inch Irrigation Main located within 10 feet of landside toe with standpipes	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	IR (G)	
433	4	396+20			Feather Water District Irrigation Production Well (facilities located 10 foot west of toe). CVFPB sent a notice of violation notice on October 4, 2011.	Cutoff Wall		well	
434	4	386+63	2,118,786.69	6,677,704.40	Abandon 8 inch pipe crossing, stand pipe on land toe has been destroyed. CVFPB sent a notice of violation on October 4, 2011.	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	4.6
435	4	365+00	2,116,703.78	6,678,265.36	Abandon 8 inch pipe crossing, stand pipe on land toe has been removed.	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	4.8
436	4	342+27	2,114,521.83	6,678,856.40	Irrigation Production Well (located xx foot west of levee toe)	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	well	
437	4	320+00			Approximately 500 horizontal feet of vertical excavation in the levee toe, cut 1 to 3 feet high. CVFPB sent out a encroachment violation notice on July 27, 2011 to Monasterio Family Trust.	Cutoff Wall		struc	
438	4	313+00			Approximately 100 horizontal feet of vertical excavation in the levee toe, cut about 3 feet high. Toe excavations are eroding and caving. CVFPB sent out a encroachment violation notice on September 12, 2011 to Monasterio Family Trust.	Cutoff Wall		struc	
	3/4	300+66			Reach 3/4 Transition				
439	3	298+89	2,110,314.83	6,679,535.86	Removal of a portion and filling with concrete a portion of an abandoned 36 inch steel pipe through the right bank levee of the Feather River	Cutoff wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(G)	
440	3	298+00			Approximately 600 horizontal feet of vertical excavation in the levee toe, cut 1 to 3 feet high. Toe excavations are eroding and caving. The CVFPB sent an encroachment violation notice on July 27, 2011 to Golden Gate Hop Ranch, Inc..	Cutoff wall		struc	
441	3	298+67	2,110,292.12	6,679,458.78	Garden Highway Mutual Water - Irrigation Production Well #23 (located 30 foot west of levee toe)	Cutoff wall		IR(W)	
442	3	298+38	2,110,262.81	6,679,553.51	Garden Highway Mutual Water 54 inch Irrigation Pump Station Discharge Pipeline through Levee. The improvements include a inlet channel from the river to the 200 feet from waterside toe of levee and irrigation canal at the toe of the landside of levee.	Cutoff wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed and new pipe. **Replace in accordance with USACE standard**	IR(G)	25.1
	3	280+90			State Maintenance Area 3 / Levee District No. 1 Levees Transition	Cutoff wall			
443	3	279+50			Garden Highway Mutual Water - Irrigation Production Well #4 (located 90 foot west of levee toe)	Cutoff wall		IR(W)	
444	3	274+50			Garden Highway Mutual Water - Irrigation Production Well #22 (located 20 foot west of levee toe)	Cutoff wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	IR(W)	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
445	3	241+75			Garden Highway Mutual Water - Irrigation Production Well #18 (located 50 foot west of levee toe)	Cutoff wall		IR(W)	
446	3	219+00			Garden Highway Mutual Water - Irrigation Production Well #19 (located 90 foot west of levee toe)	Cutoff wall with seepage berm		IR(W)	
447	3	219+00			12 inch pipe. Appears to be removed by pipe laying on ground adjacent to location	Cutoff wall with seepage berm	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	
	2/3	218+66			Reach 2/3 Transition				
448	2	209+89	2,101,737.07	6,678,031.40	Electrical service crossing for pump	Cutoff wall with seepage berm	**Relocate outside of of the proposed right-of-way.**	EL	OH
449	2	209+23	2,101,673.35	6,678,014.21	Kuster Private Irrigation Pump Station. 14 inch welded steel pipe crossing	Cutoff wall with seepage berm	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed and new pipe. **Replace in accordance with USACE standard**	IR(P)	3.0
450	2	217+00			National Audubon Society. To plant approximately 4,000 native trees on 40 acres within the right bank overflow area of the Feather River.	Cutoff wall with seepage berm		Trees	
451	2	217+00			National Audubon Society. To plant approximately 300 to 500 native trees (primarily cottonwoods) on the right bank overflow area of the Feather River.	Cutoff wall with seepage berm		Trees	

Type 1A - Removal & Disposal of Abandoned Raised Pipe

Type 1B - Removal & Disposal of Abandoned Through Pipe

Type 2A - Removal & Replace of Raised Pipe

Type 2B - Removal & Replace of Through Pipe

Type 3A - Removal & Replace of Raised Pipe Adjacent to Canal

Type 3B - Removal & Replace of Through Pipe Adjacent to Canal

Type 3C - Removal & Replace of Through Pipe Under Canal

Vegetation ETL Compliance

Relocation of Utility/Structure Outside of The Proposed ROW

Additional Works

Not Applicable/No Rehabilitation Required

SD(G)	Storm Water - Gravity
SD(P)	Storm Water - Pressure
SS (G)	Waste Water - Gravity
SS (P)	Waste Water - Pressure
IR(G)	Irrigation Line - Gravity
IR(P)	Irrigation Line - Pressure
RW (P)	Raw Water - Pressure
W(P)	Water Line - Pressure
RD	
GL	Gas Line
TL	Telephone Line

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
		EL	Electrical Line						
		SEEP							
		STRUC	Structure						

Table 4-4A Summary of Construction Contracts for Alternative SB7

Features	Contract A Reach 2A-North to 5 180+00 to 478+68 2020 - 2021	Contract SBFIP Reach 6 478+68 to 512+00 2019 – 2020	Contract B Reach 7 to 12 512+00 to 845+00 2019 - 2020	Contract C1 Reach 13 to 18 845+00 to 1213+85 2017 – 2018	Contract C2 Reach 19 to 21 1213+85 to 1433+83 2017 – 2018
No Rehabilitation Required	N/A	N/A	1,300LF	14,930LF	N/A
Cutoff Wall Only	22,200LF	3,340LF	26,150LF	11,490LF	21,520LF
Jet Grouting Cutoff Wall Only	N/A	N/A	N/A	560LF	N/A
Seepage Berm Only	N/A	N/A	N/A	350LF	N/A
Cutoff Wall with Full Levee Degrade	N/A	N/A	N/A	N/A	N/A
Cutoff Wall with Full Levee Degrade and Existing Relief Wells	N/A	N/A	N/A	5,300LF	N/A
Cutoff Wall with Existing Relief Wells	N/A	N/A	3,300LF	2,630LF	N/A
Cutoff Wall with New Relief Wells (22 Wells)	N/A	N/A	2,500LF	N/A	N/A
Cutoff Wall with Seepage Berm	7,670LF	N/A	N/A	N/A	N/A
Cutoff Wall with Levee Relocation	N/A	N/A	N/A	N/A	N/A
Cutoff Wall with Sutter Butte Canal Relocation	N/A	N/A	N/A	N/A	370LF
Cutoff Wall with Landside Toe Fill	N/A	N/A	N/A	1,870LF	N/A
DSM Cutoff Wall (subpart of the Cutoff Wall Only area)	2,000LF	N/A	N/A	2,630LF	2,400LF
Erosion Protection	N/A	N/A	5,760LF	N/A	N/A
Utilities & Encroachments (Total, Table 4-4B)	37	12	46	129	45
Utilities & Encroachments (To be modified, Table 4-4B)	27	4	19	53	20
Land Acquisition					
Number of Impacted Parcel					
Number of Potential Structural Demolition					
Closure Structure	N/A	N/A	N/A	1	N/A

Table 4-4B Summary of Utilities & Encroachments for Construction Contracts

			Construction Contracts				
		Alt. SB7	**A**	**SBFIP**	**B**	**C1**	**C2**
Color Codes	**Types of Remediation**	Item No. 1 - 451	Item No. 415 - 451	Item No. 403 - 414	Item No. 357 - 402	Item No. 228 - 356	Item No. 142 - 227
	Type 1A - Removal & Disposal of Abandoned Raised Pipe	**16**	6	0	3	6	1
	Type 1B - Removal & Disposal of Abandoned Through Pipe	**3**	2	0	0	1	0
	Type 2A - Removal & Replace of Raised Pipe	**47**	7	0	9	25	6
	Type 2B - Removal & Replace of Through Pipe	**1**	1	0	0	0	0
	Type 3A - Removal & Replace of Raised Pipe Adjacent to Canal	**0**	0	0	0	0	0
	Type 3B - Removal & Replace of Through Pipe Adjacent to Canal	**0**	0	0	0	0	0
	Type 3C - Removal & Replace of Through Pipe Under Canal	**0**	0	0	0	0	0
	Vegetation ETL Compliance	**10**	3	1	0	0	6
	Relocation of Utility/Structure Outside of The Proposed ROW	**40**	8	1	7	18	6
	Additional Works	**6**	0	2	0	3	1
	Not Applicable/No Rehabilitation Required	**146**	10	8	27	76	25
Total Number of Utilities & Encroachments		**269**	37	12	46	129	45
Total Number of Utilities & Encroachments To Be Modified		**123**	27	4	19	53	20

Table 5-1B Summary of Project Features for Alternative SB8

Engineering Appendix Paragraph	Measure	Typical Section (Plate)	Segment	Contract	Beg. STA of Measure	End. STA of Measure	Length per Segment (LF)	Length per Contract (LF)	Length per Measure (LF)
5.2.1	No Rehabilitation Required	-	1	B	831+50	844+50	1,300	1,300	
	No Rehabilitation Required	-	2	C1	923+75	1006+24	8,249		
	No Rehabilitation Required	-	3	C1	1007+70	1024+00	1,630		
	No Rehabilitation Required	-	4	C1	1027+50	1078+00	5,050	14,930	
	No Rehabilitation Required	-	5	C2	1625+00	1673+00	4,800	4,800	
	No Rehabilitation Required	-	6	D1	1769+40	1813+30	4,390	4,390	
	No Rehabilitation Required	-	7	D2	2303+00	2331+00	2,800	2,800	28,220
5.2.2	Cutoff Wall Only	G-2A	1	A	231+00	453+00	22,200	22,200	
	Cutoff Wall Only	G-2A	2	SBFIP	478+68	512+00	3,332	3,340	
	Cutoff Wall Only	G-2A	3	B	570+00	831+50	26,150	26,150	
	Cutoff Wall Only	G-2A	4	C1	1078+00	1096+00	1,800		
	Cutoff Wall Only	G-2A	5	C1	1098+10	1107+00	890		
	Cutoff Wall Only	G-2A	6	C1	1125+70	1129+99	429		
	Cutoff Wall Only	G-2A	7	C1	1130+20	1213+85	8,365	11,490	
	Cutoff Wall Only	G-2A	7	C2	1213+85	1429+00	21,515		
	Cutoff Wall Only	G-2A	8	C2	1451+50	1455+00	350		
	Cutoff Wall Only	G-2A	9	C2	1461+00	1608+50	14,750		
	Cutoff Wall Only	G-2A	10	C2	1624+70	1625+00	30		
	Cutoff Wall Only	G-2A	11	C2	1673+00	1673+30	30	36,680	
	Cutoff Wall Only	G-2A	12	D1	1766+00	1769+40	340		
	Cutoff Wall Only	G-2A	13	D1	1813+30	1900+50	8,720		
	Cutoff Wall Only	G-2A	14	D1	1903+50	2122+00	21,850	30,910	
	Cutoff Wall Only	G-2A	14	D2	2122+00	2290+00	16,800	16,800	147,570
5.2.3	Jet Grouting Cutoff Wall Only	G-2A	1	C1	1006+04	1007+90	186		
	Jet Grouting Cutoff Wall Only	G-2A	2	C1	1095+80	1098+30	250		
	Jet Grouting Cutoff Wall Only	G-2A	3	C1	1129+50	1130+67	117	560	
	Jet Grouting Cutoff Wall Only	G-2A	4	D1	1900+00	1904+00	400	400	960
5.2.4	Seepage Berm Only	G-2B	1	C1	1024+00	1027+50	350	350	
	Seepage Berm Only	G-2B	2	D2	2290+00	2303+00	1,300		
	Seepage Berm Only	G-2B	3	D2	2331+00	2368+00	3,700	5,000	5,350
5.2.5	Cutoff Wall with Full Levee Degrade and Existing Relief Wells	G-2D	1	C1	844+50	897+50	5,300	5,300	5,300
5.2.5	Cutoff Wall with Full Levee Degrade	G-2D	2	C2	1455+00	1461+00	600	600	600
5.2.6	Cutoff Wall with Existing Relief Wells	G-2C	1	B	512+00	545+00	3,300	3,300	
	Cutoff Wall with Existing Relief Wells	G-2C	3	C1	897+50	923+75	2,625	2,630	5,930
5.2.6	Cutoff Wall with New Relief Wells	G-2C	2	B	545+00	570+00	2,500	2,500	2,500
5.2.7	Cutoff Wall with Seepage Berm	G-2C	1	A	180+00	231+00	5,100		
	Cutoff Wall with Seepage Berm	G-2C	2	A	453+00	478+68	2,568	7,670	7,670

Table 5-1B Summary of Project Features for Alternative SB8

Engineering Appendix Paragraph	Measure	Typical Section (Plate)	Segment	Contract	Beg. STA of Measure	End. STA of Measure	Length per Segment (LF)	Length per Contract (LF)	Length per Measure (LF)
5.2.8	Cutoff Wall with Levee Relocation	G-2E	1	C2	1432+70	1451+50	1,880		
	Cutoff Wall with Levee Relocation	G-2E	2	C2	1608+50	1624+70	1,620		
	Cutoff Wall with Levee Relocation	G-2E	3	C2	1673+30	1674+37	107	3,610	
	Cutoff Wall with Levee Relocation	G-2E	3	D1	1674+37	1754+30	7,993	8,000	11,610
5.2.9	Cutoff Wall with Sutter Butte Canal Relocation	G-2F	1	C2	1429+00	1432+70	370	370	
	Cutoff Wall with Sutter Butte Canal Relocation	G-2F	2	D1	1754+30	1766+00	1,170	1,170	1,540
5.2.10	Cutoff Wall with Landside Toe Fill	G-2G	1	C1	1107+00	1125+70	1,870	1,870	1,870
5.2.11	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	1	A	230+00	250+00	2,000	2,000	
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	2	C1	1125+00	1129+99	499		
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	3	C1	1130+20	1151+50	2,130	2,630	
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	4	C2	1224+00	1248+00	2,400	2,400	
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	5	D1	1987+25	2002+00	1,475		
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	6	D1	2016+75	2036+75	2,000		
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	7	D1	2067+00	2088+00	2,100	5,580	
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	8	D2	2137+00	2148+00	1,100		
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	9	D2	2182+00	2196+50	1,450		
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	10	D2	2245+75	2292+00	4,625	7,180	19,790
5.2.12	Erosion Protection	-	1	B	547+00	604+60	5,760	5,760	
	Erosion Protection	-	2	C2	1582+00	1601+00	1,900	1,900	7,660
5.2.13	Closure Structure (Stop Log)	-	1	C1	1130+00	1130+00	-	-	-

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
2A North	180+00 to 202+50	2,250	Cutoff wall with undrained seepage berm	180+00 to 202+50: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 180+00 to 202+50: Cutoff wall extending to an elevation of 25 ft.	
2B	202+50 to 218+66	1,616	Cutoff wall with undrained seepage berm	180+00 to 218+66: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 202+50 to 218+66: Cutoff wall extending to an elevation of 25 ft.	
3	218+66 to 300+66	8,200	Cutoff wall Cutoff wall with undrained seepage berm	218+66 to 231+00: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 218+66 to 230+00: Cutoff wall extending to an elevation of 25 ft. with 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 230+00 to 250+00: Cutoff wall extending to an elevation of -35 ft. 250+00 to 289+00: Cutoff wall extending to an elevation of -20 ft. 289+00 to 300+66: Cutoff wall extending to an elevation of -12 ft.	
4	300+66 to 410+67	11,001	Cutoff wall	300+66 to 312+00: Cutoff wall extending to an elevation of -12 ft. 312+00 to 349+00: Cutoff wall extending to an elevation of 15 ft. 349+00 to 368+00: Cutoff wall extending to an elevation of 10 ft. 368+00 to 410+67: Cutoff wall extending to an elevation of 20 ft.	

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
5	410+67 to 478+68	6,801	Cutoff wall Cutoff wall with undrained seepage berm	453+00 to 478+00: 300 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 410+67 to 417+00: Cutoff wall extending to an elevation of 20 ft. 417+00 to 425+00: Cutoff wall extending to an elevation of 10 ft. 425+00 to 456+00: Cutoff wall extending to an elevation of 15 ft. 456+00 to 475+35: Cutoff wall extending to an elevation of 15 ft. 475+35 to 478+68: Cutoff wall extending to an elevation of 15 ft.	
6 FIP	478+68 to 512+00	3,332	Cutoff wall	478+68 to 512+00: 65ft deep (from degrade line) cutoff wall.	
7	512+00 to 596+00	8,563	Cutoff wall Cutoff wall with existing and new relief wells Erosion Protection	512+00 to 514+00: 65ft deep (from degrade line) cutoff wall. 514+00 to 526+00: Cutoff wall tip elevation +15 feet 526+00 to 570+00: Cutoff wall tip elevation -5 feet 545+00 to 570+00: 22 new relief wells at 120 feet spacing and 50 feet depth (including new concrete lined V-ditch). 570+00 to 575+00: Cutoff wall tip elevation -5 feet 575+00 to 595+00: Cutoff wall tip elevation -10 feet 595+00 to 596+00: Cutoff wall tip elevation +15 feet 547+00 to 596+00: High Performance Turf Reinforce Mat (HPTRM)	512+00 to 545+00: existing seepage interceptor system (24 relief wells, ditch and pump station) are to remain.
8	596+00 to 654+75	5,875	Cutoff wall Erosion Protection	596+00 to 654+75: Cutoff wall tip elevation +15 feet 596+00 to 604+60: High Performance Turf Reinforce Mat (HPTRM)	

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
9	654+75 to 706+50	5,175	Cutoff wall	654+75 to 670+00: Cutoff wall tip elevation +15 feet 670+00 to 697+00: Cutoff wall tip elevation +20 feet 697+00 to 706+50: Cutoff wall tip elevation -10 feet	
10	706+50 to 774+00	6750	Cutoff wall	706+50 to 726+00: Cutoff wall tip elevation -10 feet 726+00 to 746+00: Cutoff wall tip elevation -5 feet 746+00 to 754+50: Cutoff wall tip elevation +5 feet 754+50 to 774+00: Cutoff wall tip elevation +25 feet	
11	774+00 to 830+00	5,600	Cutoff wall	774+00 to 784+50: Cutoff wall tip elevation +25 feet 784+50 to 827+50: Cutoff wall tip elevation -5 feet 827+50 to 830+00: Cutoff wall tip elevation +25 feet	
12	830+00 to 845+00	1,500	No proposed rehabilitation measure with exception below Cutoff wall (transition only, at both ends of this reach)	830+00 to 831+50: Cutoff wall tip elevation +25 feet (transition only) 844+50 to 845+00: Cutoff wall tip elevation -26 feet (transition only)	829+85 to 845+25: existing cutoff wall (23.5ft deep, tip elevation 30.5)
13	845+00 to 927+00	8,200	Cutoff wall Cutoff wall with full levee degrade and existing relief wells	844+50 to 897+50: Full levee degrade and re-construction 844+50 to 849+00: Cutoff wall tip elevation -20’ to -29’ 848+00 to 863+00: Cutoff wall tip elevation -29’ 863+00 to 877+00: Cutoff wall tip elevation -30’ 877+00 to 887+00: Cutoff wall tip elevation -31’ 887+00 to 893+00: Cutoff wall tip elevation -30’ 893+00 to 897+50: Cutoff wall tip elevation -29’ 897+50 to 923+75: Cutoff wall tip elevation +25’	844+50 to 897+50: Existing seepage interceptor system (52 relief wells, ditch and pump stations) are to remain. 897+50 to 923+75: Existing seepage interceptor system (29 relief wells, ditch and pump stations) are to remain. 923+23 to 927+00: existing cutoff wall (32.5ft deep, tip elevation 42.5)

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
14	927+00 to 954+40	2,740	No proposed rehabilitation measure	---	927+00 to 954+40: existing cutoff wall (32.5ft deep, tip elevation 42.5) No as-built drawing available for the existing cutoff wall.
15	954+40 to 968+50	1,410	No proposed rehabilitation measure	---	954+40 to 968+50: existing cutoff wall (32.5ft deep, tip elevation 42.5) No as-built drawing available for the existing cutoff wall.

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
16	968+50 to 1080+00	11,150	Jet grouting cutoff wall at 5th Street bridge crossing. Toe berm at 10th Street bridge crossing. Cutoff wall (transition only, at the end of Reach 16 to overlap existing cutoff wall).	1006+04 to 1007+90 (5th Street bridge crossing): Jet grouting cutoff wall tip elevation +40 feet 1023+90 to 1027+50 (10th Street bridge crossing): Toe berm, 23 feet wide, approximately 7 feet thick at the levee toe, 4H:1V slope at toe berm. 1077+85 to 1080+00: Cutoff wall tip elevation +30 feet and backfill landside toe depression (transition only).	968+50 to 983+23: existing cutoff wall (32.5ft deep, tip elevation 42.5) 983+23 to 996+23: existing cutoff wall (22.5ft deep, tip elevation 52.5) 996+23 to 1006+24: existing cutoff wall (32.5ft deep, tip elevation 42.5) 1007+90 to 1015+70: existing cutoff wall (32.5ft deep, tip elevation 42.5) 1015+70 to 1024+42: existing cutoff wall (43ft deep, tip elevation 35) 1026+99 to 1079+66: existing cutoff wall (39ft deep, tip elevation 38)

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
17	1080+00 to 1130+86	5,086	Cutoff wall Jet grouting cutoff wall at Yuba city water treatment plant Jet grouting cutoff wall at Railroad North of Yuba City Landside toe depression filled Closure Structure	1107+00 to 1125+70: Backfill landside toe depression 1080+00 to 1089+00: Cutoff wall tip elevation +30 feet 1089+00 to 1096+00: Cutoff wall tip elevation +35 feet 1095+80 to 1098+30: Jet grouting cutoff wall tip elevation +35 feet 1098+10 to 1125+00: Cutoff wall tip elevation +35 feet 1125+00 to 1129+99: Cutoff wall tip elevation +0 feet 1129+50 to 1130+67: Jet grouting cutoff wall tip elevation +0 feet 1130+20 to 1130+86: Cutoff wall tip elevation +0 feet 1130+00: Stop log closure structure or equivalence	
18	1130+86 to 1213+85	8,299	Cutoff wall	1130+86 to 1151+50: Cutoff wall tip elevation +0 feet 1151+50 to 1159+50: Cutoff wall tip elevation +30 feet 1159+50 to 1169+50: Cutoff wall tip elevation +25 feet 1169+50 to 1189+50: Cutoff wall tip elevation +30 feet 1189+50 to 1209+50: Cutoff wall tip elevation +40 feet 1209+50 to 1213+85: Cutoff wall tip elevation +35 feet	
19	1213+85 to 1297+83	8,398	Cutoff wall	1213+85 to 1219+75: Cutoff wall tip elevation +35 feet 1219+75 to 1224+00: Cutoff wall tip elevation +5 feet 1224+00 to 1238+00: Cutoff wall tip elevation -28 feet 1238+00 to 1248+00: Cutoff wall tip elevation -42 feet 1248+00 to 1268+75: Cutoff wall tip elevation +3 feet 1268+75 to 1297+83: Cutoff wall tip elevation +35 feet	
20	1297+83 to 1374+33	7,650	Cutoff wall	1297+83 to 1298+75: Cutoff wall tip elevation +35 feet 1298+75 to 1359+00: Cutoff wall tip elevation +50 feet 1359+00 to 1369+00: Cutoff wall tip elevation +40 feet 1369+00 to 1374+33: Cutoff wall tip elevation +32 feet	

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
21	1374+33 to 1433+83	5,950	Cutoff wall Levee relocation with cutoff wall (transition only) Canal relocation	1374+33 to 1386+50: Cutoff wall tip elevation +32 feet 1386+50 to 1408+50: Cutoff wall tip elevation +55 feet 1408+50 to 1433+83: Cutoff wall tip elevation +40 feet 1432+50 to 1433+83: Levee relocation (20ft riverward, transition only) 1429+00 to 1433+83 Sutter Butte Main Canal relocation.	
22	1433+83 to 1503+83	7,000	Cutoff wall Cutoff wall with full levee degrade Levee relocation with cutoff wall	1433+83 to 1450+00: Levee relocation (20ft riverward) 1451+50 to 1451+50: Levee relocation (20ft riverward, transition only) 1455+00 to 1461+00: Full levee degrade and re-construction 1433+83 to 1448+75: Cutoff wall tip elevation +40 feet 1448+75 to 1468+83: Cutoff wall tip elevation +50 feet 1468+83 to 1503+83: Cutoff wall tip elevation +55 feet	Full levee degrade and reconstruction recommended for a portion of this reach due to severe animal burrowing
23	1503+83 to 1609+37	10,554	Cutoff wall Levee relocation with cutoff wall (transition only) Erosion Protection	1503+83 to 1508+50: Cutoff wall tip elevation +55 feet 1508+50 to 1528+75: Cutoff wall tip elevation +60 feet 1528+75 to 1566+50: Cutoff wall tip elevation +55 feet 1566+50 to 1608+75: Cutoff wall tip elevation +60 feet 1608+50 to 1609+37: Levee relocation (20ft riverward, transition only) 1582+00 to 1601+00: High Performance Turf Reinforce Mat (HPTRM)	
24	1609+37 to 1623+86	1,449	Cutoff wall Levee relocation with cutoff wall	1609+37 to 1612+00: Levee relocation (20ft riverward, transition only) 1612+00 to 1623+00: Levee relocation (20ft riverward) 1623+00 to 1623+86: Levee relocation (20ft riverward, transition only) 1608+75 to 1623+86: Cutoff wall tip elevation +28 feet	

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
25	1623+86 to 1674+37	5,051	No proposed rehabilitation measure with exception below Cutoff wall (transition only, at both ends of this reach) Levee relocation with cutoff wall (transition only)	1623+86 to 1624+50: Levee relocation (20ft riverward, transition only) 1623+86 to 1625+00: Cutoff wall tip elevation +28 feet (transition only) 1673+00 to 1674+37: Cutoff wall tip elevation +65 feet (transition only) 1673+00 to 1674+37: Levee relocation (20ft riverward, transition only)	
26	1674+37 to 1707+11	3,274	Cutoff wall Levee relocation with cutoff wall	1674+37 to 1675+00: Levee relocation (20ft riverward, transition only) 1675+00 to 1707+11: Levee relocation (20ft riverward) 1674+37 to 1707+11: cutoff wall tip elevation +65 feet	Cutoff wall tip elevations to be confirmed by additional exploration (planned)
27	1707+11 to 1721+60	1,449	Cutoff wall Levee relocation with cutoff wall	1707+11 to 1721+60: Levee relocation (20ft riverward) 1707+11 to 1721+60: cutoff wall tip elevation +65 feet	Cutoff wall tip elevations to be confirmed by additional exploration (planned)
28	1721+60 to 1769+31	4,771	Cutoff wall Canal relocation Levee relocation with cutoff wall	1721+60 to 1753+00: Levee relocation (20ft riverward) 1753+00 to 1754+50: Levee relocation (20ft riverward, transition only) 1752+00 to 1766+00: Sutter Butte Main Canal Relocation 1721+60 to 1727+75: cutoff wall tip elevation +65 feet 1727+75 to 1748+50: cutoff wall tip elevation +75 feet 1748+50 to 1769+31: cutoff wall tip elevation +45 feet	Cutoff wall tip elevations to be confirmed by additional exploration (planned)
29	1769+31 to 1813+33	4,402	No proposed rehabilitation measure	---	No proposed rehabilitation measure as existing conditions meet criteria

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
30	1813+33 to 1902+00	8,867	Cutoff wall Jet grouting cutoff wall	1813+33 to 1816+50: cutoff wall tip elevation +80 feet 1816+50 to 1848+25: cutoff wall tip elevation +30 feet 1848+25 to 1866+00: cutoff wall tip elevation +70 feet 1866+00 to 1877+75: cutoff wall tip elevation +47 feet 1877+75 to 1883+00: cutoff wall tip elevation +40 feet 1883+00 to 1900+50: cutoff wall tip elevation +27 feet 1900+00 to 1902+00: jet grouting cutoff wall tip elevation +27 feet	Waterside slope maintenance to address sloughing of steep channel bank slopes may be required in the future.
31	1902+00 to 1958+00	5,600	Cutoff wall Jet grouting cutoff wall	1902+00 to 1904+00: jet grouting cutoff wall tip elevation +27 feet 1903+50 to 1907+50: cutoff wall tip elevation +27 feet 1907+50 to 1917+50: cutoff wall tip elevation +44 feet 1917+50 to 1927+50: cutoff wall tip elevation +75 feet 1927+50 to 1937+00: cutoff wall tip elevation +50 feet 1937+00 to 1958+00: cutoff wall tip elevation +40 feet	
32	1958+00 to 1989+00	3,100	Cutoff wall	1958+00 to 1971+00: cutoff wall tip elevation +40 feet 1971+00 to 1987+25: cutoff wall tip elevation +48 feet 1987+25 to 1989+00: cutoff wall tip elevation +10 feet	
33	1989+00 to 2122+00	13,300	Cutoff wall	1989+00 to 2002+00: cutoff wall tip elevation +10 feet 2002+00 to 2016+75: cutoff wall tip elevation +90 feet 2016+75 to 2036+75: cutoff wall tip elevation +20 feet 2036+75 to 2041+00: cutoff wall tip elevation +53 feet 2041+00 to 2067+00: cutoff wall tip elevation +38 feet 2067+00 to 2088+00: cutoff wall tip elevation +33 feet 2088+00 to 2122+00: cutoff wall tip elevation +90 feet	

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
34	2122+00 to 2182+00	6,000	Cutoff wall	2122+00 to 2137+00: cutoff wall tip elevation +90 feet 2137+00 to 2148+00: cutoff wall tip elevation +20 feet 2148+00 to 2164+00: cutoff wall tip elevation +90 feet 2164+00 to 2182+00: cutoff wall tip elevation +50 feet	
35	2182+00 to 2224+00	4,200	Cutoff wall	2182+00 to 2196+50: cutoff wall tip elevation +40 feet 2196+50 to 2212+00: cutoff wall tip elevation +45 feet 2212+00 to 2218+25: cutoff wall tip elevation +50 feet 2218+25 to 2224+00: cutoff wall tip elevation +55 feet	
36	2224+00 to 2259+00	3,500	Cutoff wall	2224+00 to 2233+50: cutoff wall tip elevation +55 feet 2233+50 to 2258+25: cutoff wall tip elevation +70 feet 2258+25 to 2259+00: cutoff wall tip elevation +42 feet	
37	2259+00 to 2290+00	3,100	Cutoff wall	2259+00 to 2277+00: cutoff wall tip elevation +42 feet 2277+00 to 2290+00: cutoff wall tip elevation +45 feet	
38	2290+00 to 2303+00	1,300	Seepage berm Seepage berm with cutoff wall (transition only, extend from Reach 37 into Reach 38,)	2290+00 to 2303+00: Seepage berm up to 11 foot high that extends horizontally at elevation 200 year + 4 feet for a distance of 50 feet from the landside slope of the levee before tapering to a height of 3 feet at the berm toe at a distance of 170 feet from the centerline of the existing levee. 2290+00 to 2292+00: Cutoff wall with tip elevation of +45 feet to (transition only).	Grading work to generate a level platform area will be required prior to construction of seepage berm
39	2303+00 to 2319+00	1,600	No proposed rehabilitation measure	---	No as-built drawing available for the existing cutoff wall.
40	2319+00 to 2359+00	4,000	Seepage Berm	2319+00 to 2331+00: No mitigation measure 2331+00 to 2335+00: Seepage berm 120 feet wide, 9 feet thick at the levee toe and 3 feet at the berm toe 2335+00 to 2359+00: Seepage berm 100 feet wide, 9 feet thick at the levee toe and 3 feet at the berm toe	Grading work to generate a level platform area will be required prior to construction of seepage berm

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
41	2359+00 to 2368+00	900	Seepage berm with filter drain	2359+00 to 2368+00: Seepage berm 100 feet wide, 5 feet thick at levee toe with a 1 foot thick filter layer (ASTM C33 fine aggregate) at bottom and across seepage berm. Seepage berm thickness of 5 feet includes 1 foot of filter layer and 4 feet of seepage berm material at levee toe. A geotextile separator, compatible with ASTM C33 fine aggregate, should be placed on top of the ASTM C33 fine aggregate layer.	Near Thermalito Afterbay dam and outfall facility and old Sutter Butte Canal channel

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
		2371+00			Hamilton Bend Levee Transition	Seepage berm			
	41	2368+00			End Reach 41	Seepage berm			
1	41	2365+00			To construct After bay River Outlet and dredge tailing training dike.	Seepage berm		Struc	
2	41	2359+58	2,291,802.63	6,663,263.33	Old Sutter Butte Head Works Levee North	Seepage berm	The structure does not meet title 23 requirements. **Recommend Complete Removal**	IR(G)	
3	41	2359+57	2,291,800.70	6,663,265.27	Old Sutter Butte Head Works North	Seepage berm		IR(G)	
4	41	2359+07	2,291,752.42	6,663,249.77	Old Sutter Butte Head Works South	Seepage berm		IR(G)	
5	41	2359+05	2,291,752.84	6,663,244.36	Old Sutter Butte Head Works Levee South	Seepage berm		IR(G)	
	40/41	2359+00			Reach 40/41 Transition	Seepage berm			
6	40	2352+90	2,291,166.67	6,663,263.09	12 kv overhead electrical power line crossing	Seepage berm	**Relocate outside of of the proposed right-of-way.**	EL	OH
7	40	2352+80			24 Inch CM pipe through levee. Concrete saddle and apron with Calco Slide gate.	Seepage berm	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(G)	
8	40	2345+79	2,290,475.75	6,663,109.16	10 inch Iron Pipe through levee that appears to be abandoned	Seepage berm	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	12.7
	39/40	2319+00			Reach 39/40 Transition	No Rehabilitation Required			
9	39	2312+05			24 Inch CM pipe through levee. Concrete saddle and apron with Calco automatic drainage gate.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(G)	
	38/39	2303+00			Reach 38/39 Transition	Seepage berm			
10	38	2301+00			To excavate dredger tailings from the right bank of the Feather River. The tailings are to be excavated from an area approximately 100 feet landward of the landward levee toe. **The application was deemed incomplete on 8-4-98.**	Seepage berm		Struc	
	37/38	2290+00			Reach 37/38 Transition	Cutoff wall			
	37	2285+00			Maintenance Area 07 / Hamilton Bend Levee Transition	Cutoff wall			
11	37	2283+65	2,285,659.90	6,661,586.51	24 Inch CM pipe through levee. Concrete saddle and apron with Calco automatic drainage gate.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	15.0
12	37	2283+44	2,285,640.25	6,661,593.28	24 Inch reinforced concrete encased CM irrigation pipe through levee. Slide Gate in 36 inch CM pipe riser on the waterside slope. 8 inch Irrigation pipe ran through existing pipe, pipe ends not exposed	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR (G)	17.3
13	37	2282+57	2,285,558.49	6,661,622.35	12 kv overhead electrical power line crossing	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
14	37	2281+75			Stairs and 1 Inch Domestic Water Line. Information Provided by Owner. Supplies water the Hauler.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	DW (P)	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
15	37	2274+95	2,284,812.04	6,661,741.46	24 Inch CM pipe through levee. Automatic drainage gate on waterside outlet, headwall on land side inlet. Both ends of the pipe have been cleared to operate.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	17.8
16	37	2274+86	2,284,802.77	6,661,742.00	24 Inch CM reinforced concrete encased drainage pipe through levee. Slide Gate in 36 inch CM pipe riser on the waterside slope. Neither pipe end located or exposed.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR (G)	21.8
17	37	2268+27	2,284,144.45	6,661,772.03	24 Inch reinforced concrete encased CM irrigation pipe through levee. Slide Gate in 36 inch CM pipe riser on the waterside slope with waterside outlet broken off and plugged.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(G)	18.4
18	37	2265+50	2,283,868.22	6,661,784.45	12 kv overhead electrical power line crossing	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
19	37	2262+69	2,283,587.31	6,661,797.10	24 Inch CM drain pipe through levee with landside headwall. Automatic Drainage Gate on the waterside end with splash pan and saddle headwall.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	18.0
20	37	2262+14	2,283,532.17	6,661,800.26	Road Across Levee North	Cutoff Wall		Road	
21	37	2261+90	2,283,505.66	6,661,801.21	Road Across Levee South	Cutoff Wall		Road	
22	37	2261+56	2,283,474.37	6,661,801.73	Propane tank at landside toe	Cutoff Wall	**Recommended Removal**	struc	
23	37	2261+11	2,283,429.45	6,661,804.82	Propane tank at landside toe	Cutoff Wall	**Recommended Removal**	struc	
24	37	2260+55	2,283,374.22	6,661,809.27	24 Inch CM pipe through levee. Concrete saddle and apron with Calco automatic drainage gate.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	18.1
	36/37	2259+00			Reach 36/37 Transition	Cutoff wall			
25	36	2256+94	2,283,026.77	6,661,894.43	24 Inch CM pipe through levee. Concrete saddle and apron with Calco automatic drainage gate.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	17.1
26	36	2256+71	2,283,007.16	6,661,905.92	24 Inch reinforced concrete encased CM irrigation pipe through levee. Slide Gate in 36 inch CM pipe riser on the waterside slope. Neither pipe end located or exposed.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(G)	19.1
27	36	2270+00			To construct a 50 x 100 foot walnut processing building in the right overflow area of the Feather River	Cutoff Wall		Struc	
28	36	2250+76	2,282,559.01	6,662,297.09	24 Inch CM irrigation pipe through levee. Slide gate in 36 inch CM pipe riser on the waterside slope and slide gate in 48 inch RCP standpipe on landside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(G)	16.4
~~29~~	~~36~~	~~2250+10~~	~~2,282,509.99~~	~~6,662,339.63~~	~~Concrete structure in waterside slope of levee Removed~~	~~Cutoff Wall~~		~~struc~~	
30	36	2248+30	2,282,389.90	6,662,473.42	Underground telephone cable through levee at south side of paved road over levee	Cutoff Wall	Not sure if the conduit meets title 23 or 200 WSEL requirements. **Replace in accordance with USACE standard**	TL	
31	36	2245+52	2,282,232.77	6,662,702.59	24 Inch CM drain pipe through levee. Automatic Drainage Gate on the waterside end buried and not located.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	15.1

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
32	36	2239+66	2,281,676.83	6,662,766.65	24 Inch CM drain pipe through levee. Concrete headwall at both toes and automatic Drainage Gate in 36 inch concrete standpipe on berm. House near land toe, land end not located it could possibly be in house back yard.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	15.8
33	36				Excavation into toe of levee with cuts up to 4.5 feet high and near 1:1. The CVFPB sent an encroachment violation notice on August 17, 2011 to Deane and Edith Williams Trust.	Cutoff Wall		Struc	
	35/36	2224+00			Reach 35/36 Transition	Cutoff wall			
34	35	2216+71	2,280,223.64	6,663,692.84	12 Kv power line crossing of levee. One pole 215 feet water ward of levee toe with overhead clearance of 27 feet.	Cutoff Wall		EL	OH
35	35	2208+56	2,279,495.37	6,664,025.97	Irrigation well located near landside toe. Use temporary pipe to pump over levee. No standpipe and no permanent pipe over levee. Well Approx 10 feet from landside toe	Cutoff Wall	The temporary pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(G)	
36	35	2201+87	2,279,440.81	6,664,690.55	Abandoned 10 inch reinforced concrete encased steel irrigation pipe through levee. Slide gate in 24 inch concrete standpipe at the waterside toe. Pipe ends not located or exposed.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(G)	13.1
37	35	2182+45	2,277,864.11	6,665,182.53	Power pole at land side toe	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
	34/35	2182+00			Reach 34/35 Transition	Cutoff wall			
38	34	2178+48	2,277,831.66	6,665,565.26	To replace an existing buried telephone cable with aerial cable crossing of the right bank of the Feather River at the end of Cherry Road. The aerial telephone will be placed on an existing PG&E poles. Due to two right angle bends in the levee, the overhead cable will cross the levee crown at two locations within the extension	Cutoff Wall		EL	OH
39	34	2178+39	2,277,825.68	6,665,571.75	16 inch steel irrigation pipe through levee. Slide gate in 36 inch concrete standpipe at the waterside toe. Concrete distribution box at the landside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(G)	13.2
40	34				Excavation into toe of levee with cuts up to 3.5 feet high and near vertical around irrigation standpipes. The CVFPB sent an encroachment violation notice on September 12, 2011 to James Banes Ranch.	Cutoff Wall		Struc	
41	34				Excavation into toe of levee with cuts up to 3 feet high and near vertical. The CVFPB sent an encroachment violation notice on September 30, 2011 to Banes Family Trust.	Cutoff Wall		Struc	
42	34				Excavation into toe of levee with cuts up to 3 feet high. The CVFPB sent an encroachment violation notice on September 12, 2011 to James Banes Ranch.	Cutoff Wall		Struc	
43	34				Excavation into toe of levee with cuts up to 5 feet high and sloped 1:1. The CVFPB sent an encroachment violation notice on July 28, 2011 to Clinton & Gail Moffitt.	Cutoff Wall		Struc	
44	34				Excavation into toe of levee with cuts 3 to 5 feet high and sloped 1:1. The CVFPB sent an encroachment violation notice on July 28, 2011 to Clinton & Gail Moffitt.	Cutoff Wall		Struc	
45	34	2138+22	2,275,157.46	6,664,140.19	Power line crossing of levee and guy wire	Cutoff Wall		EL	OH
46	34	2127+33			To authorize an existing 2 inch irrigation pipeline through the right bank of the Feather Rivers. Removable pipe over levee found at 2120+50	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	2.0
47	34				Excavation into toe of levee with near vertical cut up to 5 feet high. The CVFPB sent an encroachment violation notice on July 28, 2011 to Rodney Hodges.	Cutoff Wall		Struc	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
	33/34	2122+00			Reach 33/34 Transition	Cutoff wall			
48	33				Approximately 300 feet of excavation along the landside and waterside levee toe with cuts up to three (3) feet high. The CVFPB sent an encroachment violation notice on July 28, 2011 to Rodney Hodges.	Cutoff Wall		Struc	
49	33				Excavation into toe of levee from up to 3 feet high. The CVFPB sent an encroachment violation notice on July 28, 2011 to Rodney Hodges.	Cutoff Wall		Struc	
50	33				To plant a Kiwi vineyard parallel to the direction of river flow with a minimum row spacing of 4.9 meters and 2.4 meters spacing within each row.	Cutoff Wall		Trees	
51	33	2092+90	2,272,415.47	6,665,972.41	Underground telephone cable through levee on north side of paved road over the top of the levee.	Cutoff Wall	The cable may not meet title 23 requirements. **Replace in accordance with USACE standard**	TL	
52	34	2092+37			Power line crossing of levee on south side of road	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
53	33	2092+70			5" aluminum irrigation pipe through levee.	Cutoff Wall		IR(P)	
54	33	2084+03	2,271,531.48	6,666,011.72	5" x 0.25" wall steel irrigation line through levee	Cutoff Wall	The pipeline does meets title 23 requirements and but does not have a positive shut-off structure or anti-siphon installed. **Replace in accordance with USACE standard**	IR(P)	2.2
55	33				Excavation into toe of levee from 1 to 3 feet high. The CVFPB sent an encroachment violation notice on July 27, 2011 to Jagdeep Sandu.	Cutoff Wall		Struc	
56	33				To slope and revet 2000 feet of the right bank of Feather River and to eliminate obstructions in the channel	Cutoff Wall		struc	
57	33	2037+15	2,268,425.64	6,666,455.64	Palermo-Peachton 115kv Crossing. To construct, operate, and maintain a 115 kv transmission line crossing the Feather River. The 115 kv line replaced and existing 60 kv line. No record of the 60 kv permit.	Cutoff Wall		EL	OH
58	33	2032+90			12 inch reinforced concrete encased steel irrigation pipe through levee. Slide gate in 24 inch concrete standpipe at waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(G)	14.0
59	33	2029+00			Four (4) areas of excavation into the levee toe at tree locations. Cuts up to 3.5 feet high. The CVFPB sent an encroachment violation notice on July 28, 2011 to Betty Chambers.	Cutoff Wall		Struc	
60	33	2026+40			12 inch reinforced concrete encased steel irrigation pipe through levee. Slide gate in 24 inch concrete standpipe at waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(G)	13.5
61	33	2020+81	2,267,049.65	6,665,590.75	Large steel tank on land side at toe of levee	Cutoff Wall	**Recommended Removal**		
62	33	2018+00			To retain a spur levee between the right bank project levee and the bank of the low water channel, a distance of approximately 600 feet. The spur levee is normal to the project levee and to the direction of the overbank flow. The levee varies from 3 to 6 feet above ground surface	Cutoff Wall		Struc	
63	33	2017+78	2,266,812.83	6,665,317.53	22 inch reinforced concrete encased steel irrigation pipe through levee. Slide gate in 36 inch concrete standpipe at waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR (G)	13.9

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
64	33	2013+00			Over steepended horizontal vertical levee slope 1:1 excavation at levee toe with cuts up to 5 feet high. The CVFPB sent an encroachment violation notice on July 28, 2011 to Robert Magenheimer.	Cutoff Wall		Struc	
65	33	2006+05			Irrigation well located near about 10 feet from landside toe.	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	well	
66	33	2004+86	2,265,846.14	6,664,564.55	7 inch steel pipe sleeved through the existing 12 inch steel pipe through levee. The annular space between the two pipes is plugged with concrete on both ends. Slide gate in concrete risers on both ends.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	AG
67	33	2007+00			To construct 1255 feet of spur levee from west project levee to the Feather River west bank.	Cutoff Wall		Struc	
68	33	2001+00			Over steepended levee slope and a 4 foot high long cut excavation at the levee toe. Levee slope at toe cut is 1:1 or steeper. Tree encroachment also noted by State. The CVFPB sent an encroachment violation notice on July 27, 2011 to Jack Mariani.	Cutoff Wall		Struc	
69	33	1995+00			To authorize a pear orchard on the west bank overflow area of the Feather River.	Cutoff Wall		trees	
70	33	1995+00			To authorize an existing walnut orchard on the right bank overflow area of the Feather River/	Cutoff Wall		trees	
	32/33	1989+00			Reach 32/33 Transition	Cutoff wall			
71	32	1970+00			To interplant trees in an existing pear orchard on the right bank overflow area of the Feather River	Cutoff wall		trees	
72	32	1961+03	2,264,727.12	6,660,794.20	Double 60 Inch Storm Drainage Pipes through levee. Waterside headwall with automatic drainage gates. Landside headwall within toe of levee. No positive shut-off valve.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	20.0
73	32	1959+00			Unpermitted excavation at the toe of the levee with cuts up to 5 feet high; 1:1 cut slopw at the levee toe. The CVFPB sent an encroachment violation notice on October 4, 2011 to David Henderson Trust.	Cutoff wall		struc	
	31/32	1958+00				Cutoff wall			
74	31	1957+75	2,264,471.77	6,660,429.36	To construct a earthen Berm, equipment storage shed, labor apartment and multiple-purpose building on the landward berm of the levee. The 32 foot by 34 foot building will be located adjacent to an existing shop building. The proposed building will be located on an existing earth fill located on landward slope of the levee and will be 10 feet from the toe of the levee.	Cutoff wall		Struc	
75	31	1956+20	2,264,512.56	6,660,422.66	24 inch CM irrigation pipe through levee. Slide gate in concrete riser pipe on landside berm. Pipe runs under mobile home.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(G)	11.0
76	31	1956+10			Modular Home Located on the Levee Top	Cutoff wall	**Recommended Removal**	struc	
77	31				Unpermitted excavation at the levee toe consisting of cuts up to 2 vertical feet. The CVFPB sent an encroachment violation notice on September 20, 2011 to Bassi & Dhillon, Inc.	Cutoff wall		struc	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
78	31	1947+33	2,263,626.47	6,660,477.81	Service pole 10' from water side toe with 3" steel conduit through top of levee	Cutoff wall	**Relocate pole outside of of the proposed right-of-way. Replace conduit in accordance with USACE Standard**	EL	
79	31	1934+54	2,262,349.20	6,660,521.29	24 inch steel pipe through levee. Slide gate in concrete box on the water side slope. (Corps list pipe as 36 inch CMP)	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard.**	SD(G)	17.5
80	31	1906+58			To authorize construction of stream gauging station on the right bank levee of the Feather River	Cutoff wall		Struc	
81	31	1906+58	2,259,711.16	6,661,315.13	12 kv Pole line over levee. One pole 10 foot landward and one pole on levee for DWR and service electrical to water side building	Cutoff wall		EL	OH
82	31	1903+96	2,259,482.14	6,661,442.38	To extend 3 phase No. 4 ACSR 12 kv pole line across right bank levee of the Feather River. Line to provide power to new pump for Roy Mathews	Jet Grouting		EL	OH
83	31	1902+50			For construction of a temporary fill from the left bank Feather River to a gravel bar and to excavate a channel through bar	Jet Grouting		Struc	
84	31	1902+19	2,259,338.81	6,661,543.33	Oroville-Gridley Highway Bridge Upstream	Jet Grouting		Bridge	
85	31				Open channel on land side of levee at toe	Jet Grouting	**Relocate outside of of the proposed right-of-way.**	IR(G)	
	30/31	1902+00			Reach 30/31 Transition	Jet Grouting			
86	30	1901+79	2,259,317.57	6,661,574.18	Oroville-Gridley Highway Bridge Downstream	Jet Grouting		Bridge	
87	30	1900+82	2,259,239.50	6,661,630.24	Power pole at land side toe	Jet Grouting	**Relocate outside of of the proposed right-of-way.**	EL	OH
88	30	1893+60			3/4 inch galvanized iron waterline through levee	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	WL	3.1 rd
89	30	1893+20	Not Verified		6 inch concrete encased cast iron sewer pipe through levee	Cutoff wall	**Replace in accordance with USACE standard.**	SS (G)	13.9 rd
90	30	1892+60	Not Verified		6 inch concrete encased cast iron sewer pipe through levee	Cutoff wall	**Replace in accordance with USACE standard.**	SS (G)	13.8 rd
91	30	1892+20	Not Verified		Two 4 inch concrete encased cast iron sewer lines through the levee. The Discharge end connected to the CM pump house at the landside toe of the bow levee.	Cutoff wall	**Replace in accordance with USACE standard.**	SS(P)	1.5 rd
92	30	1892+89	2,258,542.19	6,662,052.68	Pole line over the levee.	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
93	30	1891+25	2,258,506.36	6,662,137.72	Pole line over the levee.	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
94	30	1888+70	2,258,285.10	6,662,367.26	To extend 3 phase No. 4 ACSR 12 kv pole line across right bank levee of the Feather River. Line to provide power to new pump for Roy Mathews	Cutoff wall		EL	OH
95	30	1888+50	2,258,298.89	6,662,410.71	To expand an existing waste water treatment facility on the left bank of the Feather River and to install a 6 inch force main along the right bank levee of the Feather River/	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SS(P)	2.5 rd

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
96	30	1887+29	2,258,210.65	6,662,463.86	12 kv power line crossing of levee	Cutoff wall		EL	OH
97	30	1868+17			Butte County Drainage District No. 1. An 18-Inch pipe through Levee.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(G)	
98	30	1828+00			To plant a walnut and peach orchard on the right bank overflow area of the Feather River between LM 2.82 - 3.08 and LM 3.37 - 3.69.	Cutoff wall		Trees	
99	30	1849+80	2,255,332.08	6,664,793.22	18 inch cast iron sewer pipe through levee. Concrete thrust block for cutoff walls on both shoulders. Siphon breaker in concrete pipe riser on the waterside shoulder.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SS(P)	2.8 rd
100	30	1834+42	2,254,466.85	6,665,951.72	24 inch CM drainage pipe through levee. Automatic drainage gate on waterside toe. 12 inch pipe sleeved through 24 inch pipe.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR (G)	12.5
101	30	1828+00			To plant a walnut and peach orchard on the right bank overflow area of the Feather River between LM 2.82 - 3.08 and LM 3.37 - 3.69.	Cutoff wall		Trees	
102	30	1823+01	2,253,380.39	6,666,199.22	12 Inch cement coated and lined steel sewer pipe sleeved through the existing 24 inch CM pipe. Annular space pressure grouted.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SS (G)	21.8
103	30	1818+72	2,252,948.28	6,666,209.81	24 Inch CM pipe through levee. Slide gate in 36 inch CM riser on the waterside slope.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SS (G)	25.2
104	30				Sewer Ponds located within 30' of both toes of the levee	Cutoff wall		struc	
105	30	1816+63	2,252,738.86	6,666,205.04	City of Gridley. To install approximately 660 feet of chain link fence on the waterside toe and to authorize approximately 600 feet of 6 foot high chain link fence on the landside toe of the right bank levee of the Feather River.	Cutoff wall		struc	
106	30	1815+00			City of Gridley. To operate a sand borrow pit and gravel borrow pit within the Feather River Designated Floodway, located on the right bank overflow of the Feather River.	Cutoff wall		struc	
107	30	1814+00			To fill an eroded area along the right bank of the Feather River with concrete rubble and old tire wire. The eroded area is approximately 250 feet long and extends into the bank for a distance of 120 feet	Cutoff wall		struc	
108	30	1813+70			24 Inch CM pipe through levee. Concrete saddle and apron with Calco Slide gate.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(G)	
	29/30	1813+33			Reach 29/30 Transition	Cutoff wall			
109	29	1809+65	2,252,095.81	6,666,415.94	24 Inch CM pipe through levee. Automatic drainage gate on waterside propped open and concrete headwall on land side. The CVFPB sent an encroachment violation notice on September 20, 2011 to Pekeema Brothers.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	4.5
110	29	1809+00			Existing Prune and Walnut Orchard on right bank overflow area of the Feather River	No Rehabilitation Required		Trees	
111	29	1799+44	2,251,083.54	6,666,333.91	8"x .25" thick wall with exterior taped wrapped to a minimum thickness of 30 mil. The irrigation pipeline through levee	No Rehabilitation Required	The pipeline is meets Title 23 and is newer than 1995. No work required.	IR(P)	2.1

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
112	29	1792+96	2,250,482.00	6,666,094.79	24 inch CM drainage pipe through levee. Automatic drainage gate on waterside and concrete distribution box at waterside toe. Land side end of the pipe is not located. The CVFPB sent an encroachment violation notice on September 19, 2011 to Robert and Sandra Waller.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR (G)	10.2
113	29	1790+00			Leveling and planting walnut and peach orchard on right overflow area of Feather River	No Rehabilitation Required		Trees	
114	29	1785+55			24 Inch CM drain pipe through levee. Concrete Headwall at land side. Automatic Drainage Gate on waterside with splash pad.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(G)	
115	29	1785+24	2,249,771.67	6,665,793.11	24 Inch CM drain pipe through levee. Concrete Headwall at land side. Automatic Drainage Gate on waterside with splash pad.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	5.7
116	29	1777+00	2,249,094.57	6,665,330.01	24 Inch CM drain pipe through levee. Concrete Headwall at land side. Automatic Drainage Gate on Waterside. The CVFPB sent an encroachment violation notice on September 19, 2011 to Robert and Sandra Waller.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	4.5
117	29	1770+00			Existing walnut trees, located on the right bank of the Feather River.	No Rehabilitation Required		Trees	
	28/29	1769+31			Reach 28/29 Transition	Cutoff wall			
118	28	1767+67	2,248,176.53	6,665,251.10	Cox Spillway. North 60 Inch drain pipes through Levee. Slide Gates in 78 inch CM pipe wells on the waterside slope. Concrete bulkhead on both ends. Reinforced concrete spillway at the waterside end.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR (G)	8.4
119	28	1767+57	2,248,167.22	6,665,252.49	Cox Spillway. South 60 Inch drain pipes through Levee. Slide Gates in 78 inch CM pipe wells on the waterside slope. Concrete bulkhead on both ends. Reinforced concrete spillway at the waterside end.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR (G)	8.4
120	28	1767+30	2,248,140.77	6,665,254.84	To construct an 12kv aerial power line crossing of the right bank levee of the Feather River. The power line will extend from an existing pole located landward of the project levee to a new 50 foot pole located at least 20 feet water ward of the water ward toe of the levee/ The shall be 34 feet of clearance between the levee crown and the power line. The length of the span shall be 201 feet. The power line will extend from the 50 foot poles to a 30 foot pole to be located 135 downstream. This power line shall serve a pump covered by permit 11987 b Cox Brothers.	Cutoff wall		EL	OH
121	28	1766+00			To construct, operate, and maintain a 12kv aerial power line extension across the right bank levee, channel, and left bank overflow of the Feather River. A 55 foot pole will be installed 31 feet water ward of the water ward shoulder of levee. The overhead conductors will extend from an existing pole, located 138 feet landward of the landward toe of levee, the proposed 55 pole. The span between the two poles will be 212 feet. A minimum clearance of 35 feet will be provided between the overhead conductors and the top of the levee. The proposed extension will extend across the river and floodway for an additional 3,165.5 feet and will consist of an additional 10 poles.	Cutoff wall with Sutter Butte canal relocation		EL	OH
122	28	1765+33	2,247,975.94	6,665,181.76	12-inch CM pipe through the Levee. Slide Gate on the landside end and concrete distribution box on waterside.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(G)	4.5

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
123	28	1765+15	2,247,960.44	6,665,189.22	To install an irrigation pump on the right bank of the Feather River with a 12 inch steel pipe across the berm, levee, and the Sutter Butte Canal to existing orchards on the right bank downstream from Evans-Reimer Road. Concrete headwall at the waterside toe	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	0.7
124	28	1756+27	2,247,101.40	6,665,410.42	12-inch CM pipe through the Levee. Slide Gate on the landside end and concrete distribution box on waterside. The CVFPB sent an encroachment violation notice on August 16, 2011 to Mr. and Ms. Ratana.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR (G)	7.1
125	28	1753+50			To plant approximately 1.13 hectares of kiwi plants and install an irrigation system supplied by an existing water well.	Cutoff wall with levee relocation		Trees	
126	28	1753+50			To install an electrical pole line service extension to a new agricultural pump on the right bank overflow area of the Feather River.	Cutoff wall with levee relocation		EL	OH
127	28	1745+00			To retain a newly constructed barn on the right bank overflow area of the Feather River, approximately 150 feet water ward of the right bank levee of the Feather River	Cutoff wall with levee relocation		EL	OH
128	28	1741+32	2,245,620.98	6,665,550.58	Butte County Drainage District No. 1. A 16-Inch pipe through Levee. Emergency Repair Work on Pipe 3/5/02. Pipe not physically located	Cutoff wall with levee relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	9.0
129	28	1728+33	2,244,365.98	6,665,826.21	To install a 12kv pole line westerly across the right bank levee of the Feather River and the Sutter Butte Canal, then northerly approximately 180 meters for service to well pump.	Cutoff wall with levee relocation		EL	OH
130	28	1724+61	2,244,008.46	6,665,796.35	12 kv overhead electrical power line and telephone line crossing	Cutoff wall with levee relocation	**Relocate outside of of the proposed right-of-way.**	EL	OH
131	28				Over steepened, ongoing erosion and caving in the irrigation canal.	Cutoff wall with levee relocation		struc	
132	28	1700+00 to 1728+00			1800 feet of 4.5 foot tall barbed wire fence located at waterside toe of levee. The application for the fencing was denied on October 2, 2000. No indication of appeal.	Cutoff wall with levee relocation		struc	
	27/28	1721+60			Reach 27/28 Transition	Cutoff wall with levee relocation			
133	27	1721+20	2,243,713.99	6,665,636.50	End 18" wide, 12-25 feet deep cutoff wall on crown with monitoring system 2000 lineal feet.	Cutoff wall with levee relocation		struc	
134	27	1707+34	2,242,329.23	6,665,666.71	Begin 18" wide, 12-25 feet deep cutoff wall on crown with monitoring system 2000 lineal feet.			struc	
	26/27	1707+11			Reach 26/27 Transition	Cutoff wall with levee relocation			
135	26	1699+62	2,241,637.34	6,665,378.46	Propane storage tanks at waterside toe of levee	Cutoff wall with levee relocation		struc	
136	26	1697+96	2,241,496.45	6,665,289.21	To retain a telephone line aerial crossing of the right bank levee of the Feather River. The aerial telephone line extends from a pole located landward of the Sutter Butte Main Canal to a pole located near water ward toe of the levee.	Cutoff wall with levee relocation	**Relocate outside of of the proposed right-of-way.**	TL	OH
137	26	1695+85			To construct a caretaker/ranch office and remove an existing structure on the right bank designated floodway of the Feather River.	Cutoff wall with levee relocation		Struc	
138	26	1691+00			A farm buildings (a walnut processing plant and shop) on the water ward toe of the right bank levee on the Feather River, 200 feet north of Chandon Avenue. The buildings are a 30 x 80 foot walnut dehydrator and a 40 x 40 shed.	Cutoff wall with levee relocation		Struc	
139	26	1690+00			To level and plant 160 acres of land between right bank levee and Feather River, off end of Chandon Avenue and opposite mouth of Honcut Creek	Cutoff wall with levee relocation		Trees	
140	26	1675+98	2,239,584.22	6,664,224.05	12 kv power line crossing of levee	Cutoff wall with levee relocation		EL	OH

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
	26	1675+50			Maintenance Area 16/ Maintenance Area 7 Transition	Cutoff wall with levee relocation			
141	26	1675+27	2,239,518.21	6,664,204.12	Butte County Drainage District No. 1. 60" x 72" RCP culvert through levee. Slide gate in concrete well on waterside slope.	Cutoff wall with levee relocation	The pipeline appears to meet title 23 requirements but will need to be removed and replaced because of the cutoff wall. **Replace in accordance with USACE standard**	SD(G)	17.0
	25/26	1674+37			Reach 25/26 Transition	Cutoff wall with levee relocation			
142	25	1670+00			To plant kiwi plants in place of fruit and nut trees on the right bank overflow of the Feather River south of Chandon Avenue near Live Oak.	No Rehabilitation Required		Trees	
143	25	1667+00			To clear the overflow area of brush and construct a foot bridge over an old channel that meanders across the overflow area. To install a septic tank and leach lines, electric service, drill a well and park a mobile home in the overflow area.	No Rehabilitation Required		Struc	
144	25	1665+32	2,238,525.15	6,664,192.56	To construct a 12 kv aerial power line extension across the levee and into the floodway of the Feather River. An existing pole on the landside of the levee will be replaced with a new 55 foot pole to be located 13 feet from the landward toe of the levee. The overhead conductors will extend across the levee to a 55 foot pole located in the floodway 140 feet from the waterside toe of the levee. The span between the 2 poles will be 233 feet. A minimum clearance of 31 shall be provided.	No Rehabilitation Required		EL	OH
145	25	1653+15	2,237,309.20	6,664,181.79	12 Kv overhead power line crossing and along levee	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
146	25	1650+00			To retain a walnut orchard on the right bank overflow area of the Feather River. The orchard is located a narrow strip of ground between the project levee and Drainage District No. 1's drain ditch.	No Rehabilitation Required		Trees	
147	25	1639+00	2,235,906.77	6,664,006.17	RD 777 Lateral 11. There are 2-24 inch steel pipes through levee. Automatic drainage gates on waterside end of pipe. The CFVPB sent an encroachment violation notice on September 20, 2011 to MMD Ranches.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	16.2
148	25				Construction of Waterside Approach Ramp 500 feet north of Campbell Road and Meader Road	No Rehabilitation Required		struc	
149	25	1638+72	2,235,879.28	6,664,006.22	12 Kv overhead power line crossing and along levee	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
150	25	1635+00			To plant a prune orchard on the right bank overflow area of the Feather River at the end of Riviera Road	No Rehabilitation Required		trees	
	24/25	1623+86			Reach 24/25 Transition	Cutoff wall with levee relocation			
151	24	1611+30			12 Kv overhead power line crossing and along levee	Cutoff wall with levee relocation	**Relocate outside of of the proposed right-of-way.**	EL	OH
152	24	1610+92	2,233,196.84	6,664,513.54	RD 777 Lateral 12. An 18 inch CM pipe through levee. Automatic drainage gate on waterside end of pipe. The CVFPB sent an encroachment violation notice on July 26, 2011 to Theodore Bill. The violation was regarding the heavy vegetation on the waterside outfall pipe.	Cutoff wall with levee relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	17.3
	23/24	1609+37			Reach 23/24 Transition				
153	23	1585+05			Abandoned 12 inch CM pipe through levee. Automatic drainage gate on waterside end of pipe	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
154	23	1557+00			To add approximately 575 feet of 12 kv line to an existing power line on Cooley Road and within the overflow area of the Feather River	Cutoff wall		EL	OH
155	23	1556+58	2,228,785.42	6,665,751.32	To extend a 12 kv pole line from the intersection of Cooley Road and the right bank levee of the Feather across the levee and continue for 1500 feet easterly along Cooley Road. The pole line will serve a 25 HP river pump	Cutoff wall		EL	OH
156	23	1556+86			8 inch CM pipe through levee. Automatic drainage gate on waterside end of pipe.(No gate found)	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	8.0
157	23	1555+00			To install pumping plants at two locations on the right bank of the Feather River	Cutoff wall		IR(P)	
158	23	1549+63	2,228,117.97	6,665,558.67	12 inch CM pipe through levee. Automatic drainage gate on waterside end of pipe. Pipe partially plugged. The CVFPB sent an encroachment violation notice on August 16, 2011 to Hatamiya Trust.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	12.5
159	23	1548+00			To level and plant walnuts and either peaches or prunes on the right bank overflow area of the Feather River upstream from Live Oak Park.	Cutoff wall		Trees	
160	23	1539+00			To install 25 HP pumping plants at two locations on the right bank of the Feather River	Cutoff wall		IR(P)	
161	23	1536+12	2,226,796.70	6,665,666.06	RD 777 Lateral 7. There is a 36 inch CM pipe through levee. Automatic drainage gate on waterside end of pipe. The CVFPB sent an encroachment violation notice on August 16, 2011 to Hatamiya Trust.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	13.7
162	23	1535+95	2,226,780.47	6,665,668.20	To extend a 12 kv pole line 410 feet northerly to supply a 25 HP pump located in the river. The pump is pump referenced in permit 7380.	Cutoff wall		EL	OH
163	23				Excavation into toe of levee from up to 3 feet high on landside toe. The CVFPB sent an encroachment violation notice on August 16, 2011 to Hatamiya Trust.	Cutoff wall		Struc	
164	23	1535+64	2,226,750.14	6,665,678.35	To widen access road to Live Oak Recreation Area at the east end of Pennington Road on the right bank levee and berm of the Feather River	Cutoff wall		Struc	
165	23	1535+00			To Install 2500 lf of 2 inch diameter Sch 40 PVC water pipe and 600 lf of 1 inch Sch 40 PVC pipe within the west bank overflow. (Permit number has been changed to 7440-D)	Cutoff wall		W(P)	
166	23	1534+00			To construct a water supply system, a sanitary disposal system and restrooms for the Live Oak Recreational Area	Cutoff wall		Struc	
167	23	1533+40			Potential Pipe Crossing. 6" Steel through levee	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	
168	23	1532+45	2,225,437.02	6,665,722.95	Water Well adjacent to Levee about 100 feet from toe	Cutoff wall		IR(P)	
169	23	1530+00			A trailer site, a porch, a metal storage building, fence across the waterside berm and waterside slope of the levee, on the right bank of the overflow area of the Feather River.	Cutoff wall		Struc	
170	23	1524+35			Potential Pipe Crossing. 6" Steel through levee	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	
	22/23	1503+83			Reach 22/23 Transition	Cutoff wall			
171	22	1530+00			To authorize existing pear orchard and plant 10 additional acres on the right bank overflow of the Feather River downstream of Archer Road	Cutoff wall		Trees	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
172	22	1520+25			To extend approximately 1,950 feet of 12kv electric service line in the right bank overflow area of the Feather River downstream from Archer Avenue crossing	Cutoff wall		EL	OH
173	22	1493+88	2,222,717.57	6,664,731.41	Location of gate with no access	Cutoff wall		Fence	
174	22	1492+00			To construct an aerial telephone crossing of the right bank levee of the Feather River	Cutoff wall		TL	OH
175	22	1482+00			A 4 x 17 foot wooden walkway on the landside shoulder; two tool sheds, four walnut trees, a barbed wire and wooden fence within 10 feet landward of the landside toe, and an electrical gate across the crown of the right bank levee of the Feather River.	Cutoff wall		struc	
176	22	1479+98	2,221,343.18	6,664,540.45	Location of electric gate with no access	Cutoff wall		struc	
177	22	1470+15	2,220,360.26	6,664,561.50	A 4 x 17 foot wooden walkway on the landside shoulder and a 6 x 300 foot wooden lattice fence within 10 feet landward of the landside toe and parallel to the right bank of levee of Feather River.	Cutoff wall		struc	
178	22	1468+70			Four trees (oleander, pines, cherry, and birch) on the landside slope and a 5 foot high, 170 foot long wire fence within 7 feet of landward of the landside toe of the right bank levee of the Feather River.	Cutoff wall		struc	
179	22	1466+02	2,219,947.02	6,664,564.97	Transformer located 40'± from land side toe	Cutoff wall		EL	
180	22	1465+50			To construct access ramp across the right bank levee of the Feather River	Cutoff wall		struc	
181	~~22~~	~~1465+50~~			~~The existing 36 inch CMP installed in 1913 failed on March 1964. The permit was for repair of levee and removal of the pipe prior to November 1964.~~	Cutoff wall		~~IR(G)~~	
182	22	1461+00			To maintain existing your walnut orchards on the right bank of the Feather River, downstream from Bishop Avenue.	Cutoff wall with full levee degrade		Trees	
	22	1460+00			Levee District No. 9 Levees /Maintenance Area 16 Transition				
	21/22	1433+83			Reach 21/22 Transition				
183	21	1430+55	2,216,425.27	6,664,383.06	Sunset Pump Station owned an operated by Sutter Extension Main Pump Station. There is a 60 Inch steel pipe through the levee. Pump end has gate valves on structure. Automatic drainage gates on the landside end.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	15.6
184	21	1430+47	2,216,417.64	6,664,382.64	Sunset Pump Station owned an operated by Sutter Extension Main Pump Station. There is a 60 Inch steel pipe through the levee. Pump end has gate valves on structure. Automatic drainage gates on the landside end.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	15.6
185	21	1430+40	2,216,410.86	6,664,382.27	Sunset Pump Station owned an operated by Sutter Extension Main Pump Station. There is a 36 Inch steel pipe through the levee. Pump end has gate valves on structure. Automatic drainage gates on the landside end.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	15.6

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
186	21	1430+40			To construct and operate a vertical-perforated plate fish screen with a power operated brush on the right bank of Feather River. Located at Sunset Pump Plant.	Cutoff wall with Sutter Butte canal relocation		IR	
187	21	1430+00			36" CM pipe crossing through levee. The O&M manual indicates this pipeline is located 50 feet south of Sunset Pump Station but it appears this pipeline is the same pipeline addressed in Permit 4556 and 4719 located at Station 1465+50. The pipeline at Station 1465+50 was a 36 inch CMP installed in 1913 and removed in 1964. It should have shown on the O&M manual.	Cutoff wall with Sutter Butte canal relocation	There is no documenation of proper abandonment of the pipeline. We believe this pipeline was actually located at 1465+50 and removed per permit 4719. The type and size appear to match the Reclamation Board Permit. **Replace in accordance with USACE Standard.**	IR (G)	
188	21	1429+98	2,216,368.25	6,664,376.98	12 KV OH Power	Cutoff wall with Sutter Butte canal relocation		EL	OH
189	21	1429+68	2,216,338.71	6,664,376.58	12 KV OH Power	Cutoff wall with Sutter Butte canal relocation		EL	OH
190	21	1429+50			Existing rubble coffer dam constructed with Reclamation Board Permit 3610. Repair coffer dam.	Cutoff wall with Sutter Butte canal relocation		IR	
191	21	1428+50			Sutter Butte Main Canal Begin (Station 1428+50 to 1433+83) -Main Irrigation Canal approx 420 cfs	Cutoff Wall	**Recommended Relocation between station 1429+00 to 1433+83**	IR	
192	21				To construct a 12 KV pole line extension adjacent to the levee and across the floodway of the Feather River. The pole line will be located 30 feet from the waterside toe of the levee and will parallel the levee for a distance of 792 feet, thence across the floodway for a distance of 834 feet. The pole line extension will consists of three 264 foot spans and three 278 foot spans.	Cutoff Wall		EL	OH
193	21	1399+27	2,213,450.77	6,664,966.80	To install a 12 kv pole line across and along the right bank levee of the Feather River.	Cutoff Wall		EL	OH
194	21				To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. End Seepage Interceptor Trench	Cutoff Wall	No work proposed and the seepage drain can remain.	struc	
195	21				Plant 9 acres of Kiwi plants on waterside of levee between Bridgeford and Hermanson Avenues	Cutoff Wall		Trees	
196	21				Plant 14 acres of Kiwi plants on waterside of levee upstream of Hermanson Avenue	Cutoff Wall		Trees	
197	21				To construct a well and septic tanks for 2 mobile homes and to extend electrical service to well on right bank overflow area of Feather River	Cutoff Wall		Struc	
198	21				To plant 8 acres of kiwi plants, a submersible pump, and underground sprinkler system on the right bank overflow area of the Feather River	Cutoff Wall		Trees	
199	~~21~~				~~To pump storm water from landward drainage ditch over the right bank levee of the Feather River from one separate location for approximately size at the end of Hermansen Road.~~ ~~**Pipe has been removed**~~	~~Cutoff Wall~~		~~SD(P)~~	
200	21	1391+96	2,212,767.43	6,665,226.86	To extend a 12 kv pole line out into the right bank levee and overflow area of the Feather River	Cutoff Wall		EL	OH
201	21	1375+35	2,211,296.56	6,665,998.34	Sutter Extension Sunset Lateral Begin (Station 1375+35 to 1428+50) Open irrigation ditch 15 feet from landside toe	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	Struc	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
202	21	1374+94	2,211,260.36	6,666,016.66	To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. Begin Seepage Interceptor Trench	Cutoff Wall		Struc	
203	21	1375+00			To level and plant 13 acres Peach Orchard on the right bank overflow area of the Feather River	Cutoff Wall		Trees	
	20/21	1374+33			Reach 20/21 Transition				
204	20	1350+00			To plant peach trees and to establish two wells and install pumping plants in right bank overflow of the Feather River	Cutoff Wall		struc	
205	20	1350+00			To extend 12 kv pole line parallel to the water ward toe of levee for a distance of approximately 1,500 feet north from Koch Lane, on the right bank overflow area of the Feather River/	Cutoff Wall		EL	OH
206	20				Excavation into toe of levee from 1 to 3 feet high and ground is tilled adajcent to the landside toe. The CVFPB sent an encroachment violation notice on August 17, 2011 to Julie M. Filter-Correll.	Cutoff Wall		Struc	
207	20	1347+37	2,208,612.74	6,666,676.45	To install a 60 foot pole 86 feet from the landward toe of the levee, a 60 foot pole 10 feet from the water ward toe of the levee and 6 additional poles on the right bank overflow of the Feather River. The 12kv electrical service will be extend across the levee to serve a pump installed under Permit 6380. The span across the levee will be 234 feet. The clearance between the overhead wires and the top of the levee will be 31 feet.	Cutoff Wall		EL	OH
208	20	1347+00	2,208,582.82	6,666,680.19	Missile Communication Cable System. Installation of an underground cable at a minimum depth of 3 feet, a corrugated metal cutoff wall is located on each cable, from Beale Air Force Base to the vicinity of Chico Airport, crossing several channels in Butte, Placer, Sutter, and Yuba Counties. In 1968 the USACE requested approval to abandon the cable in-place and cut	Cutoff Wall	The cable does not meet title 23 requirements. According to email from US Government to WR, the cable is no longer in use and can be disposed. **Replace in accordance with USACE standard**	TL	4.0
209	20	1345+00			To plant prune orchard on the right bank overflow area of the Feather River, downstream from Koch Road	Cutoff Wall		Trees	
210	20	1345+00			To retain walnut orchard on the right bank overflow area of the Feather River, downstream from Koch Road	Cutoff Wall		Trees	
211	~~20~~	~~1328+10~~			~~To install 3 temporary discharge pipelines across the right bank levee of the Feather River. The proposed pipeline will be in installed in three separate locations at LM 3.53, 3.72, and 3.78. The pipelines will be exposed on the levee slopes and will have a pad constructed over them across the levee crown.~~ ~~**Pipe has been removed.**~~	Cutoff Wall		~~SD(P)~~	
212	20	1328+00			To construct a 12 kv aerial power line on the right bank overflow area of the Feather River	Cutoff Wall		EL	OH
213	20	1327+00	2,206,597.56	6,666,928.33	12KV overhead power line crossing	Cutoff Wall		EL	OH
~~214~~	~~20~~	~~1317+15~~			~~To install 3 temporary discharge pipelines across the right bank levee of the Feather River. The proposed pipeline will be in installed in three separate locations at LM 3.53, 3.72, and 3.78. The pipelines will be exposed on the levee slopes and will have a pad constructed over them across the levee crown.~~ ~~**Pipe has been removed.**~~	~~Cutoff Wall~~		~~SD(P)~~	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
215	20	1315+03	2,205,398.45	6,666,943.63	To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. End Seepage Interceptor Trench	Cutoff Wall		Struc	
216	20	1314+80	2,205,375.80	6,666,944.25	Micheli Storm Drainage Pump Station. To install a pump with 20 Inch steel discharge pipe through the right bank of the Feather River for the removal of stormwater.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(P)	2.0
217	20	1312+08			To plant an orchard and grade the land on the right bank overflow area of the Feather River. The project is located north of Yuba City approximately 5.5miles.	Cutoff Wall		Trees	
~~218~~	~~20~~	~~1305+30~~			~~To pump storm water from landward drainage ditch over the right bank levee of the Feather River from one separate location for approximately size at the end of Hermansen Road. **Pipe has been removed**~~	~~Cutoff Wall~~		~~SD(P)~~	
	19/20	1297+83			Reach 19/20 Transition				
219	19	1295+00			To plant an orchard and grade the land on the right bank overflow area of the Feather River. The project is located north of Yuba City approximately 1.3 miles upstream (north) of the intersection of Eager Road and Live Oak Boulevard.	Cutoff Wall		Trees	
220	19	1293+66	2,203,266.22	6,666,867.99	End Concrete Lined Ditch on landside toe of levee	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	struc	
221	19	1293+66	2,203,266.22	6,666,867.99	12 KV Overhead Power line crossing of levee. One pole 6 foot from levee toe.	Cutoff Wall		EL	OH
222	19				To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. Begin Seepage Interceptor Trench	Cutoff Wall		struc	
223	19	1284+91	2,202,406.27	6,666,705.08	Begin Concrete Lined Ditch on landside toe of levee	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	struc	
224	19	1266+71	2,200,600.09	6,666,626.50	12KV overhead power line crossing	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
225	19	1265+59	2,200,487.69	6,666,648.86	Sullivan Pump Station. 18 inch steel pipe through the levee. Pump and Gate valve in pump house on the channel bank. Concrete well on the bank. Siphon breaker in CMP riser on landside slope. (Sullivan Pump Station)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and anti-siphon device on waterside hinge of levee. The pipe line is pressurized and need to be installed above the design water surface. The current installation is at-grade. **Replace in accordance with Title 23**	IR(P)	18.3
226	19	1229+41	2,197,325.05	6,668,184.53	Kewal Singh IR PS. A 16 inch steel pipe through levee. Pump in pump house on channel bank. Gate valve on the waterside end. Concrete standpipe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and anti-siphon device on waterside hinge of levee. The pipeline is pressurized and will need to be installed about the design water surface. **Replace in accordance with USACE standard**	IR(P)	3.0 or deeper through levee?
227	19	1226+06	2,197,092.42	6,668,425.95	12 KV power pole located in landside slope	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
	18/19	1213+85			Reach 18/19 Transition				

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
228	18				Excavation into the toe of levee on waterside 0.5 to 3 feet high with near vertical slope. CFPB sent an encroachment violation notice on July 27, 2011 to Kewall Singh.	Cutoff Wall		struc	
229	18	1201+00			Wilbur Ranch Irrigation Water Well located within 50 feet of levee toe. Underconstruction as of March 6, 2012.	Cutoff Wall		well	
230	18	1200+69	2,194,694.58	6,669,169.33	Wilbur Ranch Irrigation Water Well located within 10 feet of levee toe. There is also a service pole and electrical panel.	Cutoff Wall	The water well does not meet Title 23 since too cloase to levee. The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
~~231~~	~~18~~	~~1200+69~~	~~2,194,694.58~~	~~6,669,169.33~~	~~Abandoned 10 inch steel pipe through levee. Waterside end open. Steel Plate welded on landward end. Pump and Standpipe at the landside end.~~	~~Cutoff Wall~~	~~Not sure if the abandonment meets title 23 requirements. Pipe may need to be properly abandoned or completely removed.~~	~~IR(P)~~	~~2.8~~
232	18	1195+20			12 KV power line in overflow and levee crossing north of Rednall Road	Cutoff Wall		EL	OH
~~233~~	~~18~~	~~1182+75~~			~~20 Inch steel pipeline through levee **(not installed)** - Plans prepared by MHM Job No. 78-158~~	~~Cutoff Wall~~	~~Pipe eas never installed. No work.~~	~~IR(A)~~	~~3.0~~
234	18	1181+50			Abandoned 8 inch steel pipe through levee. Pipe plugged on the waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(A)	4.0
235	18	1180+98	2,192,727.96	6,669,163.92	3 inch steel pipe through levee crown	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	1.0
236	18	1180+50			One 12 inch steel pipe through levee. Pipe exposed on landside slope	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	1.0
237	18	1180+00			To construct a 15 inch diameter corrugated metal drain pipeline across the overflow area and through the right bank of the Feather River. The proposed pipeline will be 625 feet in length and have 15 feet of cover.	Cutoff Wall		SD(G)	
~~238~~	~~18~~	~~1182+75~~			~~To install an irrigation pump and a buried pipeline landward over the right bank levee of the Feather River, upstream Rednall Road. **Not install per Reclamation Board**~~	~~Cutoff Wall~~		~~IR(P)~~	
239	18	1174+05	2,192,034.01	6,669,096.85	Water Well and Pump 20 feet from Landside toe	Cutoff Wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
240	18	1170+04	2,191,638.99	6,669,057.61	12KV overhead power line crossing	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
241	18	1152+55	2,189,899.09	6,668,879.71	Twin 110 KV Tower line across Feather River	Cutoff Wall		EL	OH
242	18	1138+22	2,188,574.27	6,668,732.99	12 KV and 40/60 KV power pole located in landside slope	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
243	18	1135+31	2,188,188.41	6,668,676.43	16 inch gas line through the levee. Marker post on the waterside shoulder	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.5
244	18	1133+00			To construct 1,180 feet of 12 kv line in the right bank overflow area of the Feather River	Cutoff wall		EL	OH
	18	1132+61			Levee District No. 1 Levees /Levee District No. 9 Transition				

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
245	18	1132+09	2,187,967.19	6,668,647.98	8-5/8" steel pipeline within railroad right-of-way parallel to tracks	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	
246	18	1131+82	2,187,840.25	6,668,647.20	Fiber optic cable	Cutoff wall	The cable does not meet title 23 requirements. **Replace in accordance with USACE standard**	TL	
	17/18	1130+86			Reach 17/18 Transition				
247	17	1130+47	2,187,705.38	6,668,643.93	Union Pacific Railroad Crossing. There is no stop log structure.	Jet Grouting		RR	6.0
248	17	1128+00			To construct a ramp on the waterside slope of the right bank levee on the Feather River adjacent to the SPRR.	Cutoff wall		Struc	
249	17	1127+48	2,187,405.84	6,668,629.29	Village Green Trailer Park - To install a 10 inch outfall pipe through the right bank levee of the Feather River to provide storm drainage for a mobile home park.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	
250	17	1125+00			An existing irrigation well in the right bank overflow area of the Feather River.	Cutoff wall with landside toe fill		Well	
251	17	1111+46	2,185,808.02	6,668,723.59	West Onstott Frontage Road Pump Station and Clark Avenue Pump Station Drainage Area. 16 Inch welded steel 7 GA asphalt coated storm drain discharge pipe over levee connected to 24 inch pipe in overflow area, outfall ditch, and pipes in floodway (Source: City of Yuba City Pump Station No. 4 and City of Yuba City Pump Station No. 2)	Cutoff wall with landside toe fill	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	1.1
252	17	1107+82	2,185,444.63	6,668,754.75	12 KV crossing & power pole located in landside slope	Cutoff wall with landside toe fill	**Relocate outside of of the proposed right-of-way.**	EL	OH
253	17				To install an intertie to an existing waste water line and abandon approximately 40 feet of 24 inch diameter pipe on the right bank of the Feather River.	Cutoff wall		RW(P)	4.0
254	17	1096+81	2,184,421.28	6,669,119.50	Yuba City Water Treatment Plant 28" (29 25/32" OD) 7 GA welded steel waterline pipe crossing of levee. New permit included installation of automatic drainage gates on pipelines. (copy of record drawings)	Jet Grouting	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	RW(P)	5.0
255	17	1096+71	2,184,412.72	6,669,124.71	Yuba City Water Treatment Plant 24" 7 GA welded steel waterline pipe crossing of levee. New permit included installation of automatic drainage gates on pipelines. (copy of record drawings)	Jet Grouting	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	RW(P)	4.7
256	17	1096+62	2,184,404.80	6,669,129.53	Yuba City Water Treatment Plant 42"cement mortar lined and coated welded steel pipe waterline crossing of levee (copy of record drawings)	Jet Grouting	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	RW(P)	2.5
257	17	1096+50	to be installed	to be installed	Yuba City Water Treatment Plant 48"cement mortar lined and coated welded steel pipe waterline crossing of levee (to be installed and requested by the City of Yuba City)	Jet Grouting	This is a new pipelines that will meet Title 23 and USACE requirements except as noted in variance column. **Replace in accordance with USACE standard**	RW(P)	2.0
258	17	1096+74	2,184,416.62	6,669,124.90	To install a 12 kv aerial pole line extension across the right bank levee of the Feather River. The pole line shall serve the Yuba City Water treatment Plant intake pump station	Jet Grouting		EL	OH
259	17	1093+12			Telephone Call box on landside hinge point	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	TL	
260	17	1086+33			Construction of an 80 foot high Monopole for a Cell Tower. The work includes a 32' x 83' compound, PG&E 100 KVA transformer box, 600 AMP PG&E Electrical Meter Service.	Cutoff wall		Cell	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
	16/17	1080+00			Reach 16/17 Transition				
261	16	1079+91	2,183,133.99	6,670,212.82	8 inch Gas Line	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.5
262	16	1073+41	2,182,671.85	6,670,670.15	16 inch Gas Line (PG&E Map shows the gas main as 12 inch)	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.5
263	16				Excavation into the levee on the waterside approximately 0.5 to 2 feet, near vertical in some places. Minor rutting, ponding, and depressions in the levee toe road. CVFPB sent a encroachment violation notice on August 16, 2011 to City of Yuba City.	No Rehabilitation Required		struc	
264	16	1054+75	2,181,074.23	6,671,588.96	Telephone Call box on landside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	
265	16	1043+52	not verified		Abandon 36 inch pipe	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SS(G)	
266	16	1043+52	2,180,149.57	6,672,223.24	Abandoned 27 inch Centrifugal Spun Concrete Pipe. City of Yuba City Drawing 214-D per 1949 plans	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SS(G)	38.6
267	16	1043+45	2,180,137.11	6,672,230.51	To install a 36 Inch discharge pipe through right bank of Feather River.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	5.0
268	16	1043+27	2,180,126.23	6,672,235.13	To install a 24 inch wrapped steel pipe through the right bank levee of the Feather River	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	2.0
269	16	1043+22	2,180,121.72	6,672,237.88	To construct a 24 inch steel pipe storm drainage discharge pipe crossing the west levee of the Feather River	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	4.0

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
270	16	1043+03	2,180,106.36	6,672,244.70	Gilsizer Slough Storm Drain Facilities. A 16 inch welded steel discharge pipe crossing of levee. (copy of record drawings)	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	1.3
271	16	1037+50	Not Verified		Abandoned 8 inch gas line through levee. Removed per Permit 1445A	No Rehabilitation Required	Not sure if the abandonment meets title 23 requirements. Pipe may need to be properly abandoned or completely removed.	GL	
272	16				To construct approximately 4,400 lineal feet of filter trench adjacent to the right bank levee of the Feather River. The proposed trench will be located at the landward levee toe, be 3 feet wide and 4 feet deep.	No Rehabilitation Required			
273	16	1028+11	2,178,636.47	6,672,461.02	Power pole in waterside slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	
274	16	1029+10	2,179,608.80	6,672,356.03	To bury existing two submarine telephone cables into two parallel trenches 100 feet apart in the channel of the Feather River. Both cables were installed per Permit 1334 in September 15, 1948. The permit stated the cable will be buried to a depth of five feet in the levees.	No Rehabilitation Required	The conduit may not meet title 23 requirements. **Replace in accordance with USACE standard**	TL	5.0
275	16	1028+10	2,179,506.59	6,672,370.16	To bury existing two submarine telephone cables into two parallel trenches 100 feet apart in the channel of the Feather River. Both cables were installed per Permit 1334 in September 15, 1948. The permit stated the cable will be buried to a depth of five feet in the levees.	No Rehabilitation Required	The conduit may not meet title 23 requirements. **Replace in accordance with USACE standard**	TL	2.0
276	16	1026+71	21,784,783.54	6,672,514.29	10" overside Drain line on the water side levee slope for bridge area drainage	Seepage berm	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	TL	
277	~~16~~	~~1026+70~~			~~To place a 10 Inch diameter conduit containing fiber optic cables across and under (bored) the channel and through the right bank of the Feather River. The permit was withdrawn on 9-6-00 according to the CVFPB file.~~	Seepage berm		TL	
278	16	1026+58	2,178,488.35	6,672,429.49	40 foot long retaining wall landside of levee just upstream of the Feather River Bridge	Seepage berm		Road	
279	16	1026+22	2,178,451.96	6,672,425.20	Feather River Bridge (SR 20) upstream side	Seepage berm		Bridge	
280	16	1025+32	2,178,375.92	6,672,443.76	Feather River Bridge (SR 20) downstream side	Seepage berm		Bridge	
281	16	1025+32	2,178,375.92	6,672,443.76	Seismic Retro of Feather River Bridge and bike paths on both sides of bridge	Seepage berm		Bridge	
282	16	1024+95	2,178,319.03	6,672,456.34	12 kv power line across levee	Seepage berm	**Relocate outside of of the proposed right-of-way.**	EL	OH
283	16	1024+70			Backfill Community Swimming Pool located near the base of the Feather River Bridge (10th Street Bridge)	Seepage berm		struc	
284	16	1024+48	2,178,296.55	6,672,470.53	40 foot long retaining wall landside of levee just downstream of the Feather River Bridge	Seepage berm		Road	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
285	16	1021+95	2,178,044.07	6,672,487.29	12 kv power line across levee	No Rehabilitation Required		EL	OH
286	16	1021+00			Telephone line on river slope of levee 260 feet downstream of Feather River Bridge (10th Street Bridge)	No Rehabilitation Required		TL	
287	16	1020+85			Abandon 4 inch pipe	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(G)	1.3
288	16	1020+30	2,177,879.35	6,672,496.38	Telephone Call box on waterside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	
289	16	1019+82	2,177,832.15	6,672,504.71	Power pole in waterside slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
290	16	1013+00			To place approximately 4,000 feet of blanket drain and filter trench on the right bank of levee of the Feather River upstream and downstream of the SR 20 Bridge	No Rehabilitation Required		Struc	
291	16	1010+75	2,176,773.87	6,672,930.97	Install Guy within in landside slope of levee, 12 kV overhead electric	No Rehabilitation Required		EL	
292	16	1008+38	2,176,779.63	6,672,929.15	12 kv power line across levee	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
293	16	1007+50			To construct approximately 1,300 feet of 12 foot wide bicycle trail on the crown of the right bank levee of the Feather River. The Project is located in Yuba City between the 5th Street Bridge and the easterly extension of Teagarden Avenue.	Jet Grouting		Struc	
294	16	1007+50			4' by 3' deep erosion pocket. 4 foot vertical bank under Twin Cities Memorial Bridge	Jet Grouting		struc	
295	16	1007+50			To construct a bicycle trail for approximately 3.5 miles on the right bank levee other the Feather River from Shanghai Bend Road to Northgate Boulevard	Jet Grouting		Road	
296	16	1007+50			Bike Path below Twin Cities Memorial Bridge	Jet Grouting		Road	
297	16	1007+51	2,176,709.34	6,672,981.09	Twin Cities Memorial Bridge upstream side	Jet Grouting		Bridge	
298	16	1007+46	2,176,706.50	6,672,984.37	Light pole in water side levee slope	Jet Grouting	**Relocate outside of of the proposed right-of-way.**	EL	OH
299	16	1007+06	2,176,671.72	6,673,005.93	Twin Cities Memorial Bridge downstream side	Jet Grouting		Bridge	
300	16	1006+93	2,176,642.84	6,672,995.25	Power line and Anchor in Levee (actual location)	Jet Grouting		EL	
301	16	1006+60	2,176,647.27	6,673,046.63	Sacramento Northern Railroad	Jet Grouting		RR	
302	16	1006+07	2,176,610.55	6,673,084.90	Power Pole and anchor in slope of levee. 100 feet south of the SNRR bridge w/ service power overhead	Jet Grouting		EL	OH
303	16	1006+00			City of Yuba City. To replace the existing retaining wall with an 8 foot high, 76 foot long concrete retaining wall on the landside of the right (east) bank levee of Feather River.	Jet Grouting		struc	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
304	16	1005+80			Concrete steps and 4 inch diameter PVC pipe on the landward slope and a pump house within 10 feet of the landward toe.	No Rehabilitation Required		struc/IR (P)	
305	16	1003+72	2,176,461.52	6,673,266.98	Power Pole and anchor in slope of levee. 300 feet south of the SNRR bridge	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
306	16	1000+50			A 3-wire barded wire fence with a gate within 5 feet of the levee toe and two mature trees at the landward toe. The project is located on Keyser Street	No Rehabilitation Required		struc	
307	16	999+90			A 120 foot long building at the landward toe	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
308	16	995+50			Authorize a 3-wire barded wire fence and two mature trees at the landward toe. The project is located at 563??? Second Street	No Rehabilitation Required		struc	
~~309~~	~~16~~	~~995+50~~			~~To excavate 25 feet into landward side of the right bank of the Feather River and construct a concrete retaining wall to provide parking lot space. The project is located at 463 2nd Street behind the Sutter County Administration Building/~~	~~No Rehabilitation Required~~		~~struc~~	
~~310~~	~~16~~	~~993+56~~			~~To install approximately 1,010 feet of 8 foot high chain link fence on the waterside side of the right bank levee of the Feather River.~~	~~No Rehabilitation Required~~		~~struc~~	
311	16	993+25			A building near the landward toe of the levee.	No Rehabilitation Required		struc	
312	16	992+00			A shed, concrete wall, and chain-link fence with gate at landward toe. The permit also covers two steel posts on the shoulder and seventeen mature trees on the landward slope	No Rehabilitation Required		struc	
313	16	991+00			A shed at the landward toe	No Rehabilitation Required		struc	
314	16	992+00			A two-story garage and shop building at the landward toe and six mature trees on the landward slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
315	16	989+75			A building at the landward toe and 21 mature trees and sprinkler system on the landward slope.	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
316	16	988+05	2,175,065.02	6,673,942.87	3 inch steel pipe, does not appear to cross levee anymore	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	
317	16	989+20			A garage and a shed at the landward toe	No Rehabilitation Required		struc	
318	16	988+50			Authorize a small building, a chain-link fence, four mature trees at the landward toe, and five clumps of oleanders on the landward slope.	No Rehabilitation Required		struc	
319	16	987+60			Authorize a small building and a chain link fence on an existing retaining wall at the landward toe, concrete stairs, a steel pipe frame, and two large mature trees on the landward slope. A hose bib on the landward shoulder of the right bank of levee.	No Rehabilitation Required	**Recommended Relocation**	struc	
320	16	986+75			A see-through fence on a 5 foot retaining wall, steps, and nine mature trees on the landward slope.	No Rehabilitation Required		struc	
321	16	986+00			Concrete steps with railing and pomegranate bush on landward slope. The permit also covers a concrete retaining wall at the landward toe.	No Rehabilitation Required		struc	
322	16	985+30			Chain Link fence with gate, three oleander trees, and steps within the landward slope.	No Rehabilitation Required		struc	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
323	16	984+50			Chain Link fence with gate, three oleander trees, and steps within the landward slope.	No Rehabilitation Required		struc	
324	16	983+20			A building, barbed wire fence, and ten trees at landward toe	No Rehabilitation Required		struc	
325	16	981+25			A 60 foot long see-through board fence and 75 foot long clothesline and landward toe. A shed 5 feet from landward toe and a mature oak tree on the landward slope	No Rehabilitation Required		struc	
326	16	980+15			A chain-link fence with gate within 10 feet of landward toe	No Rehabilitation Required		struc	
327	16	979+90			A see-through fence and storage shed within 10 feet of the landward toe. The project is located at 265 Second Street, Yuba City, CA	No Rehabilitation Required		struc	
328	16	979+40			A see-through fence and storage shed within 5 feet of the landward toe. The project is located at 261 Second Street, Yuba City, CA	No Rehabilitation Required		struc	
329	16	978+80			A Chain Link fence with gate within 5 feet of landward toe, a cedar tree at the landward toe, and stone steps on the landward slope. This project is located at 255 Second Street.	No Rehabilitation Required		struc	
330	16	976+10			A shed and three trees at the landward toe of the right bank levee of the Feather River. The project is located at 225 Second Street, Yuba City, CA 95591	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
331	16	975+40			A 6 foot high chain link fence and gate at the right bank levee of the Feather River	No Rehabilitation Required		struc	
332	16	974+25			A residence within 5 feet of the landward toe	No Rehabilitation Required		struc	
333	16	973+30			A residence at landward toe and oak on the landward slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
334	16	975+00			To construct a restroom facility with septic tank and leach lines at the Yuba City Boat Ramp on the right bank of the Feather River.	No Rehabilitation Required		struc	
335	16	972+29			2 Inch Domestic Water Line serving the Yuba City Boat Dock.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with Title 23**	W(P)	
336	16	972+00			To construct improvement for the boat launching ramp and related facilities on the right bank of the Feather River.	No Rehabilitation Required		struc	
337	16	972+00			To construct improvement for the Yuba City Boat Ramp consisting of a paved parking area, restroom facilities, floating boat dock and extension of concrete boat ramp on the right bank of the Feather River.	No Rehabilitation Required		struc	
338	16	972+00			To reconstruct an existing access road to the Yuba-Sutter Boat Ramp on the right bank of the Feather River	No Rehabilitation Required		struc	
339	16	972+00			To maintain and operate existing boat dock for public use for boating, fishing, and a campground with related facilities including a mobile home on the right bank of the Feather River.	No Rehabilitation Required		struc	
	15/16	968+50			Reach 15/16 Transition	No Rehabilitation Required			
340	15	968+00			To construct 120 lineal feet of sheet piles retaining wall, and nine 10 x 10 foot boat docks supported by seven 12 inc diameter steel piles to an existing 30 foot wide ramp (Yuba City Boat Ramp)	No Rehabilitation Required	Located within floodway. Does not affect levee project.	struc	
341	15	964+78			Telephone Call box on waterside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
	14/15	954+40			Reach 14/15 Transition	No Rehabilitation Required			
342	14	952+00			12 kv cable	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	UG
	13/14	927+00			Reach 13/14 Transition	No Rehabilitation Required			
343	13	925+16			Telephone Call box on waterside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	
344	13	925+00			To construct access ramps	No Rehabilitation Required	Located within floodway. Does not affect levee project.	struc	
345	~~13~~	~~920+00~~			~~Consolidated Area Housing Authority of Sutter County. Strom Drainage Pipe Crossings. The size and location of the pipe is unknown. They have retention pond located at southwest corner of the airport. The Airport Business Park proposed crossing but application never filed.~~	~~Cutoff Wall~~	~~The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed.~~ ~~**Replace in accordance with Title 23**~~	~~SD (P)~~	
346	13	913+19	2,168,046.21	6,673,496.81	Two 16 inch gas lines. (PG&E map shows the gas lines as 2-12 inch)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.0
347	13	894+23	2,166,221.70	6,673,147.49	To install a 12kv buried power cable through the right bank levee and across the right bank overflow of the Feather River, a total distance of 896 feet. Poles will be installed near the top of the banks of the low water channel and aerial cable will be placed between the two poles which will be connected to the underground cable.	Cutoff Wall	The cable appears to meet title 23 requirements but the cutoff wall will remove improvements. **Replace in accordance with USACE standard**	EL	UG
348	13	893+84	2,166,181.41	6,673,142.43	Garden Highway Industrial Park. To install a 12 inch steel storm drain pipeline through the right bank levee of the Feather River (Source: City of Yuba City Pump Station No. 1)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	3.3
349	13	893+78	2,166,175.45	6,673,142.43	Burns Drive Storm Water Pump Station. 16 inch steel storm drain discharge pipe through levee. (Source: City of Yuba City Pump Station No. 1)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	2.7
350	13	881+40	2,164,942.19	6,673,036.13	Levee District No. 1 Relief Well Pump Station 6" pipes located just southeast of the Waste Water Treatment Plant. The waterside outlet structure has cobbles and the flap gate is damaged or plugged. CVFPB sent a notice of encroachment violation on August 16, 2011 to Sutter County.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Recommended Removal**	RW(P)	5.1
351	13	881+43	2,164,944.70	6,673,036.17	Levee District No. 1 Relief Well Pump Station 14" pipes located just southeast of the Waste Water Treatment Plant. The waterside outlet structure has cobbles and the flap gate is damaged or plugged. CVFPB sent a notice of encroachment violation on August 16, 2011 to Sutter County.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Recommended Removal**	RW(P)	5.1
352	13	856+23	2,162,702.52	6,674,085.34	South Yuba City Seepage Interceptor Pump Station 24 inch 7 GA Steel Pipe asphalt coated and wrapped with asphalt saturated felt discharge pipe (Source: City of Yuba City Pump Station No. ?)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Recommended Removal**	SD(P)	5.2
353	13	856+08	2,162,689.81	6,674,093.30	South Yuba City Storm Drainage Pump Station 24 inch 7 GA Steel Pipe asphalt coated and wrapped with asphalt saturated felt discharge pipe (Source: City of Yuba City Pump Station No. 3)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	5.2

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
354	13				Seepage Interceptor Trench and additional relief wells. The improvements were adjacent to the River Oaks subdivision between the wastewater treatment plant and Shanghai Road. All work on landside of levee.	Cutoff wall		struc	
355	13	849+85			Telephone Call box on waterside hinge point	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	TL	
356	13				Bike Path below Twin Cities Memorial Bridge	Cutoff wall		struc	
	12/13	845+00			Reach 12/13 Transition				
~~357~~	~~12~~				~~Shanghai Bend Road Setback levee project~~	No Rehabilitation Required		~~struc~~	
358	12	832+24	to be installed	to be installed	City of Yuba City Sewer 24 inch welded steel pipe mortar lined and coated pipe discharge pipe. This pipeline shall replace the existing 24 inch located at Station 828+55. The existing pipeline will be removed and disposed.	No Rehabilitation Required	This is a new pipelines that will meet Title 23 and USACE requirements except as noted in variance column.	SS(P)	2.0
359	12	832+17	to be installed	to be installed	City of Yuba City Sewer 2-24 inch welded steel pipe mortar lined and coated pipe discharge pipe. This is a new pipeline requested by the City of Yuba City.	No Rehabilitation Required	This is a new pipelines that will meet Title 23 and USACE requirements except as noted in variance column.	SS(P)	2.0
	11/12	830+00			Reach 11/12 Transition				
360	11	828+55	2,160,267.77	6,675,134.01	City of Yuba City Sewer 24 inch welded steel pipe mortar lined and coated pipe (wall thickness 0.188" min) Discharge Pipe to river diffuser	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SS(P)	2.3
~~361~~	~~11~~				~~To place an 18 inch storm drain pipeline through the levee on the right bank of the Feather River **(project was not completed - no pipeline installed)**~~	~~Cutoff Wall~~		~~SD(P)~~	
	10/11	774+00			Reach 10/11 Transition	Cutoff Wall			
362	10	771+30			Construct a gaging station approximately 150 feet downstream form the present gaging station, known as Feather River below Shanghai Bend. It is proposed to install an 8 foot high by 5 foot 4 inch square recorder house on the right bank berm approximately 155 feet from centerline of levee.	Cutoff Wall		struc	
363	10	750+40	2,152,869.21	6,673,338.66	115 kv steel tower transmission line crossing of levee	Cutoff Wall		EL	OH
364	10	750+10	2,152,823.05	6,673,332.24	12 kv power line crossing of levee	Cutoff Wall		EL	OH
	9/10	706+50			Reach 9/10 Transition	Cutoff Wall			
365	9	692+00			To construct 140 lineal feet of sheet piles retaining wall, and nine 10 x 20 foot boat docks supported by seven 12 inch diameter steel piles to an existing 30 foot wide ramp (Boyd Pump Boat Ramp)	Cutoff Wall	Located within floodway. Does not affect levee project.	struc	
366	9	692+00			To improve the existing Boyd Pump Boat Launching Facility by widening the existing ramp to 30 feet with 4 foot walkways on each side, paving existing access road, and expanding parking area by 25 spaces, and placing riprap on the right bank of the Feather River.	Cutoff Wall		Struc	
367	9	692+00			To construct boat launching ramp, well, pump, pressure system, and sanitary facilities on the right bank overflow of the Feather River	Cutoff Wall		Struc	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
368	9	689+09	2,146,949.33	6,672,031.04	Oswald Mutual Water Company (Boyd's Pump) 18 inch epoxy coated mortar lined steel pipe through existing 24 inch concrete pipe crossing of levee	Cutoff Wall	The pipeline does not meet title 23 requirements. The facility will need to go up and over the levee and will need a positive shut-off structure installed and anti-siphon device. **Replace in accordance with USACE standard**	IR(P)	27.6
369	9	689+00	2,146,953.52	6,672,029.11	To replace an existing pole line with a new pole line across the right bank levee of the Feather River. A new pole will be placed 10 feet landward of the landward toe of the levee and another pole will be placed 24 feet water ward of the water ward toe of the levee.	Cutoff Wall		EL	OH
370	9	689+00	2,146,953.52	6,672,029.11	To place a service line on a PG&E pole crossing the right bank levee of the Feather River	Cutoff Wall		TL	OH
371	9	688+90			Irrigation Production Well (located 25 foot west of landside levee toe)	Cutoff Wall		well	
372	9	669+20			Sierra Gold Nursery. Service Pole, Electrical Panel, Meter, and Irrigation Production Well 30 feet from landside levee toe.	Cutoff Wall		well	
373	9	664+07	2,144,450.88	6,672,127.42	Sierra Gold Nursery. An 8 inch steel pipe through levee. This pipe was pressure checked and in 1984 as part of permit 13980 to connect to existing pipe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	SD(P)	3.6
374	9	664+20			To reconstruct and pave a 12 foot wide, approximately 1370 feet long road on the landside toe of the right bank levee of the Feather River	Cutoff Wall		struc	4.0
375	9	655+50			Service Pole, Electrical Panel, Water Well, Pump, and irrigation facilities	Cutoff Wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
	8/9	654+75			Reach 8/9 Transition				
376	8	649+11	2,142,954.74	6,672,128.18	Construct #3/4 ACSR 12kv pole line across the right bank levee of the Feather River, approximately 1900 feet southerly from Messick Road extended easterly to the river. Extension to serve 50 HP agricultural pump for C.E. Sullivan	Cutoff Wall		EL	OH
377	8	647+74	2,142,830.08	6,672,119.48	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.6
378	8	647+70	2,142,826.16	6,672,118.89	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.3
379	8	647+66	2,142,822.01	6,672,118.27	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.4
380	8	647+61	2,142,817.52	6,672,117.60	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.3
381	8	638+20			Service Pole, Electrical Panel, Water Well, Pump, Sand Seperator, Concrete Pad, and irrigation facilities (20 feet west of levee toe)	Cutoff Wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
382	8	622+79			Stand pipe, Service Pole, Electrical Panel, and Pump House, Water Well, and Pump at landside levee toe	Cutoff Wall	The water well does not meet Title 23 since too cloase to levee. The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
383	8	622+79	2,140,350.59	6,671,955.66	Installation of a 12kv power line crossing of the right bank of the Feather River.	Cutoff wall		EL	OH
384	8	603+50			Service Pole, Electrical Panel, Water Well, Pump, Sand Seperator, Concrete Pad, and irrigation facilities (40 feet west of levee toe)	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	well	
	7/8	596+00			Reach 7/8 Transition	Cutoff wall			
385	7	592+67	2,137,447.24	6,671,791.94	12 kv power line across levee	Cutoff wall		EL	OH
386	7	587+00	2,136,925.70	6,671,619.94	Spur Levee upstream of Abbott Lake	Cutoff wall		struc	
387	7				WS Slope varies from 3:1 near crown to 2:1 to 1:1 at toe. Sloughing and caving toe. Along slope I is hummocky; possibly from local slumping.	Cutoff wall		struc	
388	7				caving and slumping at toe. Rip rap berm toe. Diffcult to evaluate due to vegetation growth.	Cutoff wall		struc	
389	7	560+00			To fill in approximately one mile of an existing irrigation ditch at the waterside toe of the right bank of the Feather River.	Cutoff wall with existing relief wells	**Relocate outside of of the proposed right-of-way.**	Struc	
390	7				Bank caving 3 to 4 feet high, intermittent repair with rip rap berm at base of over steepened slope	Cutoff wall with existing relief wells		struc	
391	7	560+00			To construct a water well with a 14 inch casing in the right bank overflow of the Feather River at Abbott Lake	Cutoff wall with existing relief wells		well	
392	7	560+00			To extend approximately 2,500 of 12kv electric service line in the right bank overflow area of the Feather River near Abbott Lake to serve 25 HP Ag Pump for A.S. Cozzolino.	Cutoff wall with existing relief wells		EL	OH
393	7	557+00			Service Pole, Electrical Panel, Water Well, Pump, Sand Seperator, Concrete Pad, and irrigation facilities (50 feet west of levee toe)	Cutoff wall with existing relief wells	**Relocate outside of of the proposed right-of-way.**	well	
394	7	545+41	2,132,940.57	6,672,317.26	Crushed CMP Riser in Land Side Slope. Possible location of 8 inch steel pipe.	Cutoff wall with existing relief wells	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(A)	3.1
395	7	536+73	2,132,153.19	6,672,681.57	Existing 10 inch steel pipe. Removed in 1964 by Levee District No. 1 as part of permit 4775	Cutoff Wall		IR(?)	
396	7	536+64	2,132,149.73	6,672,692.81	5 inch steel drainage pipe	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(P)	2.0
397	7	532+00 to 596+00			Taylor Brothers. 15 Inch Irrigation Main located within 15 feet of landside toe	Cutoff Wall	The pipeline is within twenty (20) feet of the levee toe and does not meet Title 23. **Relocate outside of of the proposed right-of-way.**	IR (G)	
398	7	529+47	2,131,549.40	6,673,081.12	Abandon 6 inch pipe	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(A)	4.0
399	7	515+00			Seepage Interceptor Trench for Star Bend Relief Well Pumps	Cutoff Wall		struc	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
400	7	512+08	2,130,379.55	6,674,329.99	Corp of Engineers Star Bend Road Relief Well Pump Station north 15" Steel Discharge Pipe Crossings	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed. **Replace in accordance with USACE standard**	SD(P)	3.8
401	7	512+04	2,130,375.66	6,674,332.71	Corp of Engineers Star Bend Road Relief Well Pump Station south 15" Steel Discharge Pipe Crossings	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed. **Replace in accordance with USACE standard**	SD(P)	3.7
402	7	510+97	2,130,288.81	6,674,393.77	12 kv power line crossing of levee	Cutoff Wall		EL	OH
	6/7	510+37			Reach 6/7 Transition	Cutoff Wall			
403	6	510+50			To retain a 12 kv overhead service line and four power poles in the right bank overflow area of the Feather River.	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
404	6	510+36	2,130,239.19	6,674,428.41	Volcano Vista Farms 18 inch steel irrigation discharge pipe crossing of levee	Cutoff Wall		IR(P)	4.0
405	6	510+30			To install 20 hp irrigation pump and to retain an existing walnut orchard (35 acres) all on the right bank of the Feather. Now owned by Volcano Vista Farms and located on Tudor Mutual Pump Station (relocated pipeline part of permit 18438)	Cutoff Wall		IR(P)	
406	6	510+25	2,130,230.41	6,674,434.54	Tudor Mutual Water Company North 30 inch steel irrigation discharge pipes crossing of levee	Cutoff Wall		IR(P)	4.2
407	6	510+20	2,130,222.24	6,674,437.45	Tudor Mutual Water Company South 30 inch steel irrigation discharge pipes crossing of levee	Cutoff Wall		IR(P)	4.1
408	6				12 inch steel pipe through levee	Cutoff Wall	The conduit may meet title 23 requirements but will need to be replaced during cutoff wall construction. **Replace in accordance with USACE standard**		
409	6				12 kv power line crossing of levee	Cutoff Wall			
410	6				12 kv power line crossing including 9 power poles and 3 anchors (appears to cover permit 2502 and 5072)	Cutoff Wall			
411	6				Abandon 14 inch pipe (this pipeline removed as part of 2009 setback levee project). Listed as 10" Steel in original 1955 O&M manual.	Cutoff Wall	**Recommended Removal**	IR(P)	4.1
412	6	509+00			To construct approximately 1,400 lineal feet of filter trench adjacent to the right bank levee of the Feather River	Cutoff Wall		Struc	
413	6	508+00			To clear, level, and plant a peach orchard on approximately 170 acres on the right bank of the Feather River.	Cutoff Wall		Trees	
414	6				Fix in-place the existing levee with 65ft deep cutoff wall between station 478+68 and station 512+00	Cutoff Wall		struc	
	5/6	478+68			Reach 5/6 Transition	Cutoff wall with seepage berm			
415	5	475+00			To plant walnut orchard in the right overflow area of the Feather River downstream from Star Bend	Cutoff wall with seepage berm		Trees	
	5	461+00			Urban (200 year) North - Nonurban (100 year) South Transition	Cutoff wall with seepage berm			

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
416	5	460+11	2,125,845.57	6,676,268.36	Abandon 8" steel drainpipe. The CVFPB sent an encroachment violation notice on August 16, 2011 to Dan Stephens Trust.	Cutoff wall with seepage berm	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(P)	4.1
417	5	442+80	2,124,212.69	6676803.8	Abandon 8" steel drainpipe	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(P)	4.1
418	5	433+50	2,123,304.56	6,677,004.67	Power line across levee to service pole with meter on waterside slope of levee	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
419	5	409+00 to 424+00			Taylor Brothers. 15 Inch Irrigation Main located within 15 feet of landside toe	Cutoff wall	The pipeline is within twenty (20) feet of the levee toe and does not meet Title 23. **Relocate outside of of the proposed right-of-way.**	IR (G)	
420	~~5~~	~~417+66~~	~~Not Verified~~		~~Abandon Existing 24 inch pipe through levee. The permit was revised to removal of 24 inch via 4666A so there should not be any pipe.~~	~~Cutoff wall~~		~~SD(G)~~	
	4/5	410+67			Reach 4/5 Transition	Cutoff wall			
421	4	410+53	2,121,173.09	66,776,661.21	Power line crossing to Feather Water District Pumps	Cutoff wall		EL	OH
422	4	409+84	2,121,105.29	6,677,660.77	To install a 2 inch electrical conduit through the levee. The conduit will be buried in the levee slopes and through the crown with one foot of cover. The conduit will provide electrical service to an existing pumping plant in the floodway of the Feather River.	Cutoff wall	The conduit may meet title 23 requirements but will need to be replaced during cutoff wall construction. **Replace in accordance with USACE standard**	EL	2.0
423	4	409+66	2,121,086.77	6,677,660.88	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	0.8
424	4	409+62	2,121,082.47	6,677,660.77	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	0.9
425	4	409+58	2,121,078.48	6,677,660.82	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	0.8
426	4	409+55	2,121,075.08	6,677,660.80	Taylor Brothers Farm Irrigation Pump Station. A inclined pump located on the waterside slope of levee with 14 Inch Pipeline through levee	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.4
427	4	409+50	2,121,069.88	6,677,660.77	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.7
428	4	407+72	2,120,892.86	6,677,656.42	Abandoned pipe and structure at landside toe, pipe is 8 inch, but the headwall appears that it is ran through a larger older pipe possibly and old drainage pipe.	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	21.8
429	4	407+72	2,120,892.86	6,677,656.42	Taylor Brothers Production Water Well (facilities located at levee toe).	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	well	
430	4	396+32	2,119,752.28	6,677,651.86	8 inch pipe crossing. Headwall at land toe, art on land side of crown, and cut pipe near water side toe. CVFPB sent a notice of violation notice on October 4, 2011.	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(P)	4.1
431	4	396+50 to 409+00			Taylor Brothers. 15 Inch Irrigation Main located within 15 feet of landside toe	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	IR (G)	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
432	4	396+50 to 409+00			Feather Water District. 42 Inch Irrigation Main located within 10 feet of landside toe with standpipes	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	IR (G)	
433	4	396+20			Feather Water District Irrigation Production Well (facilities located 10 foot west of toe). CVFPB sent a notice of violation notice on October 4, 2011.	Cutoff Wall		well	
434	4	386+63	2,118,786.69	6,677,704.40	Abandon 8 inch pipe crossing, stand pipe on land toe has been destroyed. CVFPB sent a notice of violation on October 4, 2011.	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	4.6
435	4	365+00	2,116,703.78	6,678,265.36	Abandon 8 inch pipe crossing, stand pipe on land toe has been removed.	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	4.8
436	4	342+27	2,114,521.83	6,678,856.40	Irrigation Production Well (located xx foot west of levee toe)	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	well	
437	4	320+00			Approximately 500 horizontal feet of vertical excavation in the levee toe, cut 1 to 3 feet high. CVFPB sent out a encroachment violation notice on July 27, 2011 to Monasterio Family Trust.	Cutoff Wall		struc	
438	4	313+00			Approximately 100 horizontal feet of vertical excavation in the levee toe, cut about 3 feet high. Toe excavations are eroding and caving. CVFPB sent out a encroachment violation notice on September 12, 2011 to Monasterio Family Trust.	Cutoff Wall		struc	
	3/4	300+66			Reach 3/4 Transition				
439	3	298+89	2,110,314.83	6,679,535.86	Removal of a portion and filling with concrete a portion of an abandoned 36 inch steel pipe through the right bank levee of the Feather River	Cutoff wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(G)	
440	3	298+00			Approximately 600 horizontal feet of vertical excavation in the levee toe, cut 1 to 3 feet high. Toe excavations are eroding and caving. The CVFPB sent an encroachment violation notice on July 27, 2011 to Golden Gate Hop Ranch, Inc..	Cutoff wall		struc	
441	3	298+67	2,110,292.12	6,679,458.78	Garden Highway Mutual Water - Irrigation Production Well #23 (located 30 foot west of levee toe)	Cutoff wall		IR(W)	
442	3	298+38	2,110,262.81	6,679,553.51	Garden Highway Mutual Water 54 inch Irrigation Pump Station Discharge Pipeline through Levee. The improvements include a inlet channel from the river to the 200 feet from waterside toe of levee and irrigation canal at the toe of the landside of levee.	Cutoff wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed and new pipe. **Replace in accordance with USACE standard**	IR(G)	25.1
	3	280+90			State Maintenance Area 3 / Levee District No. 1 Levees Transition	Cutoff wall			
443	3	279+50			Garden Highway Mutual Water - Irrigation Production Well #4 (located 90 foot west of levee toe)	Cutoff wall		IR(W)	
444	3	274+50			Garden Highway Mutual Water - Irrigation Production Well #22 (located 20 foot west of levee toe)	Cutoff wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	IR(W)	
445	3	241+75			Garden Highway Mutual Water - Irrigation Production Well #18 (located 50 foot west of levee toe)	Cutoff wall		IR(W)	
446	3	219+00			Garden Highway Mutual Water - Irrigation Production Well #19 (located 90 foot west of levee toe)	Cutoff wall with seepage berm		IR(W)	
447	3	219+00			12 inch pipe. Appears to be removed by pipe laying on ground adjacent to location	Cutoff wall with seepage berm	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	
	2/3	218+66			Reach 2/3 Transition				
448	2	209+89	2,101,737.07	6,678,031.40	Electrical service crossing for pump	Cutoff wall with seepage berm	**Relocate outside of of the proposed right-of-way.**	EL	OH

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
449	2	209+23	2,101,673.35	6,678,014.21	Kuster Private Irrigation Pump Station. 14 inch welded steel pipe crossing	Cutoff wall with seepage berm	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed and new pipe. **Replace in accordance with USACE standard**	IR(P)	3.0
450	2	217+00			National Audubon Society. To plant approximately 4,000 native trees on 40 acres within the right bank overflow area of the Feather River.	Cutoff wall with seepage berm		Trees	
451	2	217+00			National Audubon Society. To plant approximately 300 to 500 native trees (primarily cottonwoods) on the right bank overflow area of the Feather River.	Cutoff wall with seepage berm		Trees	

Type 1A - Removal & Disposal of Abandoned Raised Pipe

Type 1B - Removal & Disposal of Abandoned Through Pipe

Type 2A - Removal & Replace of Raised Pipe

Type 2B - Removal & Replace of Through Pipe

Type 3A - Removal & Replace of Raised Pipe Adjacent to Canal

Type 3B - Removal & Replace of Through Pipe Adjacent to Canal

Type 3C - Removal & Replace of Through Pipe Under Canal

Vegetation ETL Compliance

Relocation of Utility/Structure Outside of The Proposed ROW

Additional Works

Not Applicable/No Rehabilitation Required

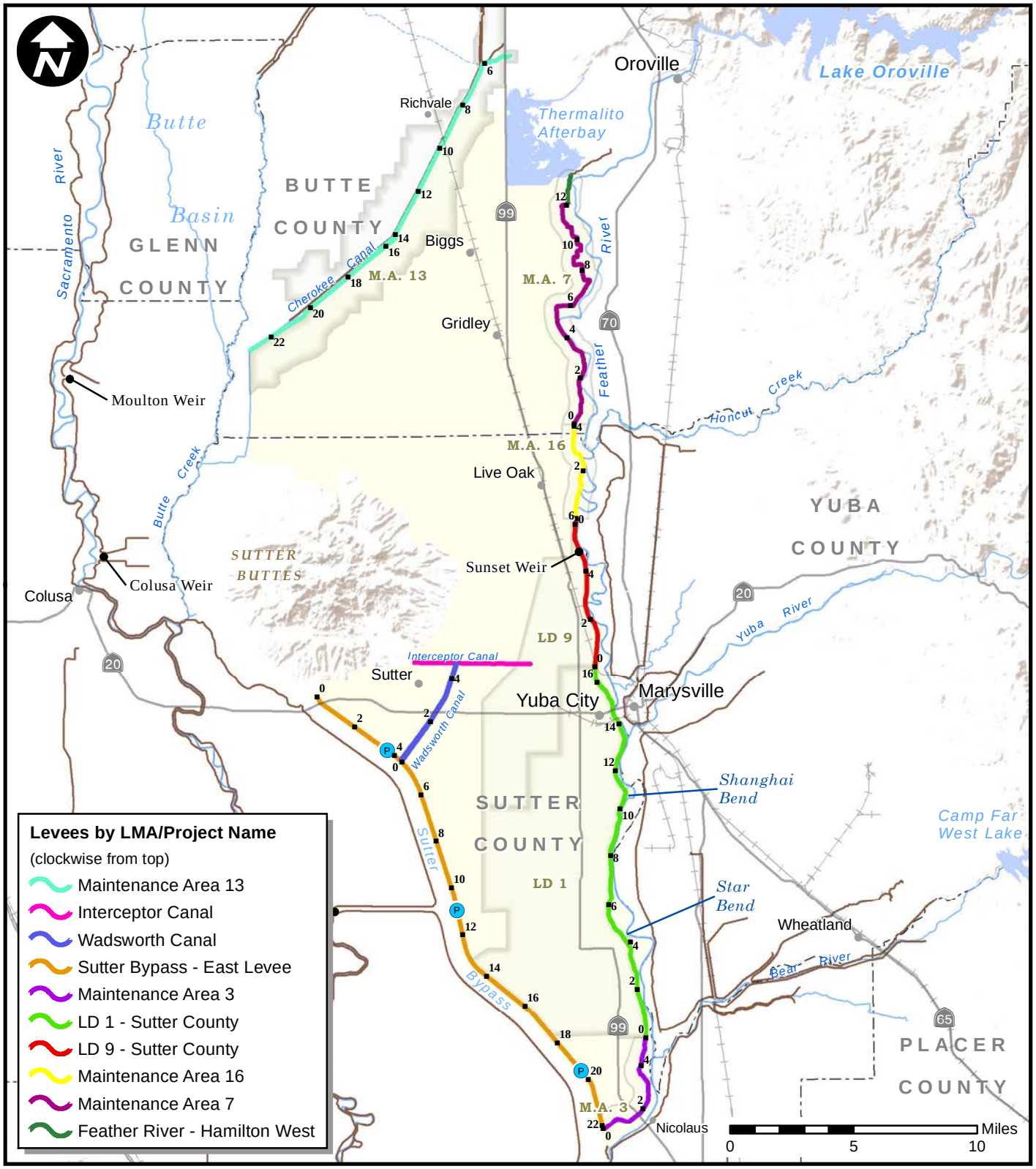
SD(G)	Storm Water - Gravity
SD(P)	Storm Water - Pressure
SS (G)	Waste Water - Gravity
SS (P)	Waste Water - Pressure
IR(G)	Irrigation Line - Gravity
IR(P)	Irrigation Line - Pressure
RW (P)	Raw Water - Pressure
W(P)	Water Line - Pressure
RD	
GL	Gas Line
TL	Telephone Line
EL	Electrical Line
SEEP	
STRUC	Structure

Table 5-4A Summary of Construction Contracts for Alternative SB8

Features	Contract A Reach 2A-North to 5 180+00 to 478+68 2022 - 2023	Contract SBFIP Reach 6 478+68 to 512+00 2021 – 2022	Contract B Reach 7 to 12 512+00 to 845+00 2021 - 2022	Contract C1 Reach 13 to 18 845+00 to 1213+85 2017 – 2018	Contract C2 Reach 19 to 25 1213+85 to 1674+37 2018 – 2019	Contract D1 Reach 26 to 33 1674+37 to 2122+00 2019 – 2020	Contract D2 Reach 34 to 41 2122+00 to 2638+00 2020 - 2021
No Rehabilitation Required	N/A	N/A	1,300LF	14,930LF	4,800LF	4,390LF	2,800LF
Cutoff Wall Only	22,200LF	3,340LF	26,150LF	11,490LF	36,680LF	30,910LF	16,800LF
Jet Grouting Cutoff Wall Only	N/A	N/A	N/A	560LF	N/A	400LF	N/A
Seepage Berm Only	N/A	N/A	N/A	350LF	N/A	NA	5,000LF
Cutoff Wall with Full Levee Degrade	N/A	N/A	N/A	N/A	600LF	NA	N/A
Cutoff Wall with Full Levee Degrade and Existing Relief Wells	N/A	N/A	N/A	5,300LF			
Cutoff Wall with Existing Relief Wells	N/A	N/A	3,300LF	2,630LF	N/A	NA	N/A
Cutoff Wall with New Relief Wells (22 Wells)	N/A	N/A	2,500LF	N/A	N/A	NA	N/A
Cutoff Wall with Seepage Berm	7,670LF	N/A	N/A	N/A	N/A	NA	N/A
Cutoff Wall with Levee Relocation	N/A	N/A	N/A	N/A	3,610LF	8,000LF	N/A
Cutoff Wall with Sutter Butte Canal Relocation	N/A	N/A	N/A	N/A	370LF	1,170LF	N/A
Cutoff Wall with Landside Toe Fill	N/A	N/A	N/A	1,870LF	N/A	NA	N/A
DSM Cutoff Wall (subpart of the Cutoff Wall Only area)	2,000LF	N/A	N/A	2,630LF	2,400LF	5,580LF	7,180LF
Erosion Protection	N/A	N/A	5,760LF	N/A	1,900LF	NA	N/A
Utilities & Encroachments (Total, Table 5-4B)	37	12	46	129	86	94	47
Utilities & Encroachments (To be modified, Table 5-4B)	27	4	19	53	37	52	31
Land Acquisition							
Number of Impacted Parcel							
Number of Potential Structural Demolition							
Closure Structure	N/A	N/A	N/A	1	N/A	N/A	N/A

Table 5-4B Summary of Utilities & Encroachments for Construction Contracts

Color Codes	Types of Remediation	Alt. SB8	Construction Contracts						
			A	SBFIP	B	C1	C2	D1	D2
		Item No. 1 - 451	Item No. 415 - 451	Item No. 403 - 414	Item No. 357 - 402	Item No. 228 - 356	Item No. 142 - 227	Item No. 48 - 141	Item No. 1 - 47
	Type 1A - Removal & Disposal of Abandoned Raised Pipe	**21**	6	0	3	6	4	2	0
	Type 1B - Removal & Disposal of Abandoned Through Pipe	**12**	2	0	0	1	1	5	3
	Type 2A - Removal & Replace of Raised Pipe	**57**	7	0	9	25	6	6	4
	Type 2B - Removal & Replace of Through Pipe	**24**	1	0	0	0	3	9	11
	Type 3A - Removal & Replace of Raised Pipe Adjacent to Canal	**1**	0	0	0	0	0	1	0
	Type 3B - Removal & Replace of Through Pipe Adjacent to Canal	**3**	0	0	0	0	0	3	0
	Type 3C - Removal & Replace of Through Pipe Under Canal	**4**	0	0	0	0	1	3	0
	Vegetation ETL Compliance	**26**	3	1	0	0	12	10	0
	Relocation of Utility/Structure Outside of The Proposed ROW	**57**	8	1	7	18	9	9	5
	Additional Works	**18**	0	2	0	3	1	4	8
	Not Applicable/No Rehabilitation Required	**228**	10	8	27	76	49	42	16
Total Number of Utilities & Encroachments		**451**	37	12	46	129	86	94	47
Total Number of Utilities & Encroachments To Be Modified		**223**	27	4	19	53	37	52	31



Legend

- Study Area Extent
- Levee Maintenance Agency
- Federal Levee
- Levee Mile
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

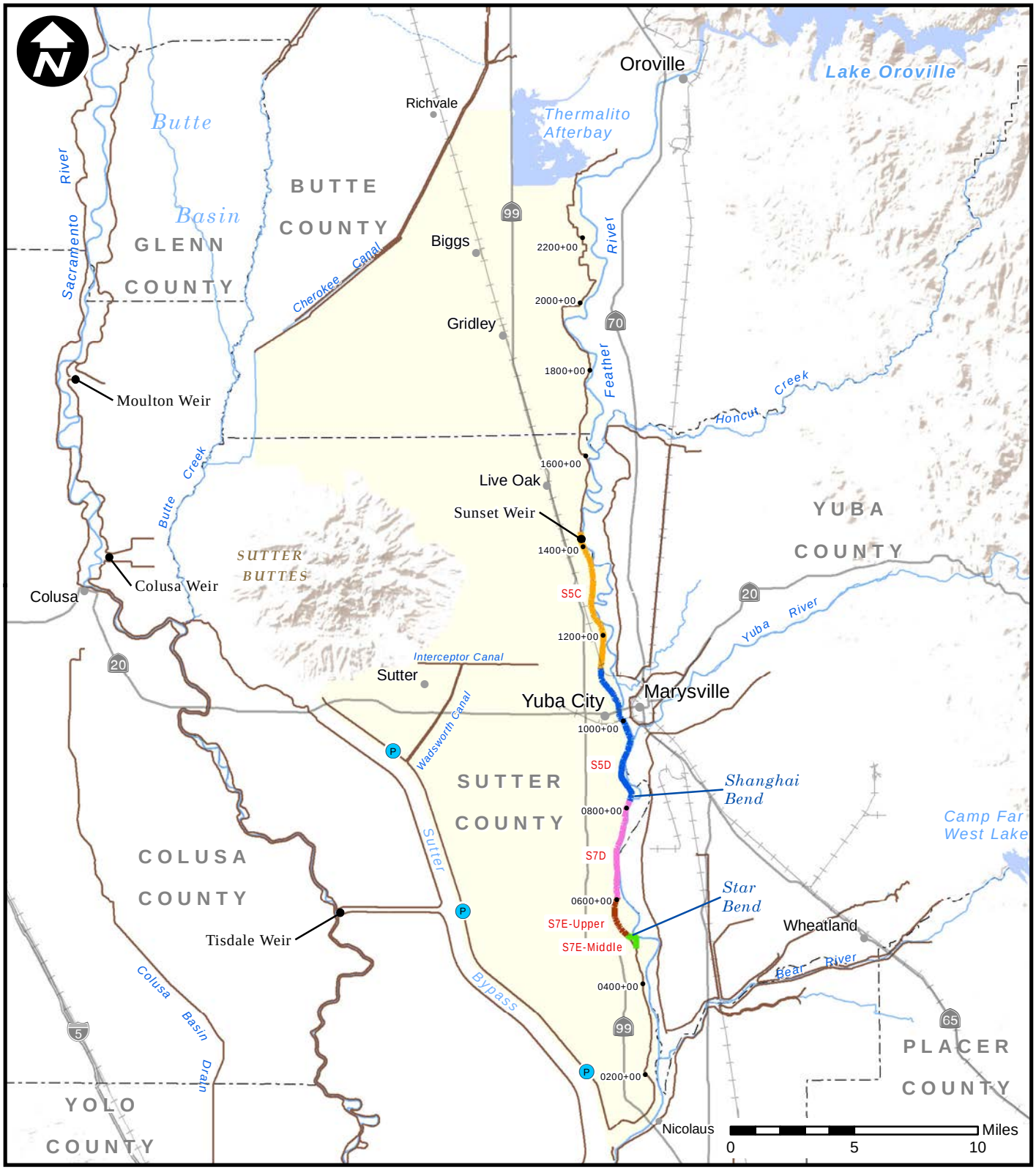
SUTTER BASIN PROJECT AREA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-1



Legend

- Study Area Extent
- Project Reach (S5B)
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

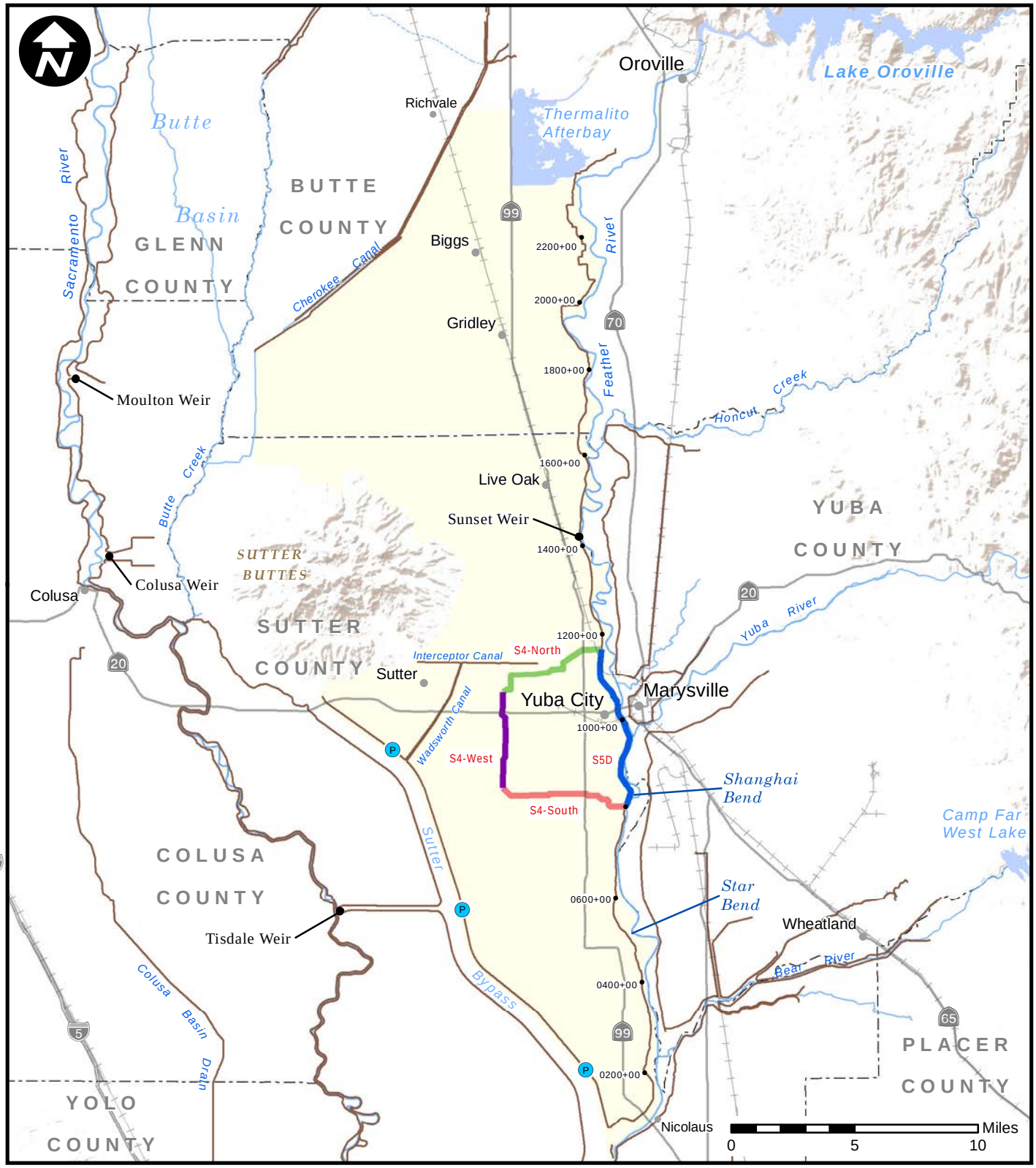
ALTERNATIVE SB-2: MINMAL FIX-IN-PLACE FEATHER RIVER LEVEES: SUNSET WEIR TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-2



Legend

- Study Area Extent
- S5B Project Reach
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

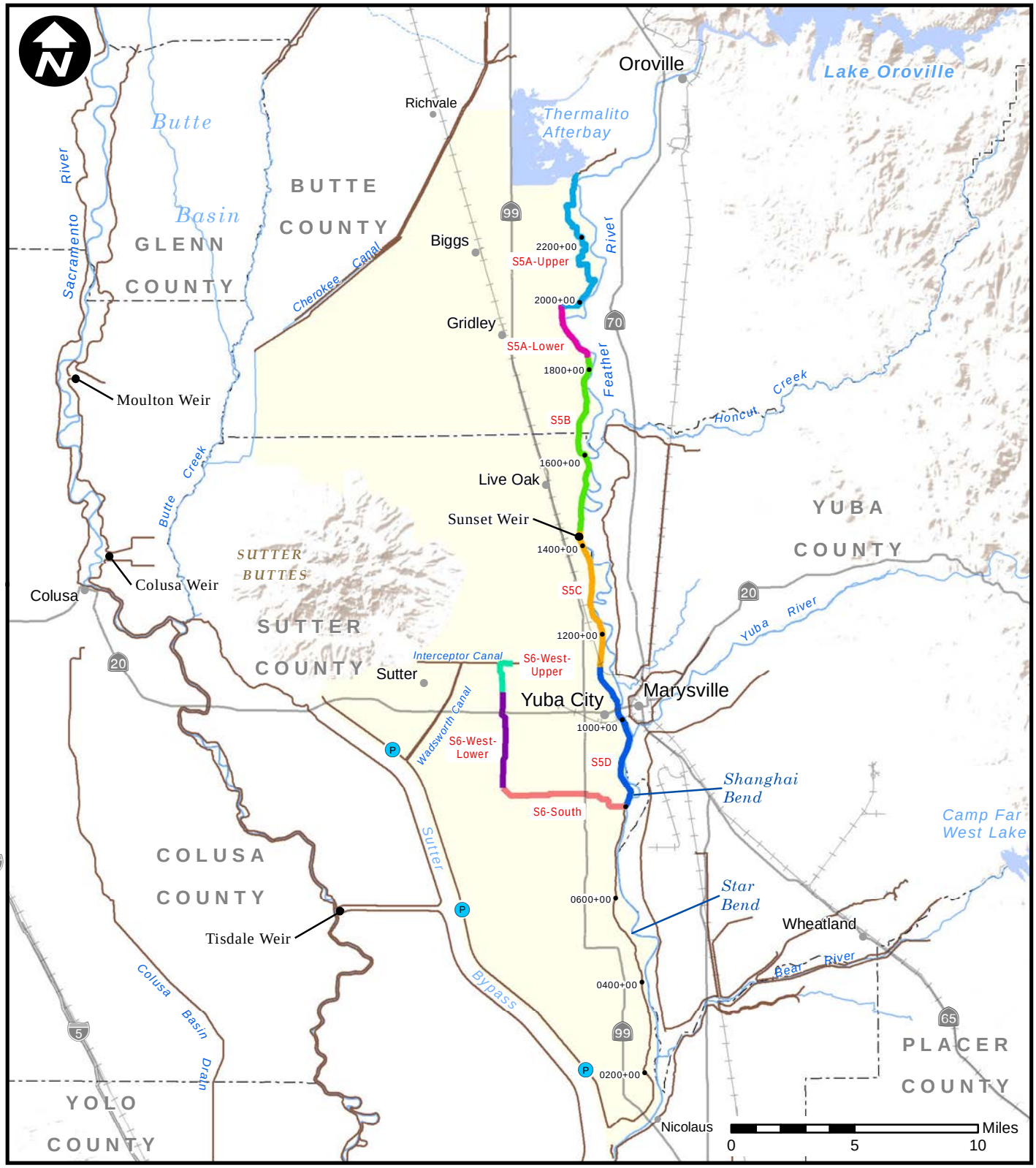
ALTERNATIVE SB-3: YUBA CITY RING LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-3



Legend

- Study Area Extent
- S5B Project Reach
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

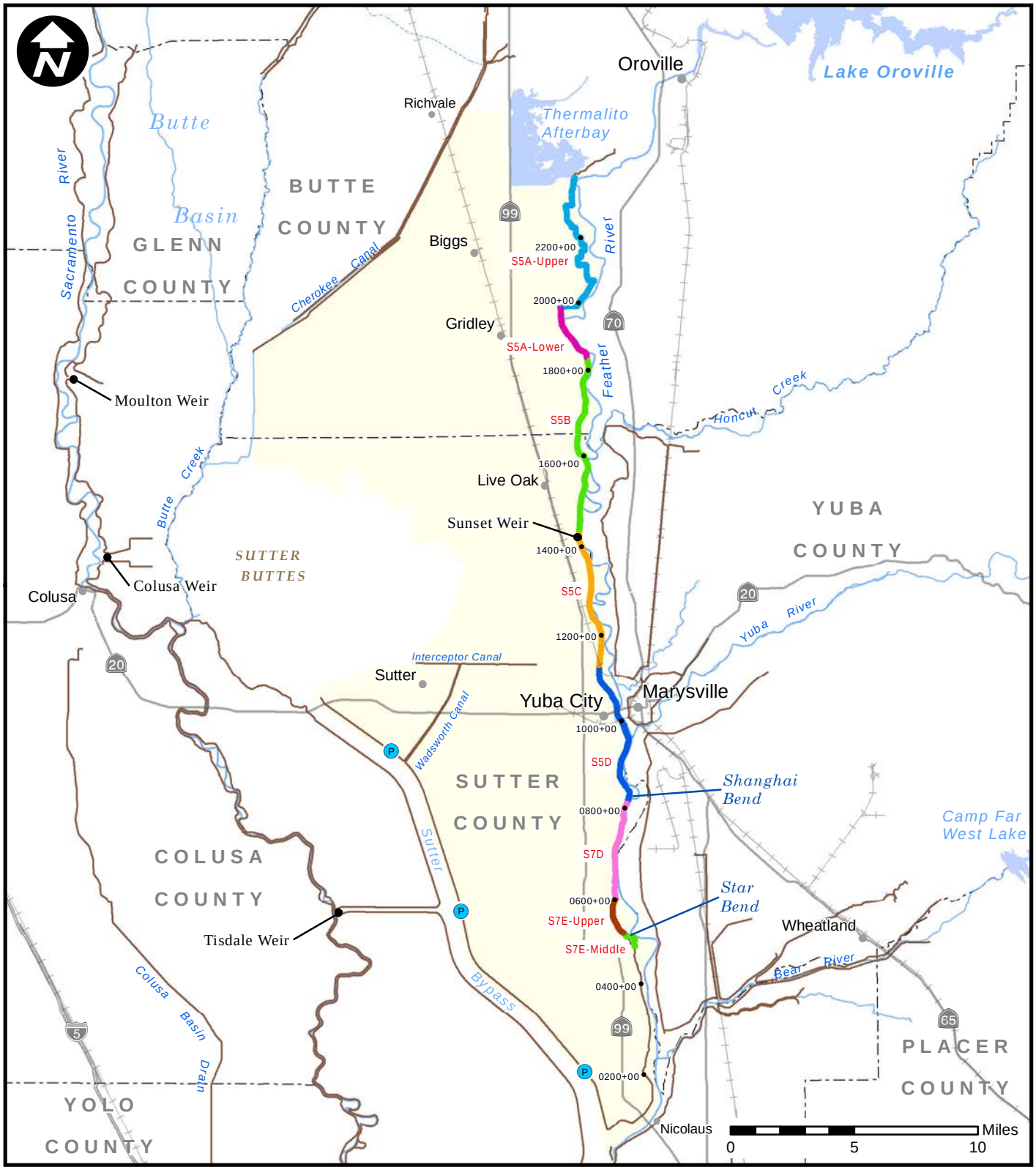
ALTERNATIVE SB-4: LITTLE J LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-4



Legend

- Study Area Extent
- S5B Project Reach
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

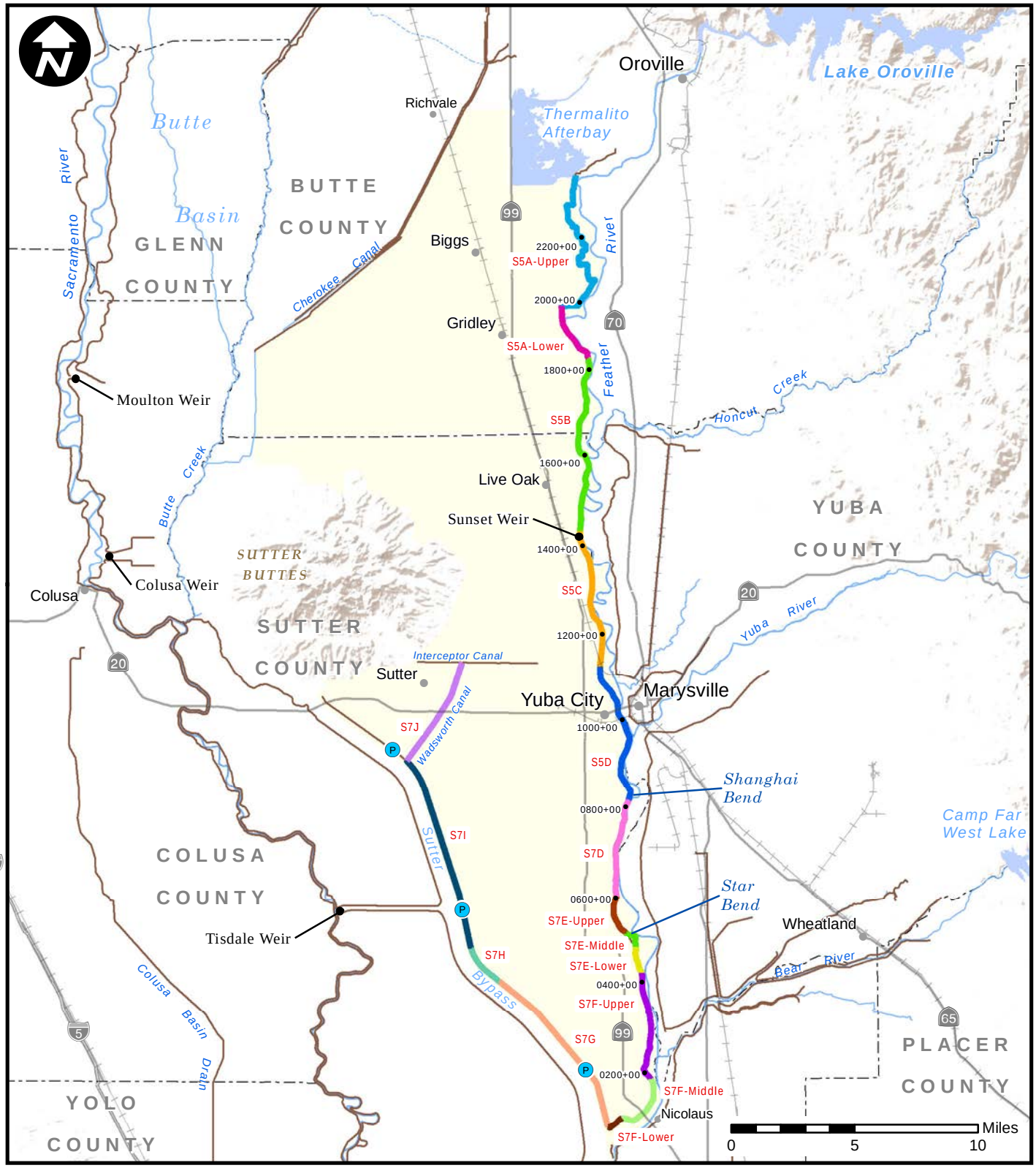
ALTERNATIVE SB-5: FIX-IN-PLACE FEATHER RIVER LEVEES: THERMAILTO TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-5



Legend

- Study Area Extent
- Project Reach (S5B)
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-6: FIX-IN-PLACE FEATHER RIVER, SUTTER BYPASS, AND WADSWORTH CANAL LEVEES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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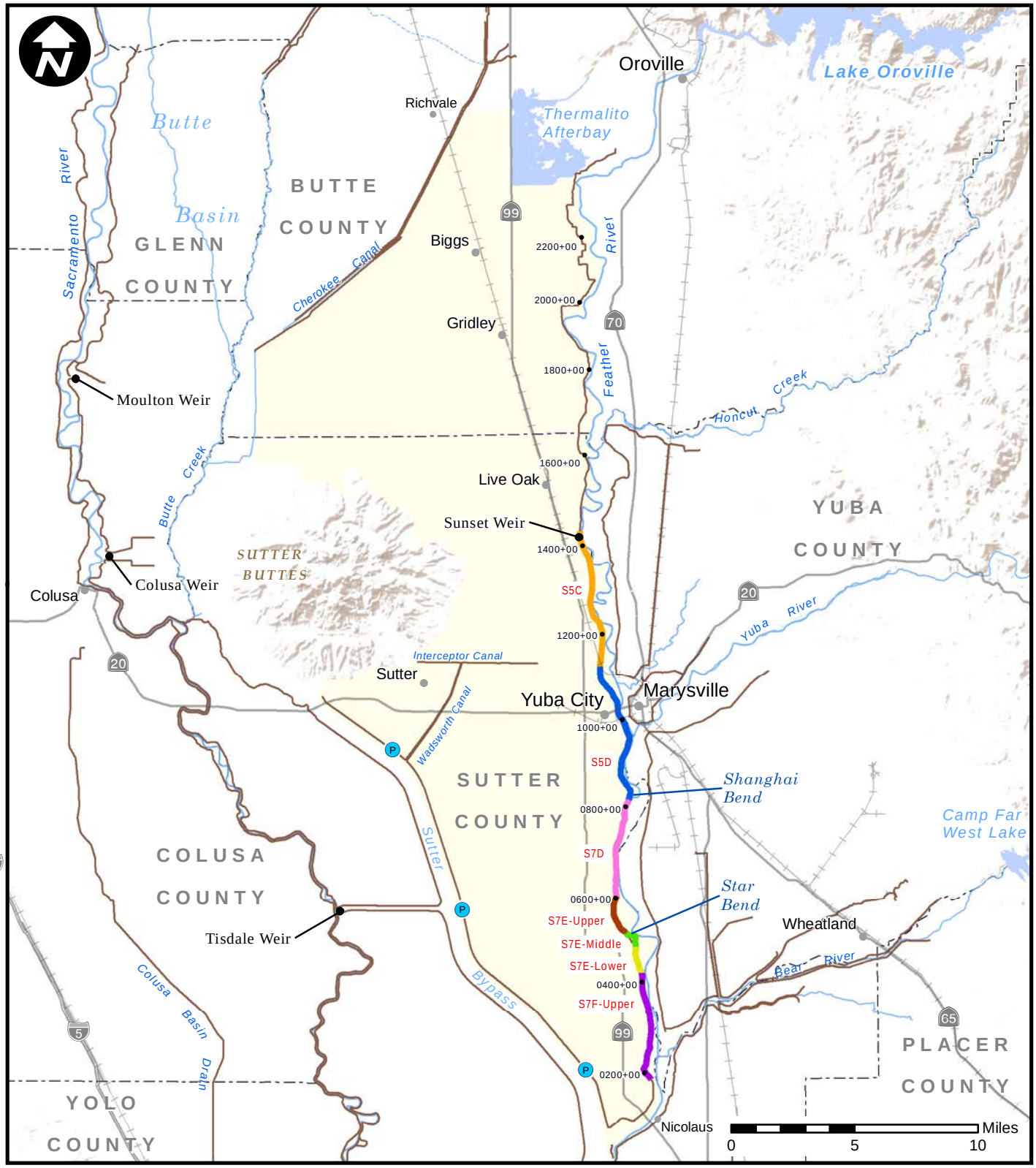
PLATE 1-6



Legend

- Study Area Extent
- Project Reach (S5B)
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-7: FIX-IN-PLACE FEATHER RIVER LEVEES: SUNSET WEIR TO LAUREL AVE

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SACRAMENTO DISTRICT

Prepared by Jim Mars

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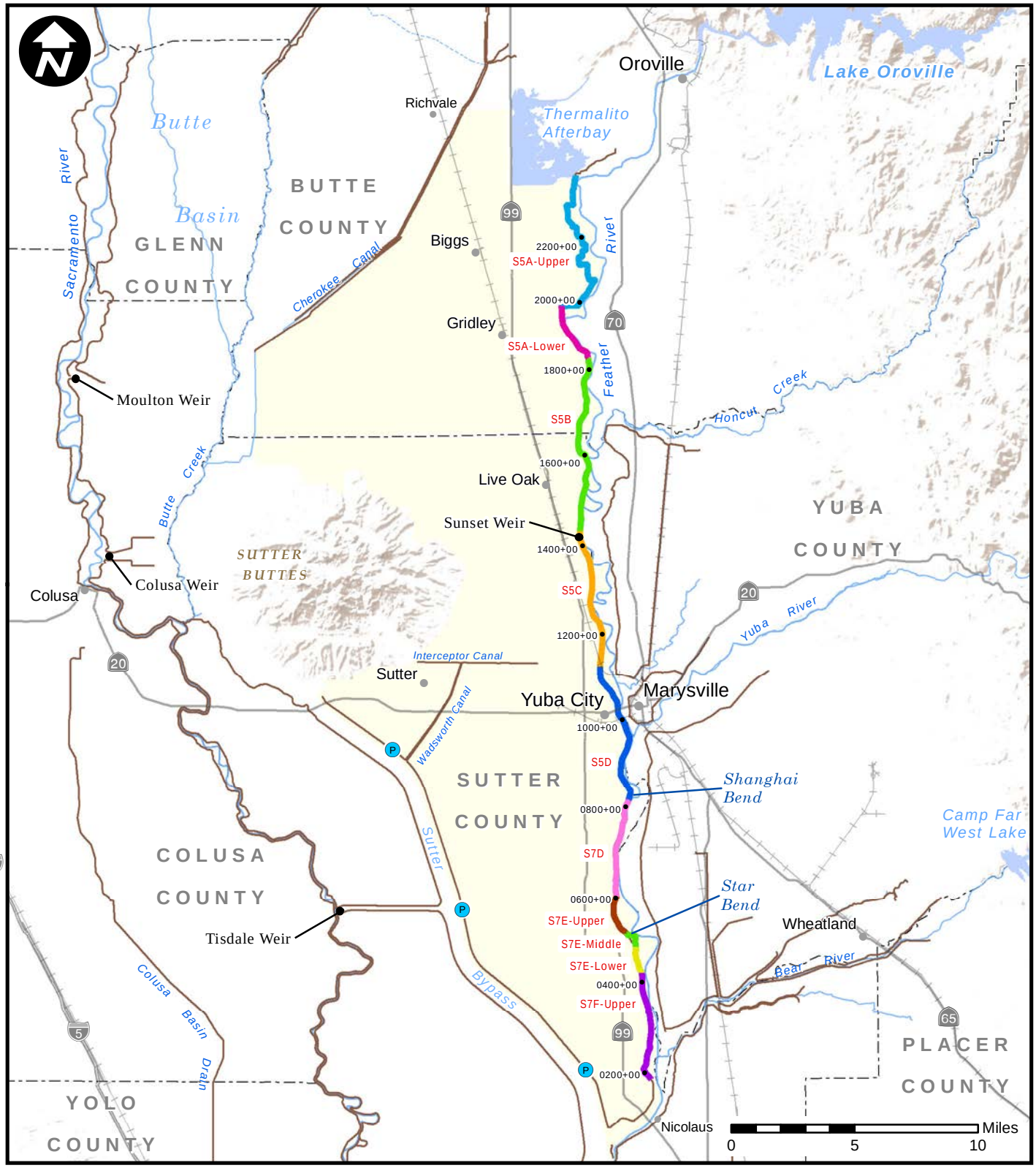
PLATE 1-7



Legend

- Study Area Extent
- S5B Project Reach
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-8: FIX-IN-PLACE FEATHER RIVER LEVEES: THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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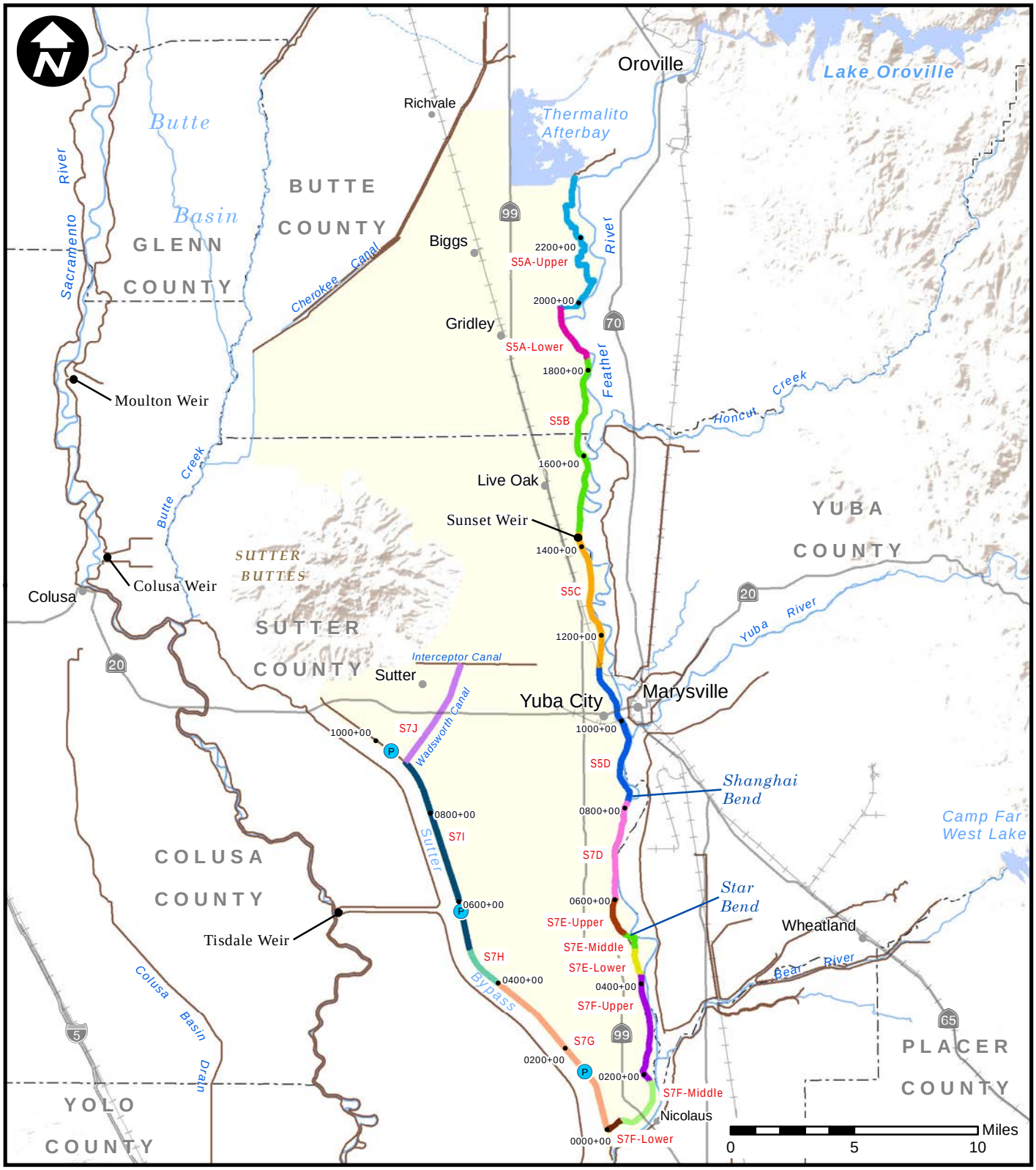
PLATE 1-8



Legend

- Study Area Extent
- Project Reach (S5B)
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

PROJECT REACHES FOR CONCEPTUAL ALTERNATIVES

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SACRAMENTO DISTRICT

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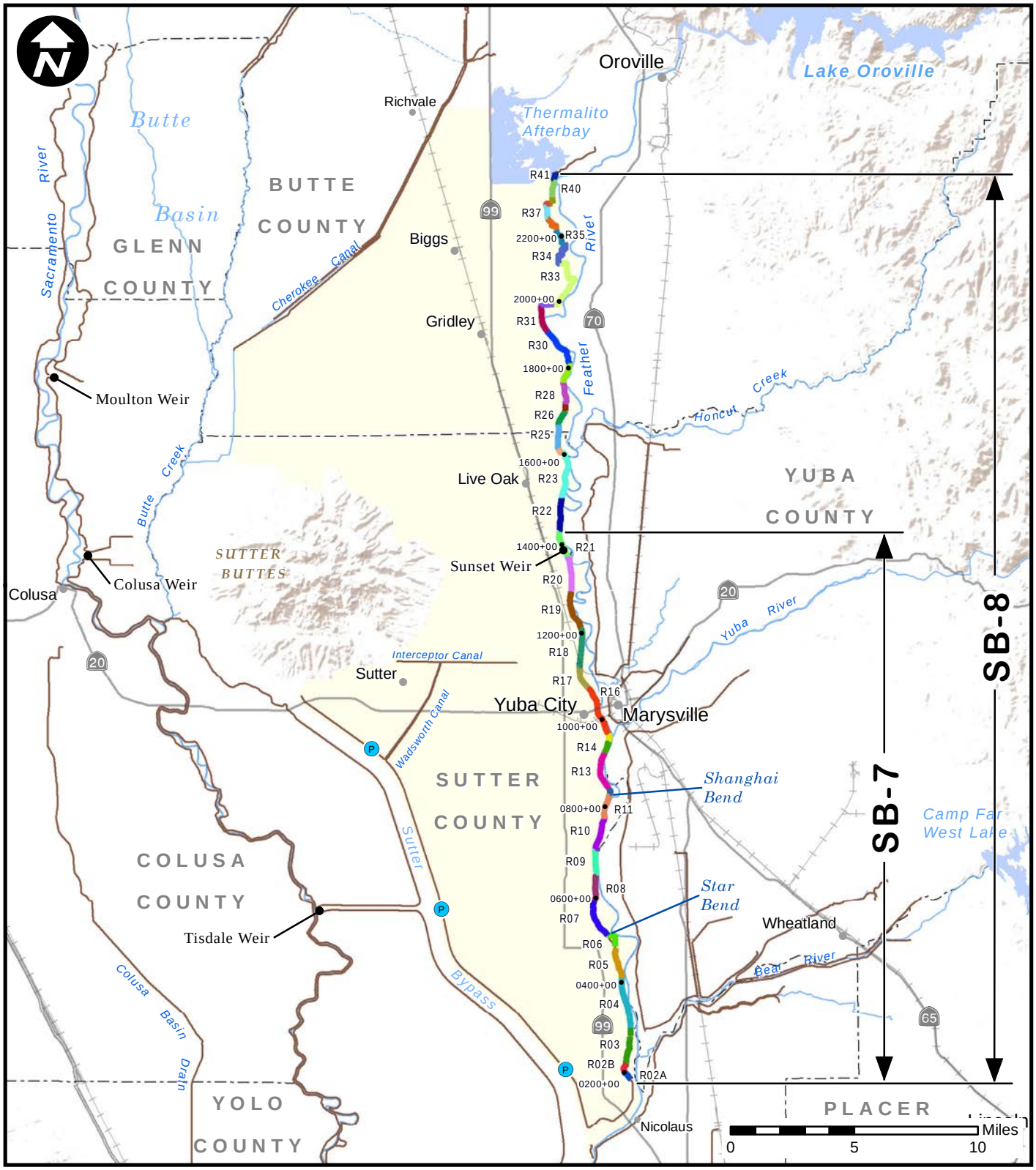
PLATE 2-1



Legend

- Study Area Extent
- Project Reach (R5)
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROJECT REACHES FOR FINAL ALTERNATIVES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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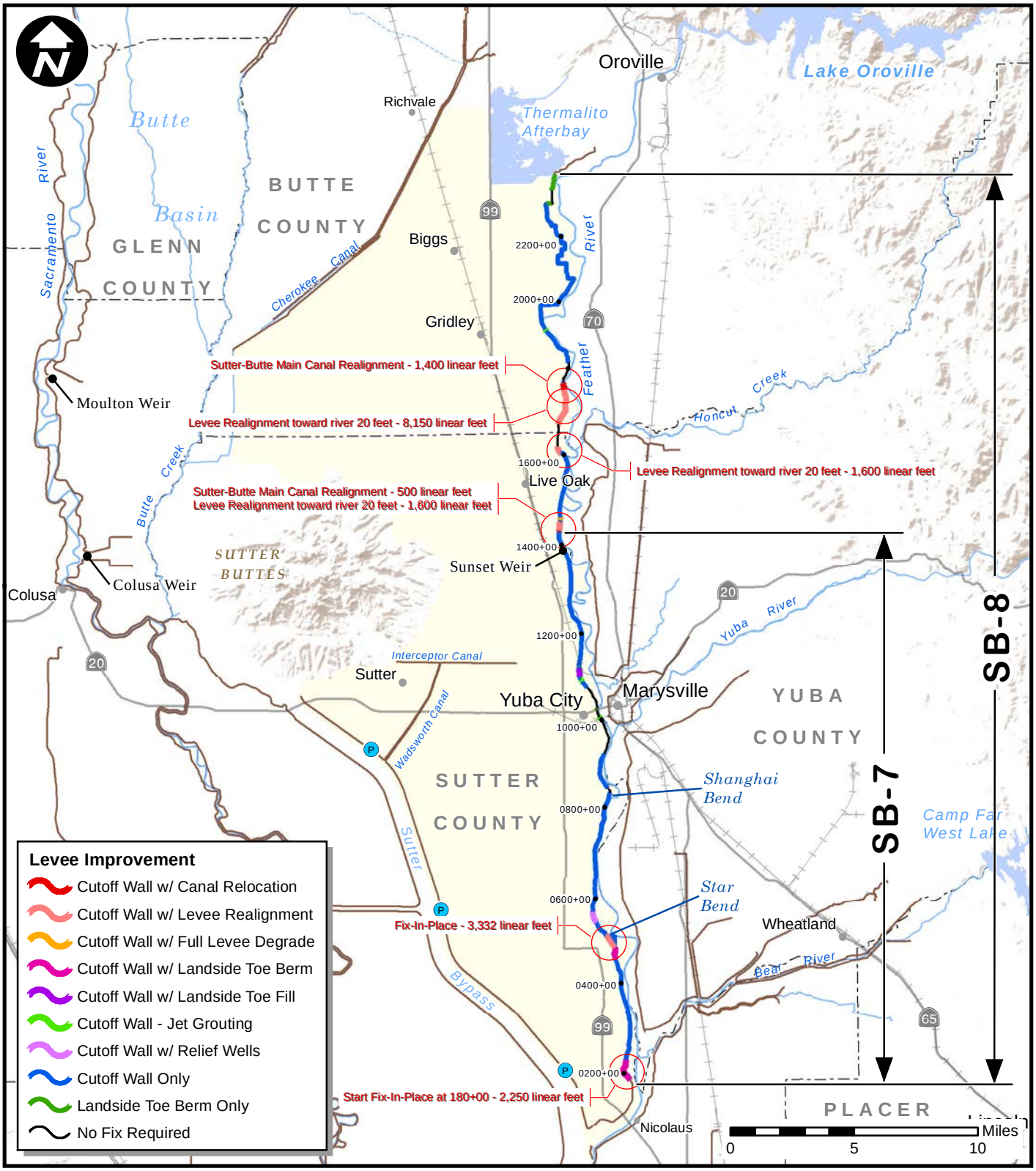
PLATE 2-2



Legend

- Levee Improvement Site
- Study Area Extent
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

LEVEE IMPROVEMENTS FOR FINAL ALTERNATIVES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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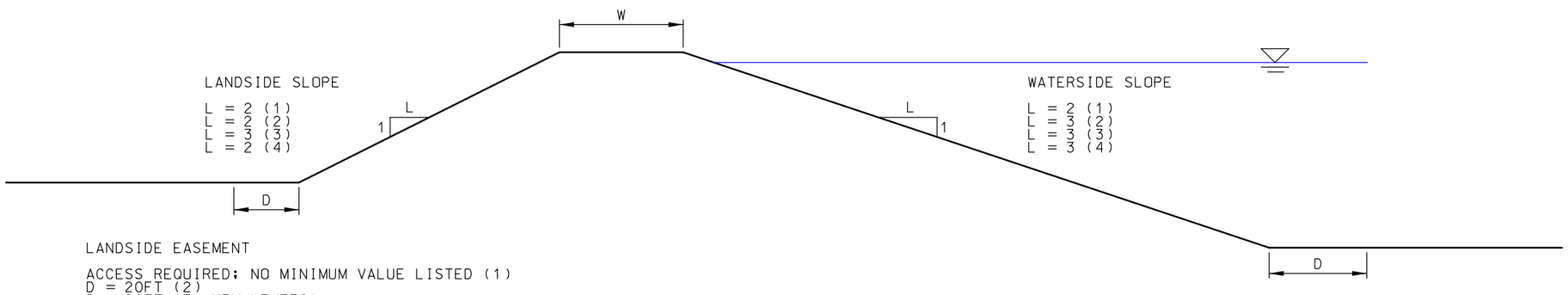
PLATE 2-3

LANDSIDE

CREST WIDTH

W = 10FT (1)
W = 20FT (2)
W = 20FT (3)
W = 20FT (4)

WATERSIDE



LANDSIDE SLOPE

L = 2 (1)
L = 2 (2)
L = 3 (3)
L = 2 (4)

WATERSIDE SLOPE

L = 2 (1)
L = 3 (2)
L = 3 (3)
L = 3 (4)

LANDSIDE EASEMENT

ACCESS REQUIRED; NO MINIMUM VALUE LISTED (1)
D = 20FT (2)
D = 20FT (3, NEW LEVEES)
D = 10 - 20FT (3, EXISTING LEVEES)
D = 10FT (4)

WATERSIDE EASEMENT

D = 15FT (2)
D = 15FT (3)

REFERENCES

(1) EM 1110-2-1913, DESIGN & CONSTRUCTION OF LEVEES, APRIL 2000
(2) SPK, GEOTECHNICAL LEVEE PRACTICE (REFP10L0 OR SOP3), 11 APRIL 2008
(3) DWR, URBAN LEVEE DESIGN CRITERIA, MAY 2012 (NEW LEVEES, EXCEPTIONS MAY BE ALLOWED FOR RECONSTRUCTION OF EXISTING LEVEES
(4) CCR TITLE 23, WATERS DIVISION 1, CVFPB REGULATIONS, 22 JAN 2010

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Dwn by: TUNG LE
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Submitted by: -
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Spec No.: -
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Drawing Code: -
File name: -
Plot date: 28-MAR-2013
Plot scale: -

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SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
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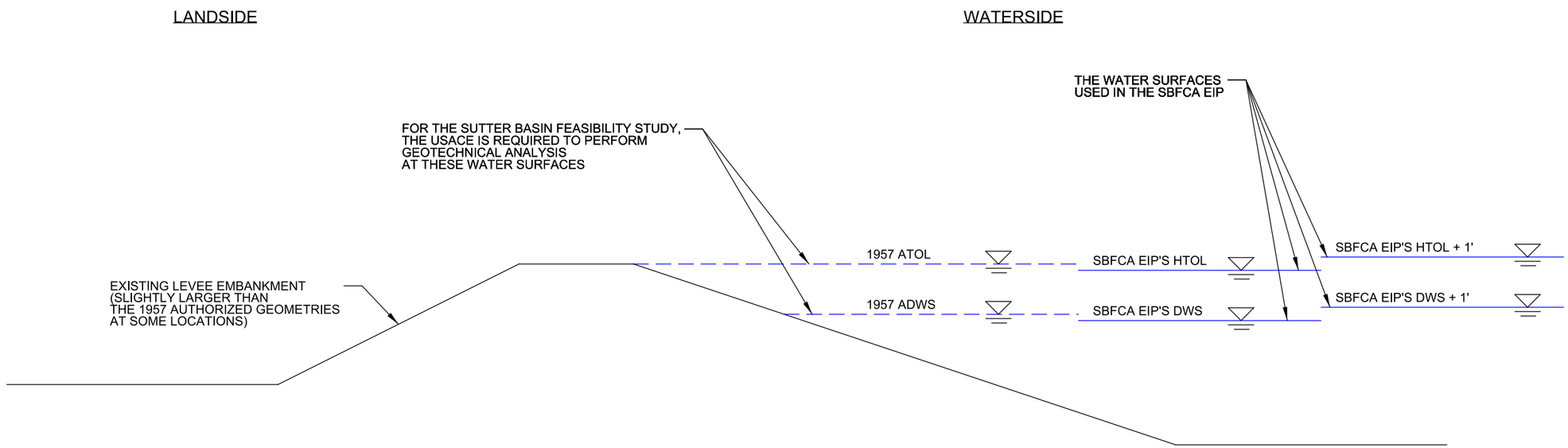
SACRAMENTO, CA 95814-2922

CHIEF, CIV ENGR DES SEC A

SUTTER BUTTE COUNTY CALIFORNIA
SUTTER BASIN FEASIBILITY STUDY
ENGINEERING APPENDIX

PLATE 2-4
TYPICAL LEVEE GEOMETRIES
MINIMUM REQUIREMENTS

Sheet reference number:
-
Sheet - of -
AM-XX



(NOT TO SCALE)

1957 ADWS: THE 1957 AUTHORIZED DESIGN WATER SURFACE
1957 ATOL: THE 1957 AUTHORIZED TOP OF LEVEE

SBFCA: SUTTER BUTTE FLOOD CONTROL AGENCY
EIP: EARLY IMPLEMENTATION PROJECT
SBFCA EIP'S DWS: THE "DESIGN" WATER SURFACE USED IN THE SBFCA EIP
SBFCA EIP'S HTOL: THE "HYDRAULIC TOP OF LEVEE" WATER SURFACE USED IN THE SBFCA EIP

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Spec No.: -
Design file no: -
Drawing Code: -
File name: -
Plot date: 28-MAR-2013
Plot scale: --

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SUTTER BUTTE COUNTY CALIFORNIA
SUTTER BASIN FEASIBILITY STUDY
ENGINEERING APPENDIX

PLATE 2-5
CURRENT AUTHORIZATION & GEOTECHNICAL ANALYSIS

Sheet reference number:
—
Sheet - of -
AM-XX

SUTTER BUTTE FLOOD CONTROL AGENCY FEATHER RIVER

WEST LEVEE PROJECT

PROPOSED NOMENCLATURE AND PROJECT APPROACH TO LEVEE ENCROACHMENTS

Levee Encroachment

All Utilities and Structures Within the Levee Footprint or Project Right-of-Way (ROW) Limits

Levee Prism Encroachment[1]

Encroachment Located Within the Levee Prism

ROW Encroachment[1]

Encroachment Located Within Project ROW Limits[2] Only

Levee Prism Structure Encroachment[3]

Retaining Wall
Railroad Tracks
Home
Shed
Roadway/Bridge

Levee Prism Wet Utility Encroachment[3]

Pump Discharge Line
Gravity Drainage Pipeline
Sewer Outfall
Natural Gas Pipeline
Ag Turnout

Levee Prism Dry Utility Encroachment[3]

Telephone Cable
Overhead Power
Fiber Optic Cable

ROW Structure Encroachment

Home
Shed
Roadway
Railroad Tracks

ROW Wet Utility Encroachment

Ag or Drainage Canal[4]
Water Supply Pipeline
Sewer Pipeline
Natural Gas Pipeline
Ag well
Ag Turnout

ROW Dry Utility Encroachment

Telephone Cable
Overhead Utility[4]
Fiber Optic Cable

Notes:

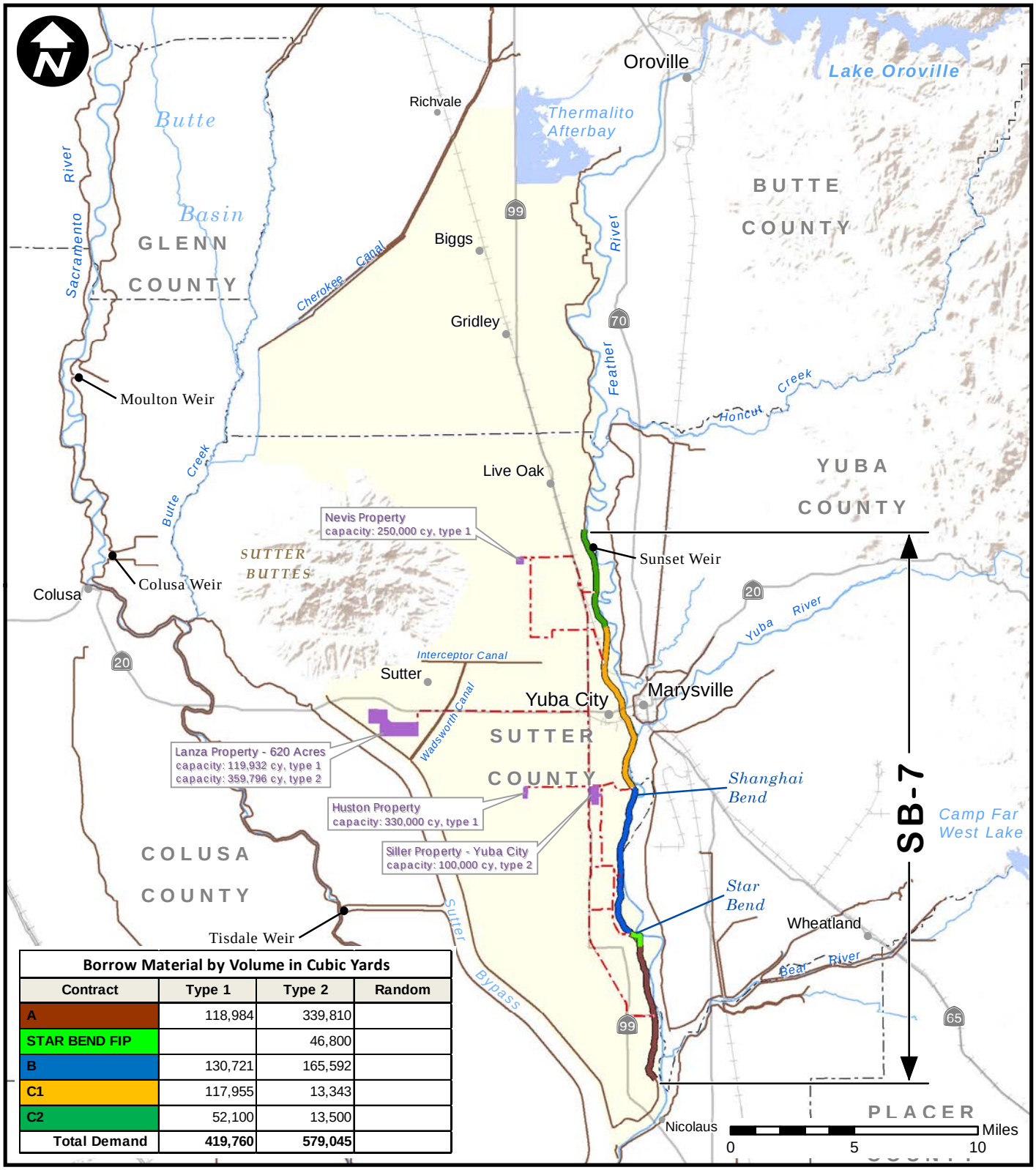
1. All utilities running parallel to the levee, unless located within the levee prism, are considered ROW Encroachments. All utilities running perpendicular to the levee are considered Levee Prism Encroachments, with the exception of overhead utilities, which are ONLY a levee prism encroachment if a supporting pole is located within the levee prism.

2. ROW Encroachments are those encroachments that fall within the limits of the Project ROW, 20 feet from landside levee toe, and 15 feet from waterside levee toe.

3. In general, levee prism structure and wet utility encroachments will be relocated or otherwise modified as part of the levee improvement contract. Levee prism dry utility encroachments will be addressed where expeditious or necessary to do so in advance of the levee improvement contract.

4. ROW wet or dry utility encroachments will be relocated prior to the levee improvement contract if they are deemed an impediment to construction access.

PLATE 2-6 UTILITY HANDLE CHART



Borrow Material by Volume in Cubic Yards			
Contract	Type 1	Type 2	Random
A	118,984	339,810	
STAR BEND FIP		46,800	
B	130,721	165,592	
C1	117,955	13,343	
C2	52,100	13,500	
Total Demand	419,760	579,045	

Legend

- Borrow Site
- Haul Route
- Contract Extent
- Federal Levee
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

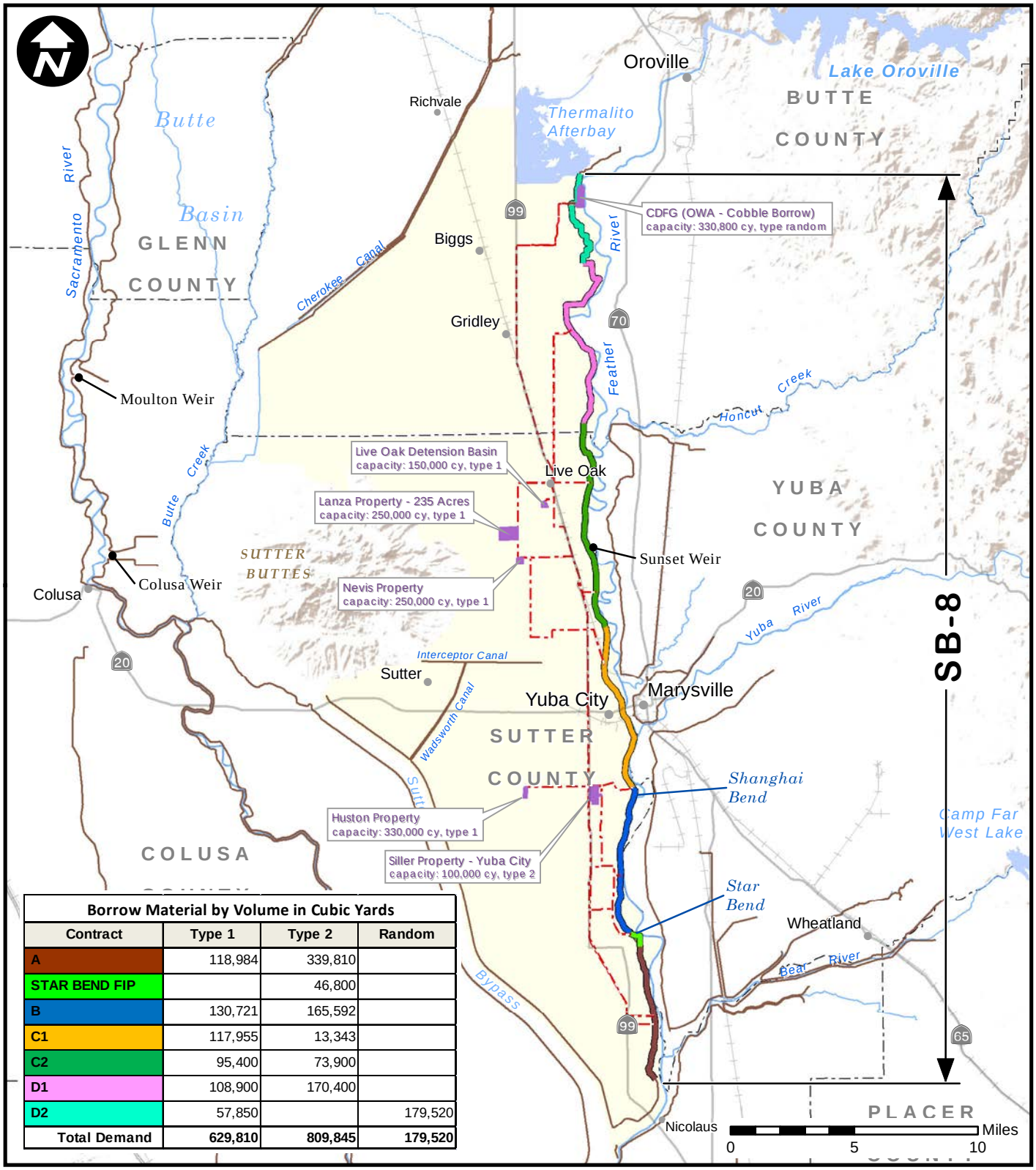
ALTERNATIVE SB-7: CONSTRUCTION CONTRACT BORROW SITES AND HAUL ROUTES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 4-3



Borrow Material by Volume in Cubic Yards			
Contract	Type 1	Type 2	Random
A	118,984	339,810	
STAR BEND FIP		46,800	
B	130,721	165,592	
C1	117,955	13,343	
C2	95,400	73,900	
D1	108,900	170,400	
D2	57,850		179,520
Total Demand	**629,810**	**809,845**	**179,520**

Legend

- Borrow Site
- Haul Route
- Contract Extent
- Federal Levee
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-8: CONSTRUCTION CONTRACT BORROW SITES AND HAUL ROUTES

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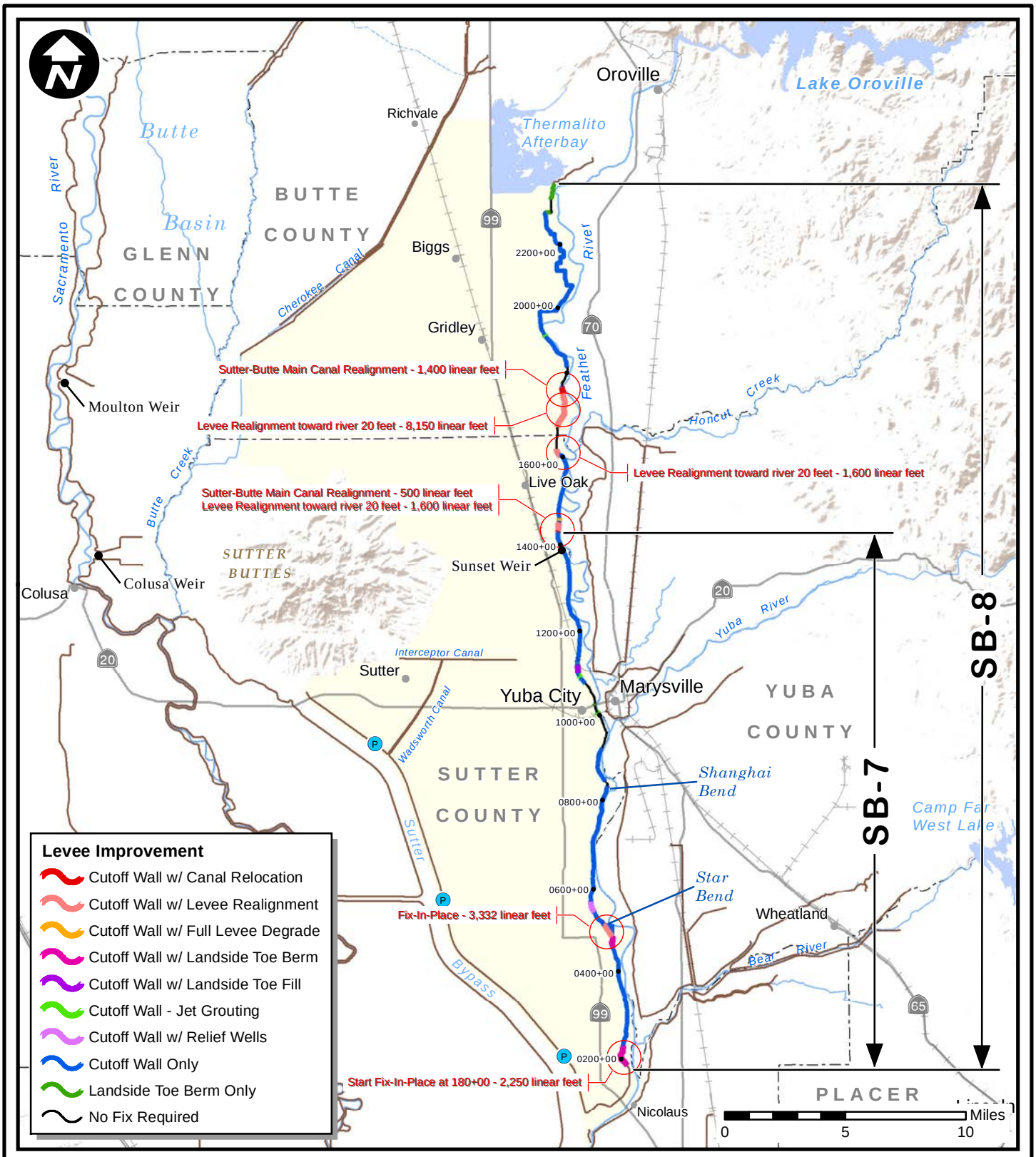
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 5-3



Legend

- Levee Improvement Site
- Study Area Extent
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

LEVEE IMPROVEMENTS FOR FINAL ALTERNATIVES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE G-1

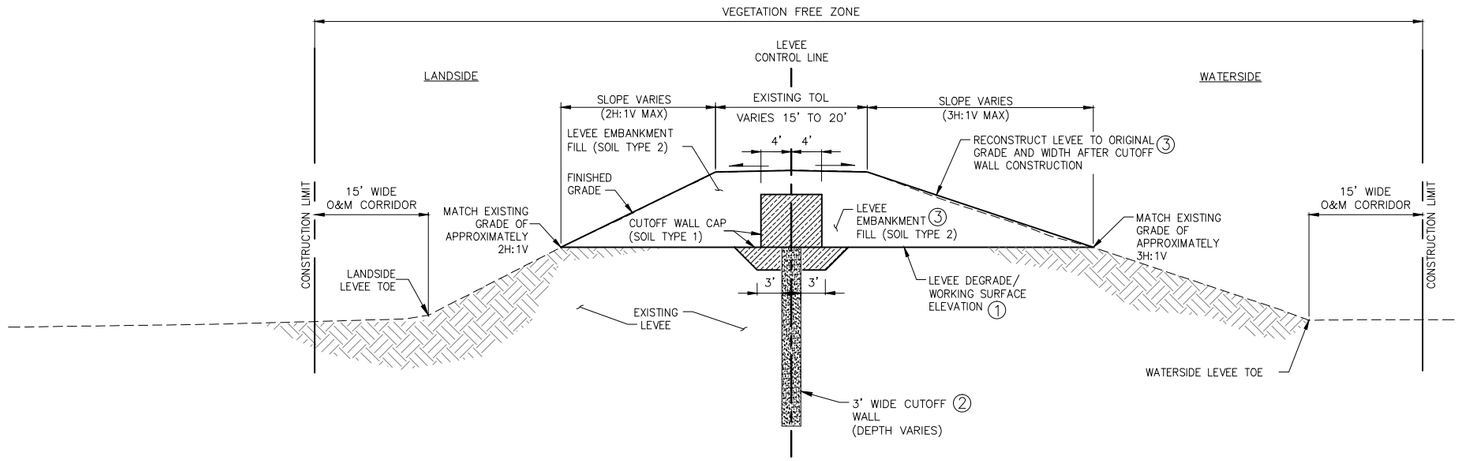


PLATE G-2A: TYPICAL CUTOFF WALL

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.

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Symbol	Description	Date	Approved
D8	DESCRIPTION8	DATE8	APPROVAL8
D7	DESCRIPTION7	DATE7	APPROVAL7
D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX
PLATE G-2A
TYPICAL LEVEE IMPROVEMENT-CUTOFF WALL

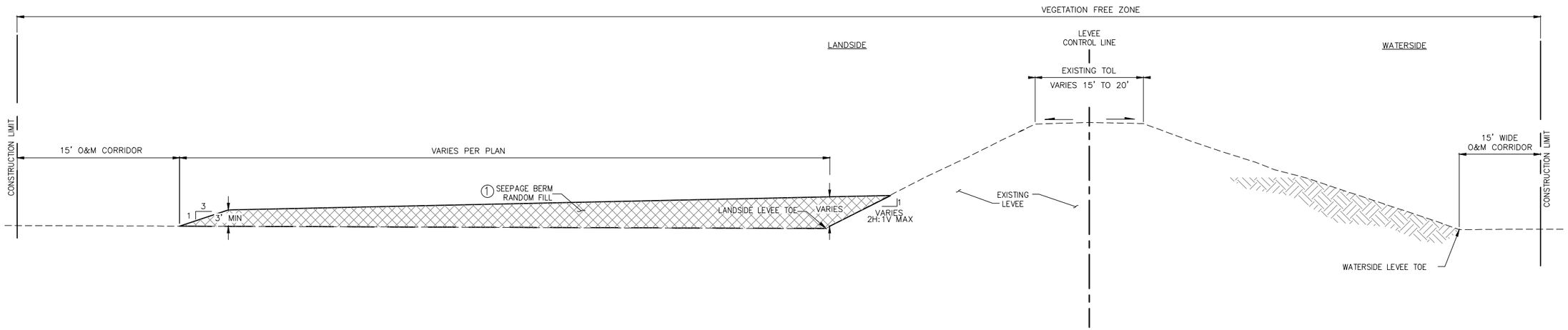

PLATE G2-B: TYPICAL SEEPAGE BERM

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. INSTALL RANDOM FILL FOR SEEPAGE BERM

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D7	DESCRIPTION7	DATE7	APPROVAL7
D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

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Reviewed by: –		Drawing Code: –	
Submitted by: – CHIEF, CIV ENGR DES SEC A		File name: $$$$dwf$$$$ Plot date: Plot scale: –	

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

PLATE G-2B

TYPICAL LEVEE IMPROVEMENT - SEEPAGE BERM

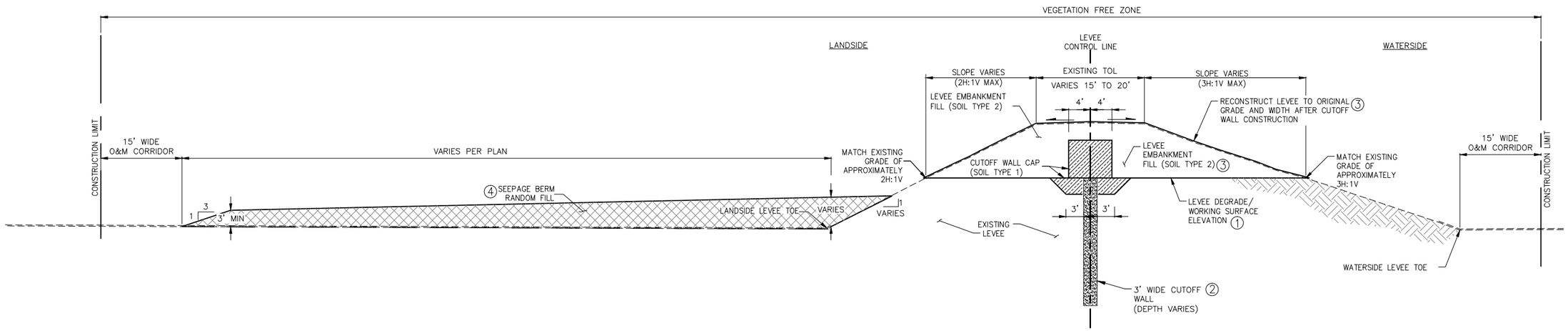

PLATE G-2C1: TYPICAL CUTOFF WALL WITH SEEPAGE BERM

SCALE: NONE

CONSTRUCTION SEQUENCE:

(1) DEGRADE EXISTING LEVEE.
(2) CONSTRUCT CUTOFF WALL.
(3) RECONSTRUCT LEVEE EMBANKMENT.
(4) INSTALL RANDOM FILL FOR SEEPAGE BERM

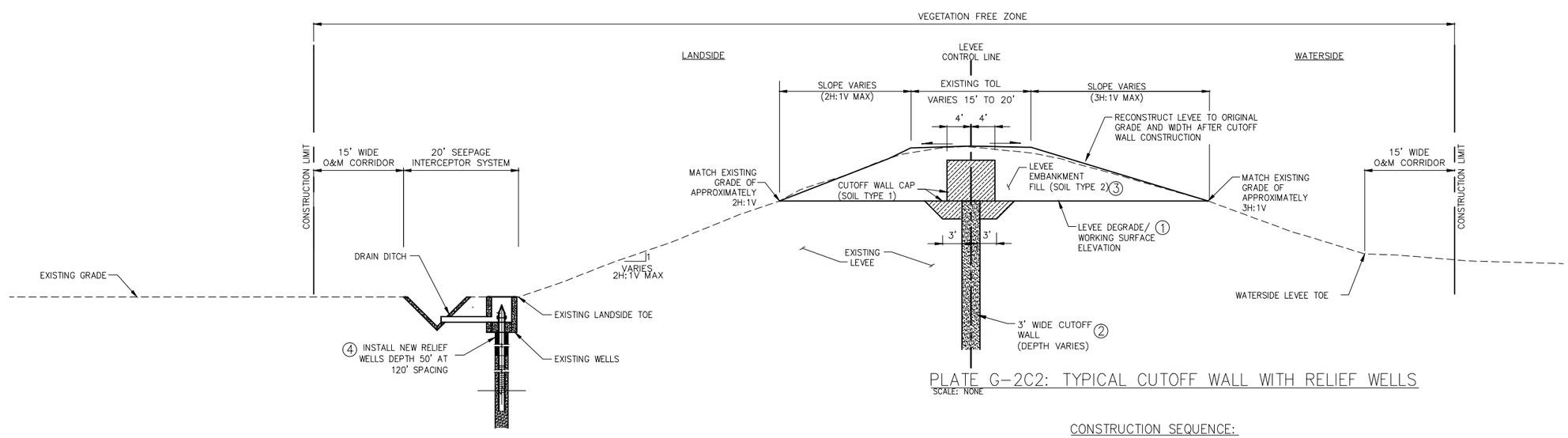

PLATE G-2C2: TYPICAL CUTOFF WALL WITH RELIEF WELLS

SCALE: NONE

CONSTRUCTION SEQUENCE:

(1) DEGRADE EXISTING LEVEE.
(2) CONSTRUCT CUTOFF WALL.
(3) RECONSTRUCT LEVEE EMBANKMENT.
(4) INSTALL ADDITIONAL RELIEF WELLS (WHERE APPLICABLE)

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D7	DESCRIPTION7	DATE7	APPROVAL7
D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

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Dwn by: –
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Submitted by: –
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Date: –
Spec No.: –
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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX
PLATE G-2C
TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH SEEPAGE BERM OR RELIEF WELLS

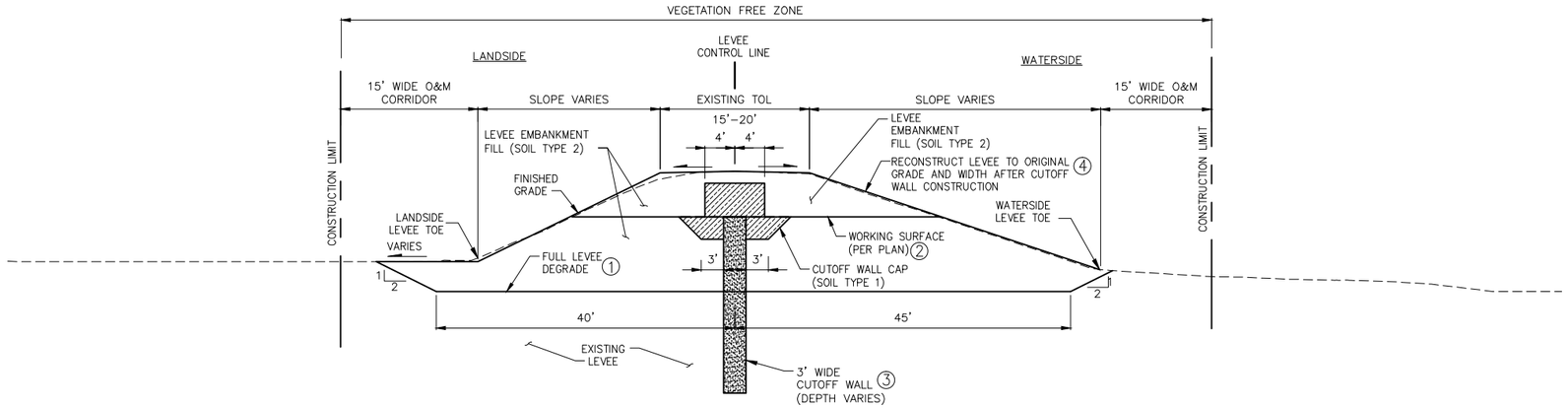

PLATE G-2D1: TYPICAL CUTOFF WALL WITH FULL LEVEE DEGRADE

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. FILL UP TO WORKING SURFACE ELEVATION
3. CONSTRUCT CUTOFF WALL.
4. RECONSTRUCT LEVEE EMBANKMENT.

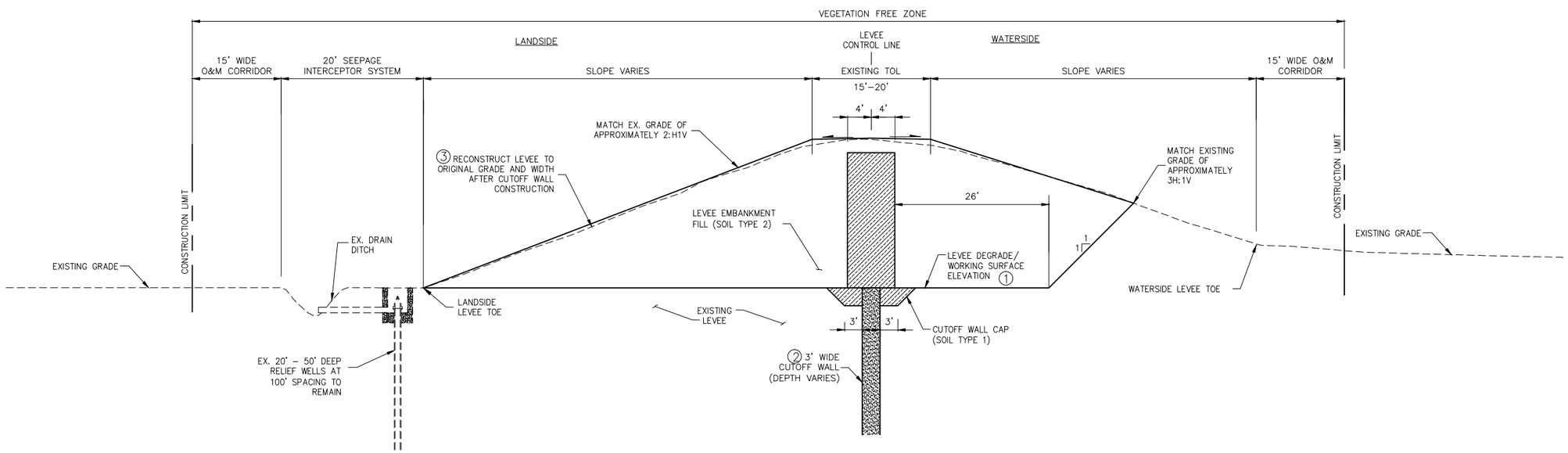

PLATE G-2D1: TYPICAL CUTOFF WALL WITH FULL LEVEE DEGRADE AND RELIEF WELLS

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.

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D7	DESCRIPTION7	DATE7	APPROVAL7
D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

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Spec No.: –
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Plot scale: –
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ENGINEERING APPENDIX

PLATE G-2D

TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH FULL LEVEE DEGRADE AND RELIEF WELLS

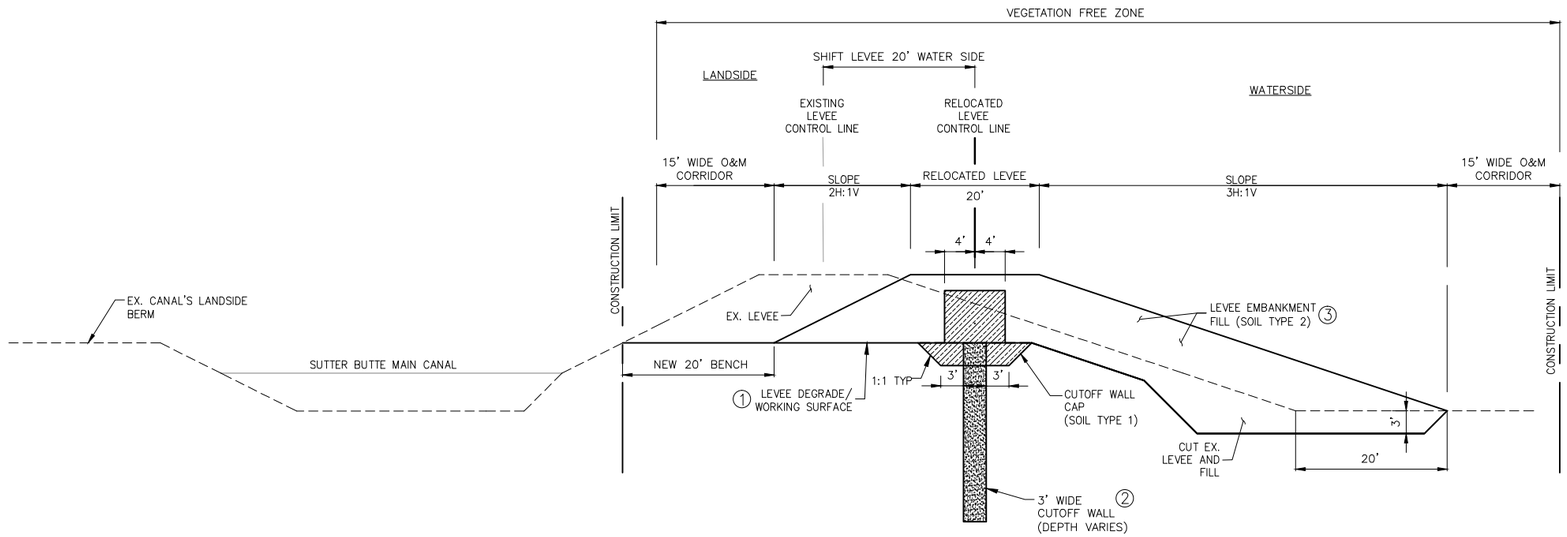

PLATE G-2E: TYPICAL CUTOFF WALL WITH LEVEE RELOCATION

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. CONSTRUCT RELOCATED LEVEE EMBANKMENT.

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D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

PLATE G-2E

TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH LEVEE RELOCATION

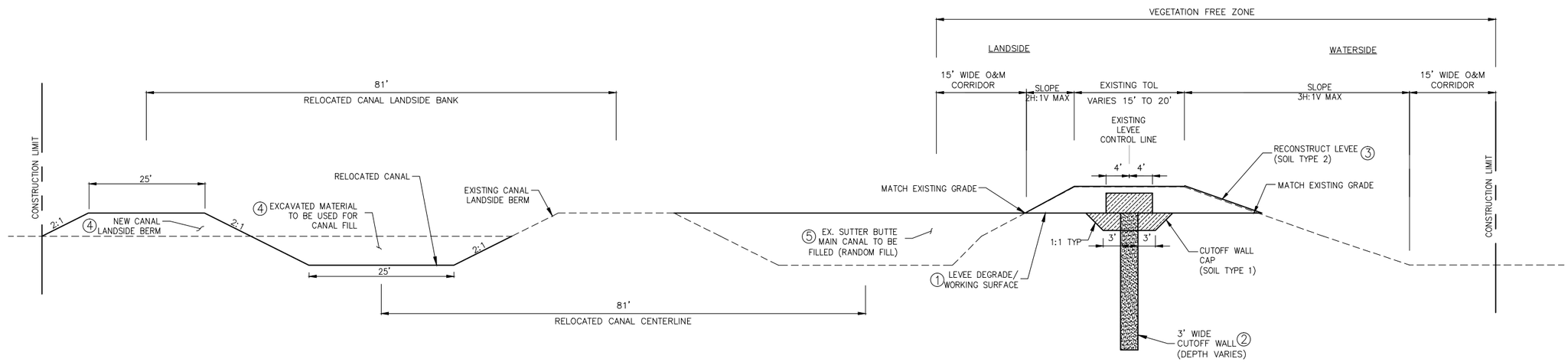

PLATE G-2F: TYPICAL CUTOFF WALL WITH CANAL RELOCATION

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.
4. EXCAVATE NEW SUTTER BUTTE CANAL AND CONSTRUCT NEW CANAL LANDSIDE BERM.
5. FILL SUTTER BUTTE CANAL WITH EXCAVATED MATERIAL

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D7	DESCRIPTION7	DATE7	APPROVAL7
D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
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D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

Designed by: –
Dwn by: –
Spec No.: –
Reviewed by: –
Submitted by: –
CHIEF, CIV ENGR DES SEC A
Date: –
Design file no: –
Drawing Code: –
File name: $$$$date$$$$
Plot date:
Plot scale: –
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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX
PLATE G-2F
TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH CANAL RELOCATION

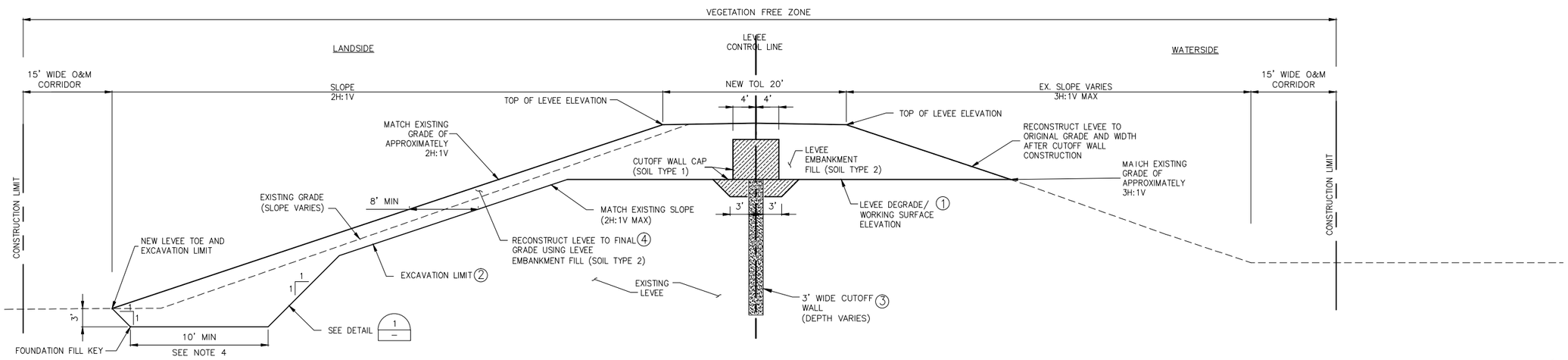

PLATE G-2G: TYPICAL CUTOFF WALL WITH LANDSIDE TOE FILL

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE LANDSIDE OF EXISTING LEVEE.
3. CONSTRUCT CUTOFF WALL.
4. RECONSTRUCT LEVEE EMBANKMENT.

1 FILL KEY AND BENCHING DETAIL

NTS

TYPICAL KEY & BENCHING NOTES:

1. PLACE FILL IN HORIZONTAL LIFTS AGAINST VERTICAL FACES CUT INTO EXISTING LEVEE MATERIAL.
2. THE BOTTOM OF THE KEY TRENCH SHALL BE SCARIFIED TO A DEPTH OF 8 INCHES AND RECOMPACTED TO 95% MAXIMUM DENSITY PER ASTM D698.
3. THE LEVEE KEY TRENCH SHALL BE INSPECTED BY THE AGENCY'S GEOTECHNICAL ENGINEER BEFORE PLACEMENT OF FILL.
4. WHERE EMBANKMENT FILL IS GREATER THAN 10' IN WIDTH, FOUNDATION KEY SHALL EXTEND FROM THE TOE OF THE NEW LEVEE TO THE TOE OF THE EXISTING LEVEE. IN NO CASE SHALL THE FOUNDATION KEY WIDTH BE LESS THAN 10'.

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D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

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Dwn by: – | Spec No.: – | Design file no: –
Reviewed by: – | Drawing Code: –
Submitted by: – | File name: | Plot date: $$$$date$$$$ | Plot scale: –
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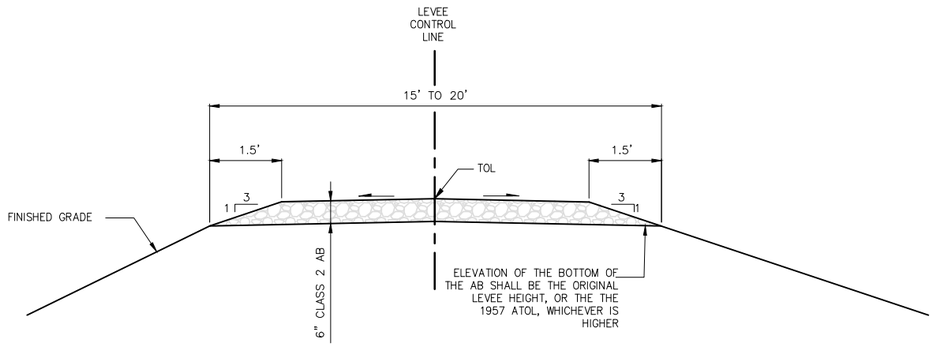
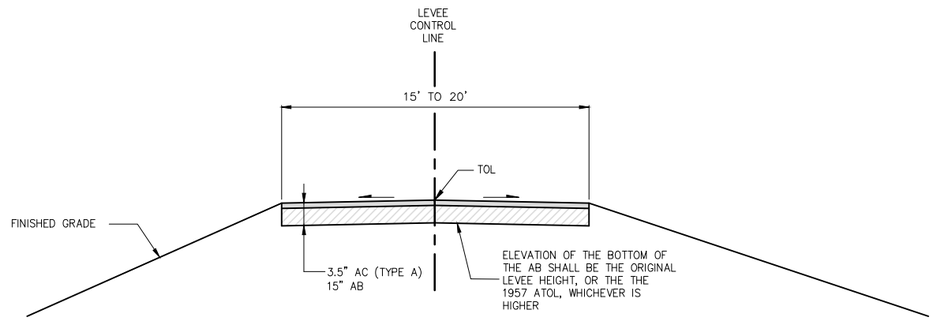
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX
PLATE G-2G
TYPICAL LEVEE IMPROVEMENT – TYPICAL CUTOFF WALL WITH LANDSIDE TOE FILL



CROWN SURFACING DETAIL (TYP)

NTS



PAVED LEVEE ROAD SECTION

NTS

PLATE G-2H: TYPICAL LEVEE ROAD DETAIL

NTS

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D7	DESCRIPTION7	DATE7	APPROVAL7
D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

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Reviewed by: –		Drawing Code: –	
Submitted by: –		File name: $$$$.dwg	
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		Plot scale: –	

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ENGINEERING APPENDIX

PLATE G-2H

TYPICAL LEVEE IMPROVEMENT – TYPICAL LEVEE ROAD DETAIL

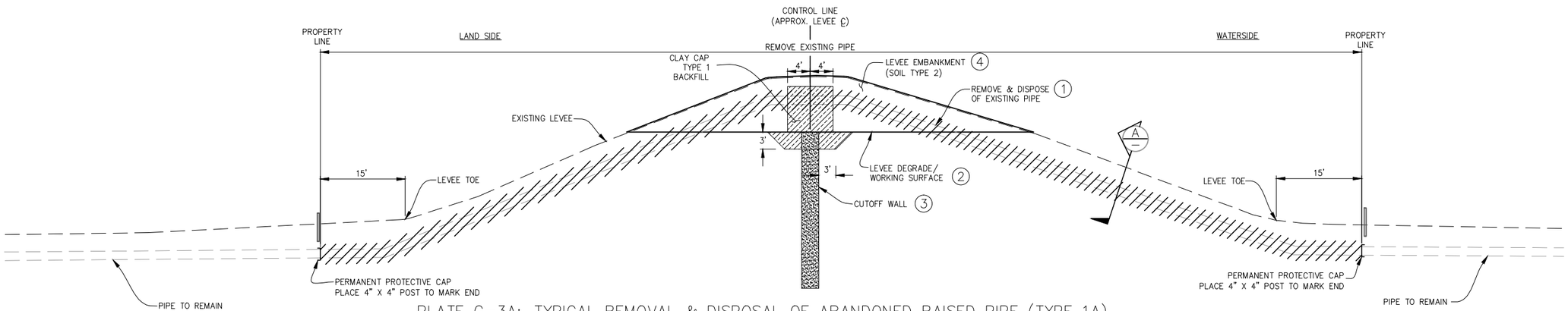
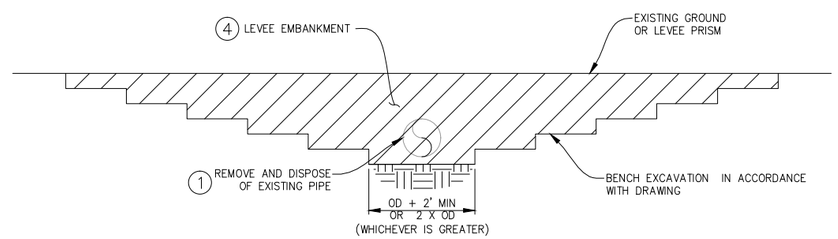


PLATE G–3A: TYPICAL REMOVAL & DISPOSAL OF ABANDONED RAISED PIPE (TYPE 1A)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE.
2. DEGRADE EXISTING LEVEE.
3. CONSTRUCT CUTOFF WALL.
4. RECONSTRUCT LEVEE EMBANKMENT.



SECTION (A/1)

SCALE: NONE

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D7	DESCRIPTION7	DATE7	APPROVAL7
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D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

Designed by: –
Dwn by: –
Spec No.: –
Reviewed by: –
Submitted by: –
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Date: –
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Drawing Code: –
File name: –
Plot date: $$$$date$$$$
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ENGINEERING APPENDIX
PLATE G–3A
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND DISPOSAL OF ABANDONED RAISED PIPE

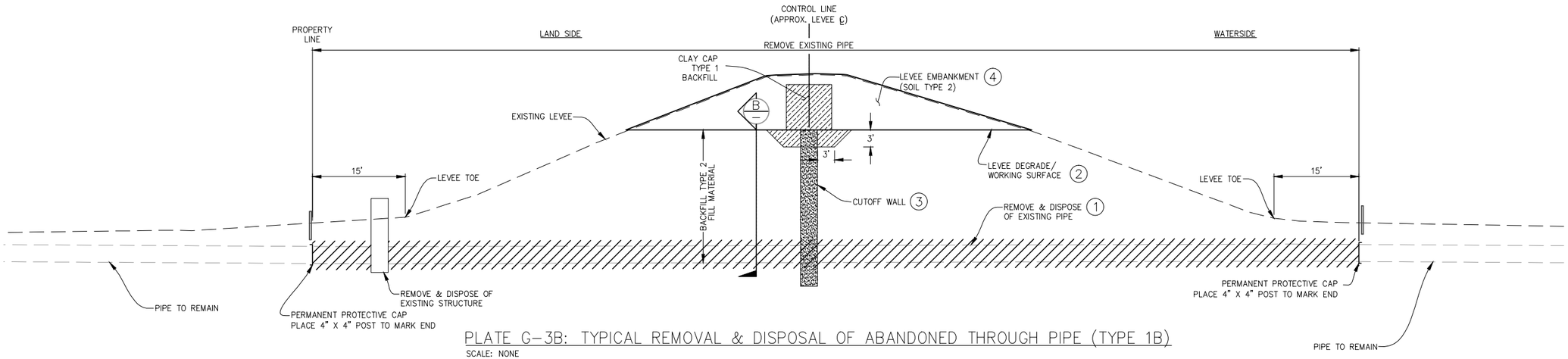
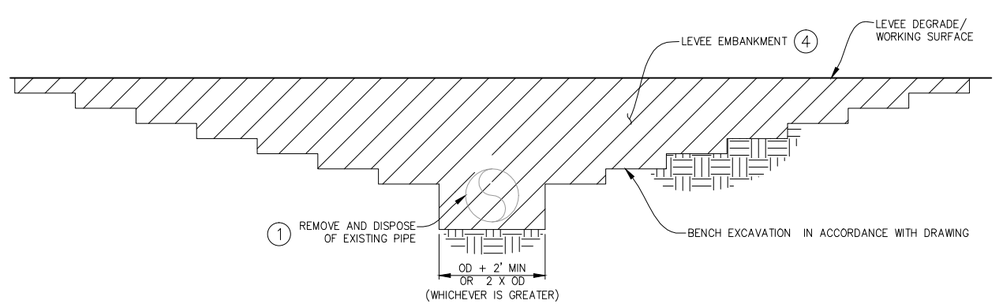


PLATE G-3B: TYPICAL REMOVAL & DISPOSAL OF ABANDONED THROUGH PIPE (TYPE 1B)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE.
2. DEGRADE EXISTING LEVEE.
3. CONSTRUCT CUTOFF WALL.
4. RECONSTRUCT LEVEE EMBANKMENT.



SECTION B/1

SCALE: NONE

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D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

Designed by: –
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Spec No.: –
Reviewed by: –
Submitted by: –
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Date: –
Design file no: –
Drawing Code: –
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SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX
PLATE G-3B
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND DISPOSAL OF ABANDONED THROUGH PIPE

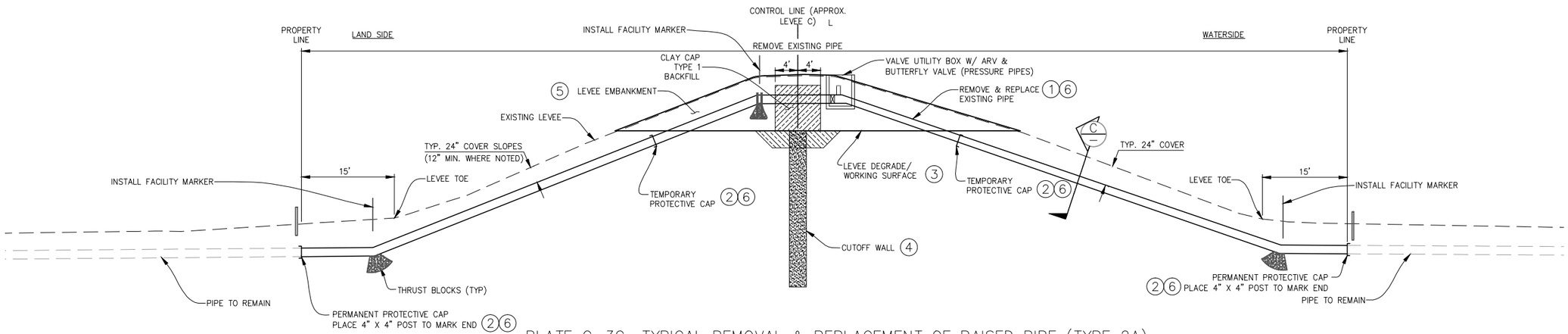


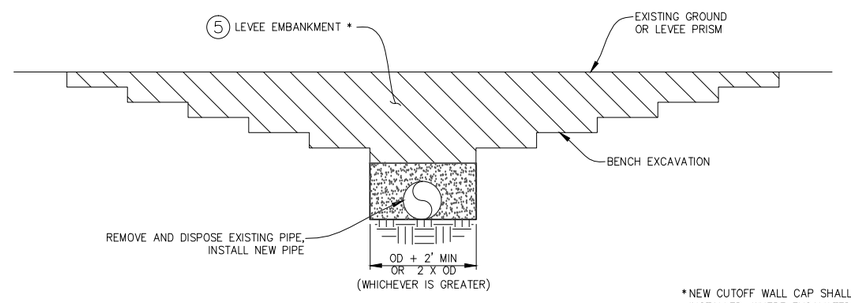
PLATE G-3C: TYPICAL REMOVAL & REPLACEMENT OF RAISED PIPE (TYPE 2A)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO DEGRADE / WORKING SURFACE.
2. PROVIDE CAP AND MARKER AT THE END OF THE EXISTING PIPE WITH PROPER THRUST BLOCK OR RESTRAINED JOINT FOR PRESSURIZED PIPES.
3. DEGRADE EXISTING LEVEE.
4. CONSTRUCT CUTOFF WALL.
5. RECONSTRUCT LEVEE EMBANKMENT.
6. EXCAVATE, INSTALL NEW PIPE, CONNECT TO EXISTING PIPE, INSTALL MARKER AND BACKFILL

NOTE: THE BOTTOM OF THE NEW PIPE SHALL BE ABOVE THE FREEBOARD ELEVATION AT THE LEVEE CROWN



SECTION C

SCALE: NONE

*NEW CUTOFF WALL CAP SHALL BE INSTALLED, WHERE EXCAVATED, FOUR (4) FEET BOTH SIDES FOR WALL.

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D7	DESCRIPTION7	DATE7	APPROVAL7
D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
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D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

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Dwn by: –
Spec No.: –
Reviewed by: –
Submitted by: –
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Date: –
Design file no: –
Drawing Code: –
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PLATE G-3C
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF RAISED PIPE

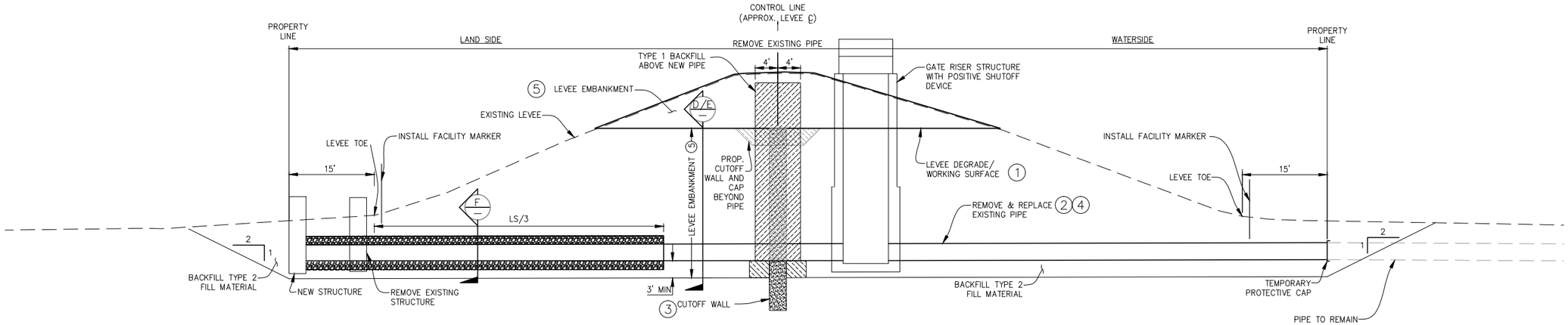
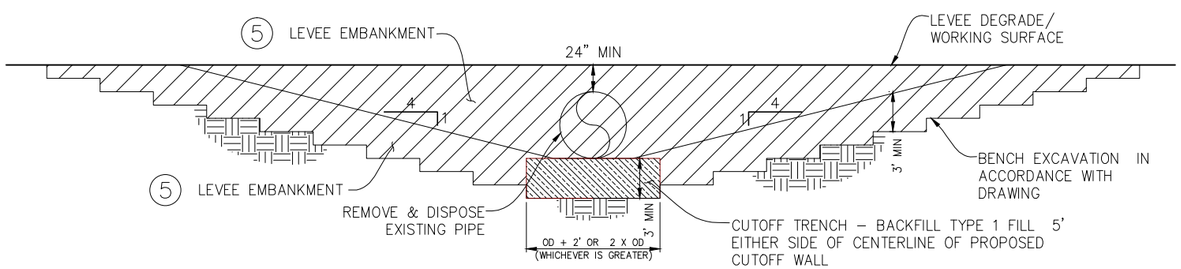


PLATE G-3D: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE (TYPE 2B)

SCALE: NONE

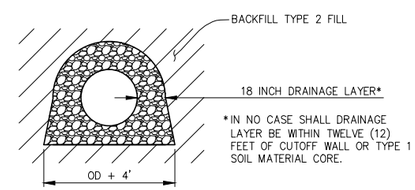
CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE (SEE SECTION D).
3. CONSTRUCT CUTOFF WALL.
4. EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE (SEE SECTION E).
5. RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AN RISER INSTALLATION.



SECTION D

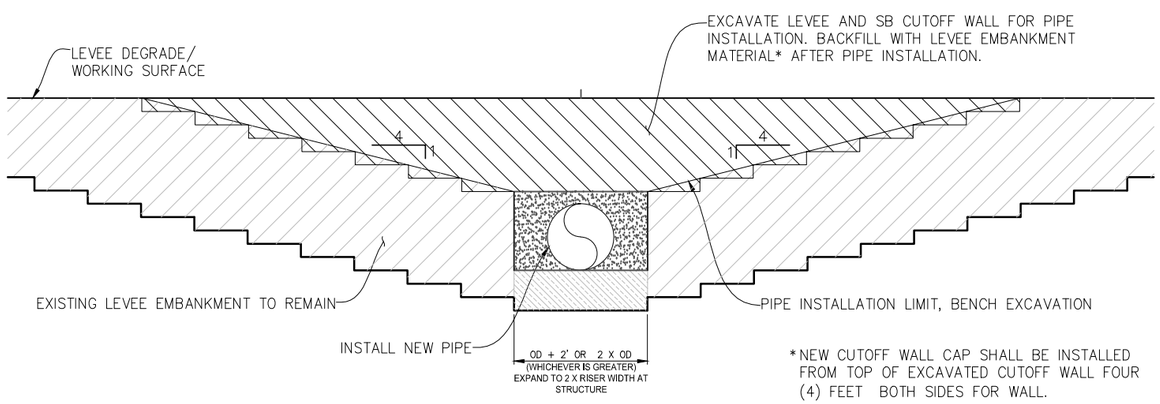
SCALE: NONE



*IN NO CASE SHALL DRAINAGE LAYER BE WITHIN TWELVE (12) FEET OF CUTOFF WALL OR TYPE 1 SOIL MATERIAL CORE.

SECTION F

SCALE: NONE



*NEW CUTOFF WALL CAP SHALL BE INSTALLED FROM TOP OF EXCAVATED CUTOFF WALL FOUR (4) FEET BOTH SIDES FOR WALL.

SECTION E

SCALE: NONE

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D7	DESCRIPTION7	DATE7	APPROVAL7
D6	DESCRIPTION6	DATE6	APPROVAL6
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D1	DESCRIPTION1	DATE1	APPROVAL1

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Reviewed by: – | Drawing Code: –
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ENGINEERING APPENDIX
PLATE G-3D
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF THROUGH PIPE

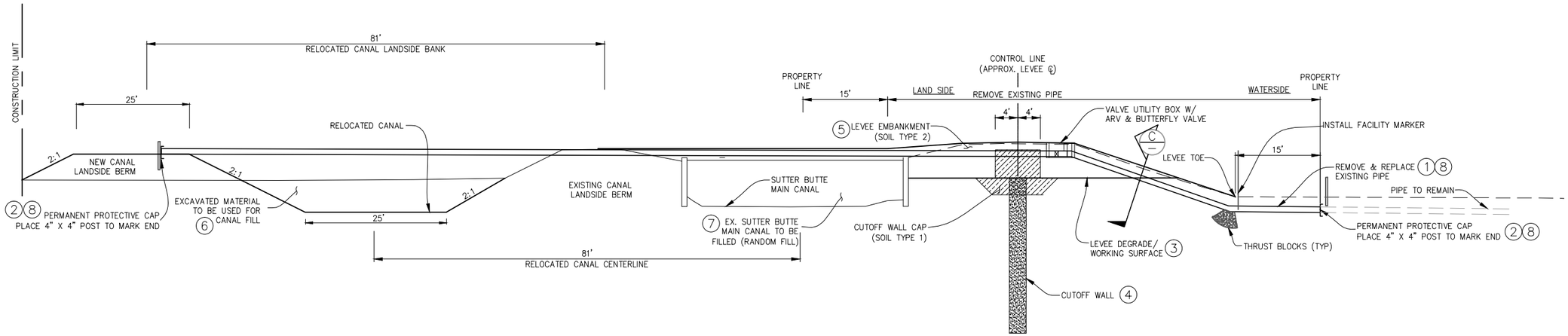
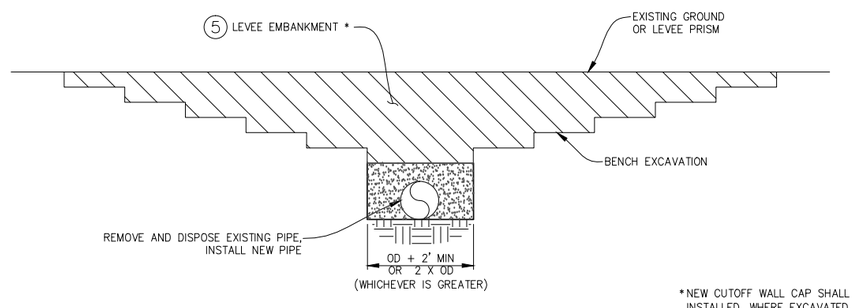


PLATE G-3E1: TYPICAL REMOVAL & REPLACEMENT OF RAISED PIPE WITH CANAL RELOCATION (TYPE 3A1)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO DEGRADE / WORKING SURFACE.
2. PROVIDE CAP AND MARKER AT THE END OF THE EXISTING PIPE WITH PROPER THRUST BLOCK OR RESTRAINED JOINT FOR PRESSURIZED PIPES.
3. DEGRADE EXISTING LEVEE.
4. CONSTRUCT CUTOFF WALL.
5. RECONSTRUCT LEVEE EMBANKMENT.
6. EXCAVATE NEW SUTTER BUTTE CANAL AND CONSTRUCT NEW LANDSIDE BERM
7. FILL SUTTER BUTTE CANAL WITH EXCAVATED MATERIAL
8. EXCAVATE, INSTALL NEW PIPE, CONNECT TO EXISTING PIPE, INSTALL MARKER AND BACKFILL



SECTION (C/—)

SCALE: NONE

*NEW CUTOFF WALL CAP SHALL BE INSTALLED, WHERE EXCAVATED, FOUR (4) FEET BOTH SIDES FOR WALL.

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D7	DESCRIPTION7	DATE7	APPROVAL7
D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
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D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

Designed by: –
Dwn by: –
Spec No.: –
Reviewed by: –
Submitted by: –
CHIEF, CIV ENGR DES SEC A
Date: –
Design file no: –
Drawing Code: –
File name: $$$$date$$$$
Plot date: –
Plot scale: –
Rev. –

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

PLATE G-3E1
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF RAISED PIPE W/ CANAL RELOCATION

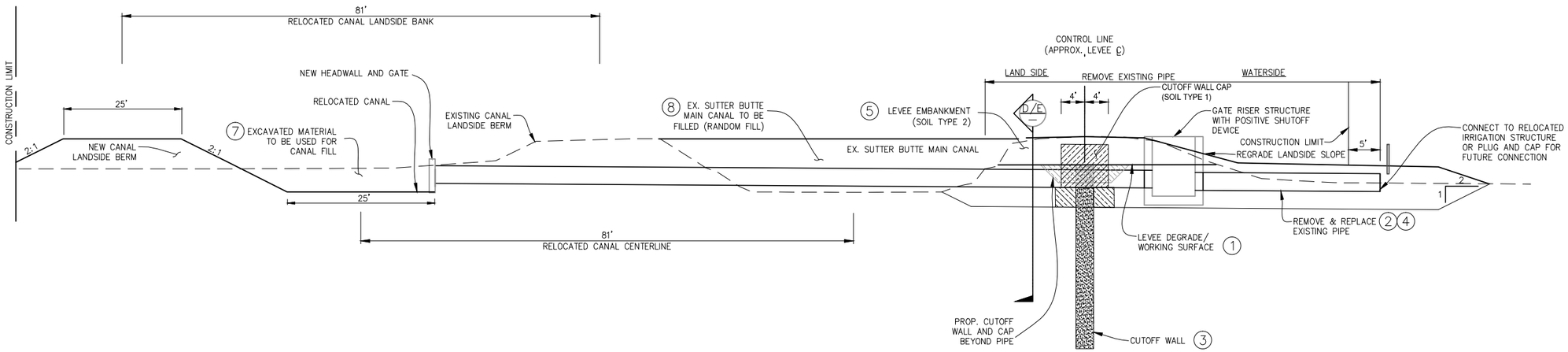
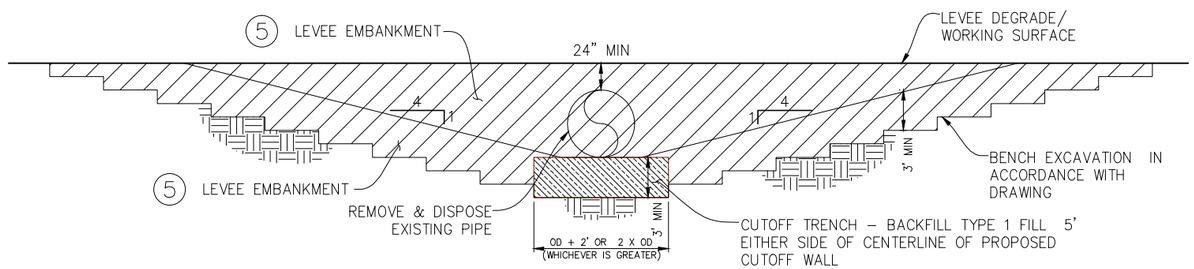


PLATE G-3E2: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE WITH CANAL RELOCATION (TYPE 3A2)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE.
3. CONSTRUCT CUTOFF WALL.
4. EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE.
5. RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AND RISER INSTALLATION.
6. EXCAVATE NEW SUTTER BUTTE CANAL AND CONSTRUCT LANDSIDE BERM
7. BACKFILL OLD SUTTER BUTTE CANAL



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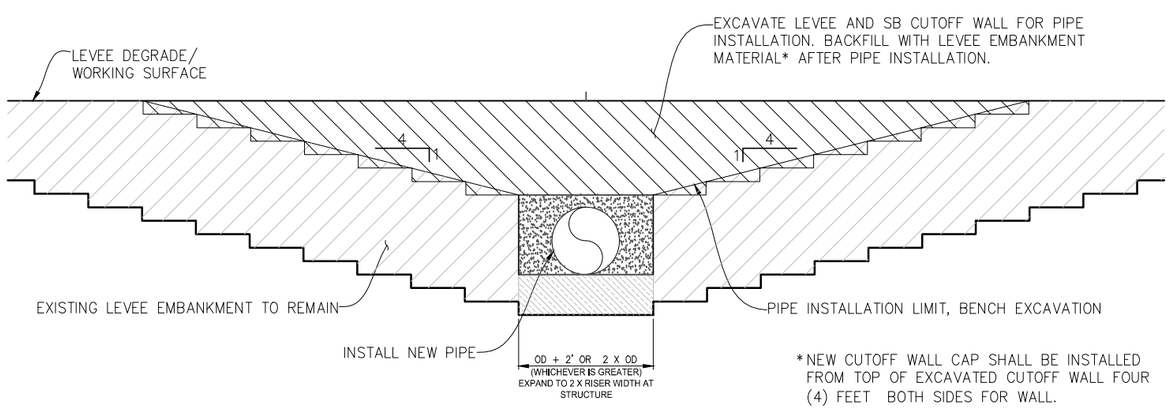

*NEW CUTOFF WALL CAP SHALL BE INSTALLED FROM TOP OF EXCAVATED CUTOFF WALL FOUR (4) FEET BOTH SIDES FOR WALL.

SECTION E/–

SCALE: NONE

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PLATE G-3E2

TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF THROUGH PIPE W/ CANAL RELOCATION

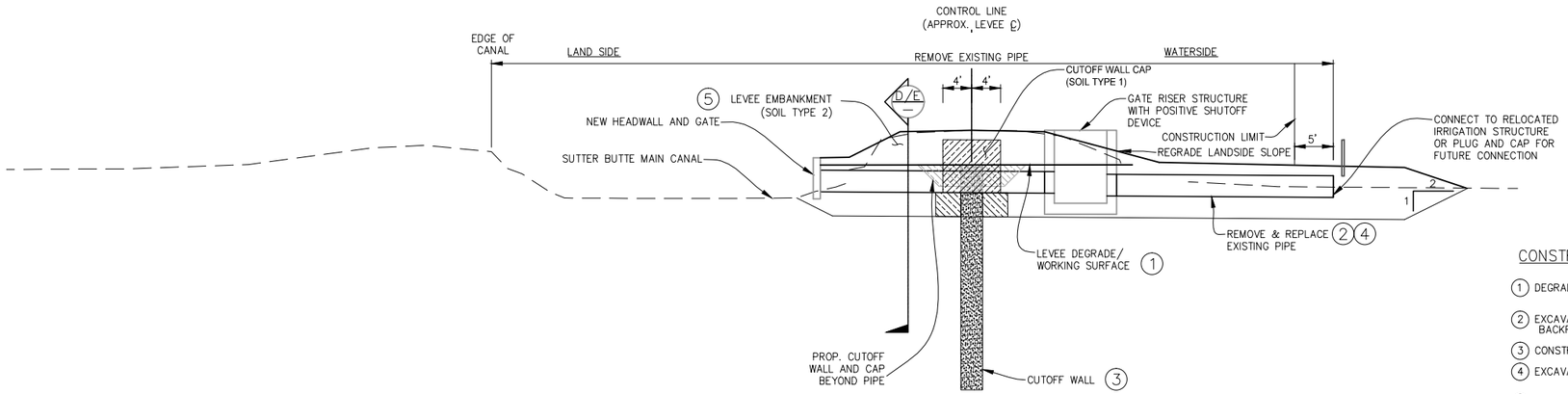
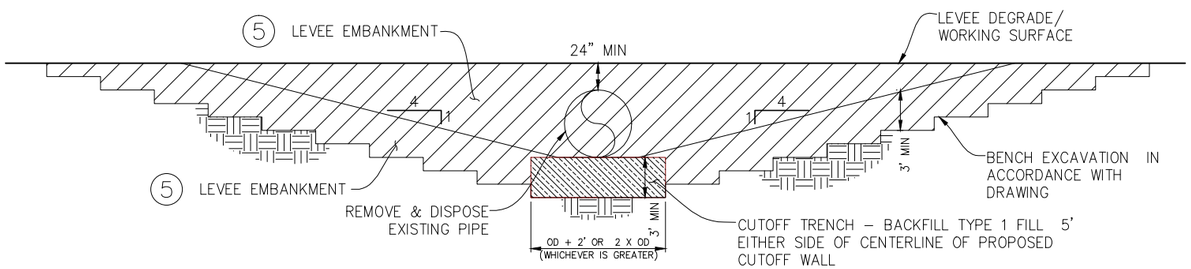


PLATE G-3F: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE ADJACENT TO CANAL (TYPE 3B)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE.
3. CONSTRUCT CUTOFF WALL.
4. EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE.
5. RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AND RISER INSTALLATION.



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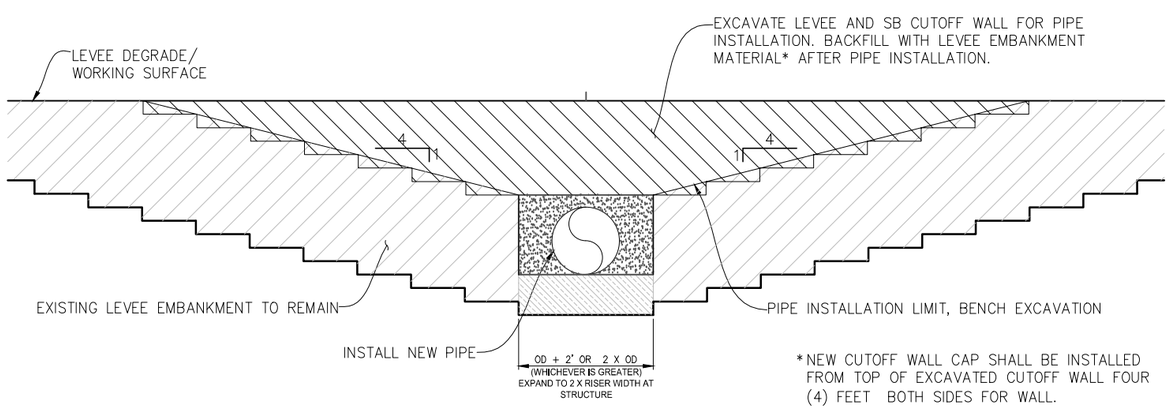

*NEW CUTOFF WALL CAP SHALL BE INSTALLED FROM TOP OF EXCAVATED CUTOFF WALL FOUR (4) FEET BOTH SIDES FOR WALL.

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SCALE: NONE

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D2	DESCRIPTION2	DATE2	APPROVAL2
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ENGINEERING APPENDIX
PLATE G-3F
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF THROUGH PIPE ADJACENT TO CANAL

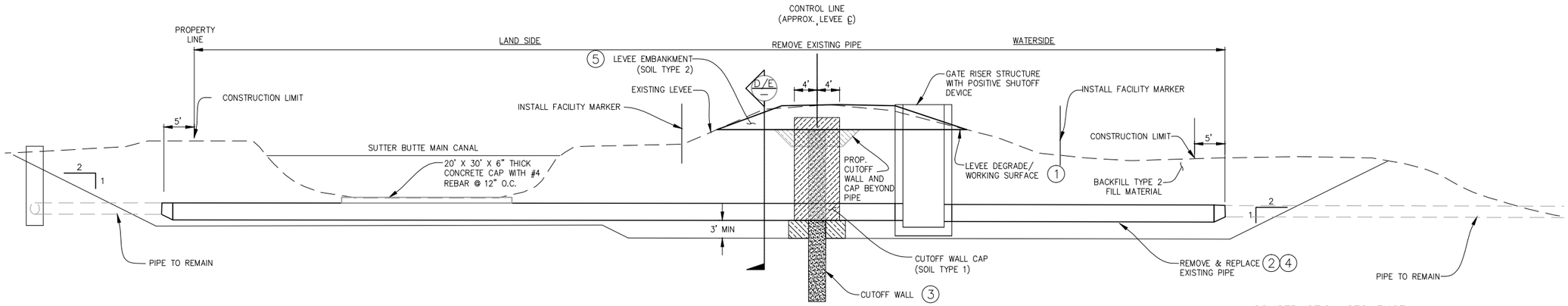
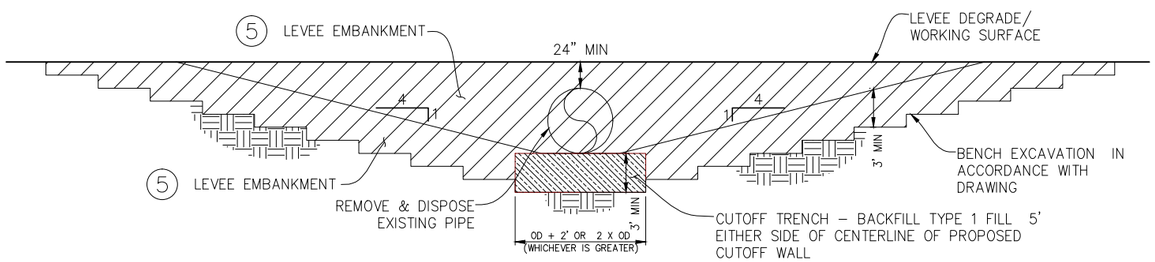


PLATE G-3G1: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE UNDER CANAL (TYPE 3C1)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE (SEE SECTION D).
3. CONSTRUCT CUTOFF WALL.
4. EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE (SEE SECTION E).
5. RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AND RISER INSTALLATION.



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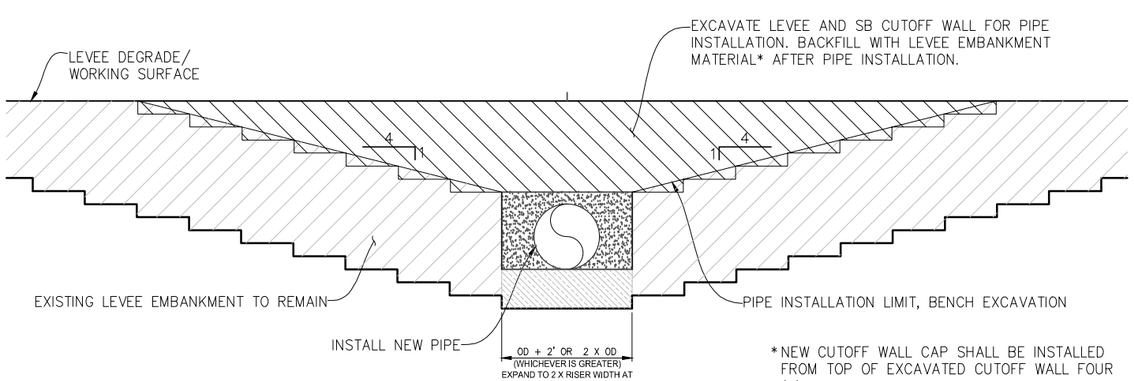

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SCALE: NONE

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ENGINEERING APPENDIX
PLATE G-3G1
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF THROUGH PIPE UDNER CANAL

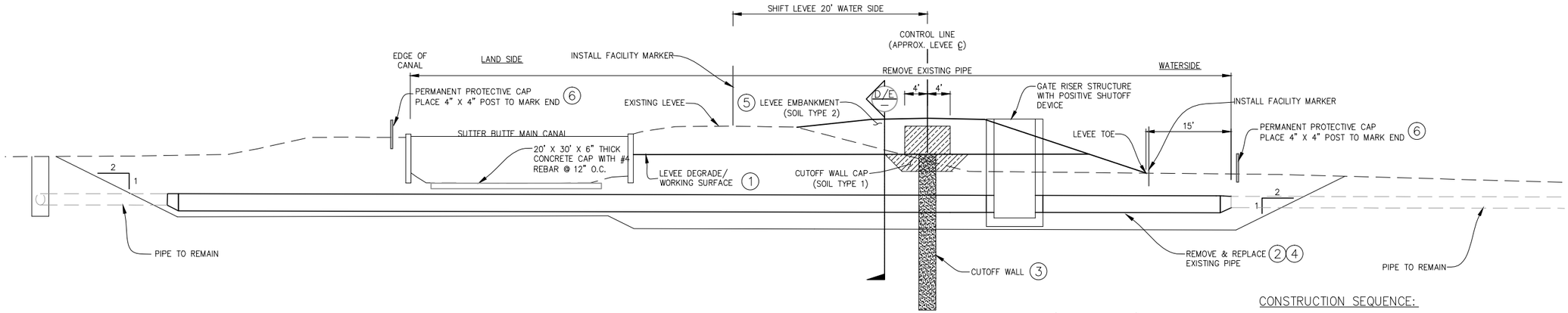
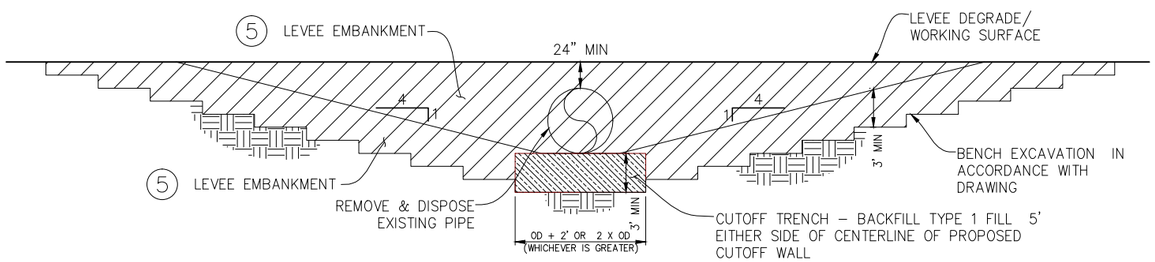


PLATE G-3G2: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE UNDER CANAL WITH LEVEE RELOCATION (TYPE 3C2)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE (SEE SECTION D).
3. CONSTRUCT CUTOFF WALL.
4. EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE (SEE SECTION E).
5. RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AN RISER INSTALLATION.
6. EXCAVATE, INSTALL NEW PIPE, CONNECT TO EXISTING PIPE, INSTALL MARKER AND BACKFILL



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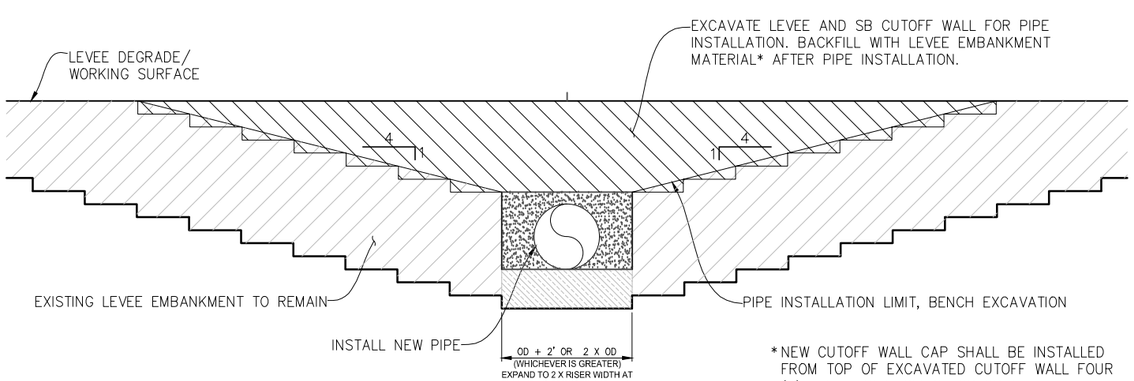

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ENGINEERING APPENDIX

PLATE G-3G2

TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF THROUGH PIPE UDNER CANAL W/LEVEE RELOCATION

C1a. Hydrology Summary Report

US Army Corps of Engineers®

Sacramento District

Sutter Basin Feasibility Study

Butte and Sutter Counties, California

HYDROLOGY OFFICE SUMMARY REPORT

January 2013

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA
HYDROLOGY OFFICE REPORT

January 2013

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SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA
HYDROLOGY OFFICE REPORT

JUNE 2012

1. Purpose, Scope, and Authority

1.1 PURPOSE AND NEED FOR THE PROJECT AND REPORT

A high risk of flooding from levee failure threatens the public safety of approximately 80,000 people, as well as property and critical infrastructure throughout the Sutter Basin study area. Past flooding has caused loss of life and extensive economic damages. Recent geotechnical analysis and evaluation of historical performance during past floods indicate the project levees do not meet U.S. Army Corps of Engineers (USACE) levee design standards and are at risk of breach failure at stages less than overtopping. Within the study area, as throughout the Sacramento Valley, floodplain and native habitats have been lost or degraded. Federally listed species and other special status species that are dependent on floodplain habitats have declined. Opportunities exist to restore land formerly converted by mining or agriculture to more natural habitats through Ecosystem Restoration (ER) in conjunction with flood risk management (FRM). There are also opportunities to provide outdoor recreational features on FRM and ER project lands. The purpose of the Sutter Basin Feasibility Study is to address FRM in conjunction with ER and recreation.

The purpose of this hydrology report is to describe the hydrologic features of the basin and to document the design rainfall, the wind-wave analysis, the Sutter Bypass and Feather River discharge frequency, the Cherokee Canal discharge frequency, and the tributary/interior hydrology of the Sutter basin to include the Wadsworth canal discharge-frequency.

1.2 STUDY AUTHORITY

The authority for the U.S. Army Corps of Engineers (USACE) to study FRM and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, is provided in the Flood Control Act of 1962 (Public Law 87-874).

2. Descriptive Information

The study area is located in Sutter and Butte Counties California and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The study area covers approximately 300 square miles and is approximately 43 miles long and 9 miles wide. The study area includes the communities of Yuba City, Live Oak, Gridley, Biggs, and Sutter with a total population of approximately 80,000. Yuba City is the largest community in the study area, with a population of approximately 65,000. A map of the watershed is included as Plate 1 and a map of the study area is included as Plate 2.

The study area is essentially encircled by project levees of the Sacramento River Flood Control Project shown on Plate 3 and high ground of the Sutter Buttes. In 1917, the Federal government authorized the Sacramento River Flood Control Project, which adopted a system of locally built levees as Federal levees, and constructed additional levees, bypasses, overflow weirs, and pumping facilities. Although the Sacramento River Flood Control Project levees were often constructed of poor foundation materials such as river dredge spoils that would not meet today's engineering standards, the levees are relied upon today to provide FRM for numerous communities.

The primary sources of flooding within the study area are the Butte Basin, Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal, and local interior drainage. Flood depths and frequency vary throughout the study area. Probability of flooding within the study area is primarily related to the stage of floodwaters within the river channels and the geotechnical probability of levee failure at flood stage.

The Butte Basin is a natural overflow and flood storage area north west of the Sutter Buttes and east of the Sacramento River. The basin provides approximately 1 million acre-feet of transitory storage at flood stage (DWR, 2010). Excess floodwaters from the Sacramento River enter Butte Basin via overbank areas along the river and through the Moulton and Colusa weirs. Butte Creek and its tributaries, including Cherokee Canal, also flow into the Butte Basin. Outflow from the Butte Basin is regulated by hydraulic conditions of Butte Slough and floodplain topography at the upstream entrance to the Sutter Bypass. In order to maintain the flood storage capabilities within Butte Basin, California has included regulation of the overflow area in Title 23 of the California Code of Regulations. In general these standards require approval from the board for any encroachments that could reduce or impede flood flows or would reclaim any of the floodplain within the Butte Basin (DWR, 2010).

The Sutter Bypass is a leveed flood control channel approximately three quarters of a mile wide, bordered on each side by levees. The bypass is an integral feature of the Sacramento River Flood Control Project's flood bypass system. The Sutter Bypass conveys flood waters from the Butte Basin, Sacramento River, and Feather River to the confluence of the Sacramento River and Yolo Bypass at Fremont Weir. Additional flood flows from the Sacramento River enter the Sutter Bypass through Tisdale Bypass. The lower portion of the Sutter Bypass also conveys the Feather River. Within this reach the Feather River is separated from the main conveyance of the bypass by a low levee. This design maintains higher velocities and sediment transport capacity within the Feather River during low flow events while utilizing the large conveyance of the Sutter Bypass during larger events. The Sutter Bypass also receives minor natural flow and agricultural return flow from Reclamation District 1660 to the west and from Wadsworth Canal and DWR pumping plants 1, 2, and 3 to the east. The Sutter Bypass is described by four hydrologic reaches based on tributary inflows; Butte Slough to Wadsworth Canal, Wadsworth Canal to Tisdale Bypass, Tisdale Bypass to Feather River, Feather River to Sacramento River. The Feather River is a major tributary to the Sacramento River, merging with the Sutter Bypass upstream from the Sacramento River and Fremont Weir. The Yuba and Bear Rivers are major tributaries to the Feather River. Two major flood management reservoirs are located within the Feather River watershed: Oroville on the Feather River and New Bullards Bar on the Yuba River. The Feather River is described by four hydrologic reaches based on significant inflows;

Thermalito to Honcut Creek, Honcut Creek to Yuba River, Yuba River to Bear River, and Bear River to Sutter Bypass.

The Cherokee Canal is a tributary to Butte Creek and the Butte Basin. The leveed canal was constructed between 1959 and 1960 by USACE. The canal drainage area is 94 square miles and varies in elevation from 70 feet to 2200 feet. The drainage area is bounded by the Feather River watershed to the east and southeast, Butte Creek and its tributaries to the north and west, and by Wadsworth Canal drainage to the south.

The Wadsworth Canal is a leveed tributary to the Sutter Bypass near the town of Sutter. The canal conveys flow from the East and West interceptor canals to the Sutter Bypass. The East and West interceptor canals collect runoff from canals and shallow floodplain runoff into the Wadsworth Canal.

3. Flood Problems

3.1 GENERAL CHARACTERISTICS

Historically, large areas outside the low-water channel were inundated by Feather River flows in the valley, generally extending from the City of Oroville to the Sacramento River near Verona and encompassing some 292,000 acres, much of which is now agricultural land consisting primarily of orchards, dairy farms, and truck crops. The communities of Marysville and Yuba City are particularly vulnerable to inundation. The average elevation of these two leveed cities varies from 5 to 20 feet below the high water level in the river.

3.2 TOPOGRAPHY

The watershed above Oroville Dam includes mountain crests over 8,000 feet high, mountain valleys at elevations as high as 5,000 feet, deep canyons, and rolling foothills. Elevations range from 10,466 feet at Mt. Lassen Peak to 900 feet at the dam site. A topographic map and stream profiles of the Feather River Basin are presented in Plates 4 and 5.1 and 5.2, respectively. About 58 percent of the basin area is above an elevation of 5,000 feet, and only 7 percent is below 2,500 feet. Table 1 shows the distribution of the basin area above Oroville Dam and the corresponding area-elevation curve is shown on Plate 6. The percentage of the drainage area controlled by the major dams in the Feather River basin and Sacramento River basin downstream to the streamgage at Verona are sown in table 2 below.

TABLE 1

AREA ELEVATION (Percent of Area in Each Elevation)		
ELEVATION RANGE (ft)	AREA (SQMILES)	PERCENT OF AREA
<1000	33	0.9
1000-2000	115	3.2
2000-3000	178	4.9
3000-4000	337	9.4
4000-5000	854	23.7
5000-6000	1,257	34.9
6000-7000	710	19.7
7000-8000	113	3.1
8000-9000	4	0.1
>9000	0.01	0.0
Source: USGS 30 meter DEM		

TABLE 2

Drainage Area and Area Controlled in the Sacramento Basin to Verona						
huc_cd	Station_name	USGS_Stn#	Total Darea(sq-mi)	Local Darea(sq-mi)	Percent of Area Controlled	Elev (ft)
18020005	SACRAMENTO R A KENNETT CA	11369500	6355	6355	100.0%	618
---	Shasta Lake and Dam		6421	6421	100.0%	585
18020101	SACRAMENTO R A KESWICK CA	11370500	6468	47	99.3%	480
18020103	SACRAMENTO R NR RED BLUFF CA	11378000	9020	2599	71.2%	254
18020103	SACRAMENTO R NR HAMILTON CITY CA	11383800	10833	4412	59.3%	
18020103	STONY C NR HAMILTON CITY CA	11388500	773	773	100.0%	150
18020104	SACRAMENTO R A BUTTE CITY CA	11389000	12075	4881	59.6%	
18020104	SACRAMENTO R A COLUSA CA	11389500	12090	4896	59.5%	
18020104	SACRAMENTO R BL WILKINS SLOUGH NR GRIMES CA	11390500	12915	5721	55.7%	
18020104	SACRAMENTO R A KNIGHTS LANDING CA	11391000	14535	7341	49.5%	
18020123	COMPUTED INFLOW TO LK OROVILLE CA	11406799	3607	3607	100.0%	
---	Oroville Lake and Dam		3611	3611	100.0%	180
18020106	FEATHER R A OROVILLE CA	11407000	3624	13	99.6%	
18020106	FEATHER R NR GRIDLEY CA	11407150	3676	65	98.2%	
---	New Bullards Bar Lake and Dam		489	489	100.0%	1392
18020125	N YUBA R BL BULLARDS BAR DAM CA	11413500	487	487	100.0%	1390
18020125	N YUBA R LOW FLOW REL BL NEW BULLARDS BAR DAM CA	11413517	489	2	99.6%	1280
18020125	YUBA R BL NEW COLGATE POWERPLANT NR FRENCH CORRAL	11413700	717	230	67.9%	550
18020125	YUBA R BL ENGLEBRIGHT DAM NR SMARTSVILLE CA	11418000	1108	621	44.0%	
18020125	YUBA R A SMARTSVILLE CA	11419000	1200	713	40.6%	264
18020106	YUBA R A DAQUERRA PT NR BROWNS VALLEY CA	11420800	1330	843	36.6%	
18020107	YUBA R NR MARYSVILLE CA	11421000	1339	852	36.4%	
18020106	FEATHER R BL SHANGHAI BEND NR OLIVEHURST CA	11421700	5334	1236	76.8%	
18020108	BEAR R NR WHEATLAND CA (6.5 mi d/s of Camp Far West Dam)	11424000	292	292	100.0%	72
18020106	FEATHER R NR NICOLAUS	11425000	5921	1531	74.1%	
18020109	SACRAMENTO R A VERONA CA	11425500	21251	10440	50.9%	43

Data Source: USGS gage station inventory at http://nwis.waterdata.usgs.gov/nwis/inventory
Data Source for Dams: Pertinent data sheets for Water Management, Sacramento District, USACE.

3.3 GEOLOGY AND SOILS

Geologically, the Feather River Basin includes portions of the Cascade and Sierra Nevada Ranges. The basin is bounded on the northwest and north by volcanic ridges and mountains radiating from Mt. Lassen, the predominant feature of the northern extremity of the Feather River Basin and the southern limit of the Cascades. On the northeast and east, the basin boundaries correspond roughly to the northern and eastern limits of the Sierra Nevada. The Feather River Basin terminates on the south with the northern boundary of the American River Basin. The majority of the basin is located within the Sierra Nevada, a huge monoclinal fault block tilted very slightly westward and extending beneath the alluvium filled Sacramento Valley on the west. The geologic formations in the basin consist of a wide variety of metamorphic rocks into which granitic rocks of various types have intruded. Recent (in geologic time) stream channel deposits comprise an' important portion of the basin including mountain meadows and stream floodplains, which consist of boulders, gravel, sand and silt. Several faults and fault systems located in areas adjacent to the basin are considered active.

Soils of the Feather River Basin consist of those residual soils formed in place by deterioration and weathering of underlying parent rock; valley fill soils, with the older soils having been modified during the period since deposition and the recent fills showing little change in physical or chemical composition since deposition; and lacustrine soils derived from decomposition of organic materials under marshy conditions. The residual soils are found on mountainous areas and vary in depth from very shallow with considerable surface rock to soils having good depth and little or no surface rock. The older alluvial soils usually have been modified by leaching processes to form dense clay pans or cemented hardpans. These soils are found in lower valley-floor areas, particularly on the west, where they join the alluvial areas of the Sacramento Valley floor. The rich soil of the valley floor below the dam grows a great variety of farm crops.

3.4 SEDIMENT

Sedimentation rates in the Feather River Basin and adjacent basins are relatively low due to limited development, the general shallowness of soils and a low rate of upstream erosion. The annual sediment yield for the drainage area above Lake Oroville is estimated to be about 0.2 acre-feet per square mile, which corresponds to 720 acre-feet/year. Much of the recent deposition that has occurred in the lower Feather River Basin was due to the extensive use of hydraulic mining in the late nineteenth century. DWR conducted a siltation study of Lake Oroville during 1993-1994. The study concluded that 18,000 acre-feet of sediment deposition has occurred since completion of the project. This corresponds to an annual rate of 667 acre-feet/year.

4. Climate

4.1 GENERAL

The climate of the Feather River Basin is significantly influenced by the topography of the area and there are marked variations in temperature and precipitation within short distances. Climate is characterized by cool, wet winters and hot, dry summers. The majority of the annual rainfall

occurs in 2 or 3 of the winter months. The seasons are so distinctly different that the period from May to October may be termed the dry season and November to April the wet season.

4.2 TEMPERATURE

Temperatures in the valley are high in the summer and moderate in the winter. Temperatures in the mountains decrease generally with elevation; the summers are moderate at higher elevations while the winters are severe. Observed temperature extremes are113 and 17 degrees at Marysville, 115 and 12 degrees at Oroville, 110 and -24 degrees at Quincy, and 104 and -29 degrees at Sierraville. The monthly and annual distribution of mean, maximum, and minimum temperatures at representative stations are presented in Table 3.Except for extremely high elevations, these temperatures are representative of the whole watershed area.

TABLE 3

MONTHLY AND ANNUAL
MEAN, MAXIMUM, AND MINIMUM TEMPERATURES
(Degrees Fahrenheit)

Month	Marysville (57 ft)			De Sabla (2720 ft)			Canyon Dam (4560 ft)			Portola (4850 ft)		
	Mean	Max	Min	[Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
January	46.0	54.1	38.0	41.7	51.4	31.9	30.5	39.1	21.9	29.9	41.9	17.9
February	51.4	61.1	41.7	43.9	54.4	33.3	33.5	43.4	23.5	33.3	46.1	20.6
March	55.3	66.3	44.3	46.4	57.8	34.9	37.8	49.0	26.6	37.9	51.3	24.4
April	60.8	73.7	47.9	51.4	64.3	38.5	43.8	57.3	30.2	43.2	58.5	27.8
May	67.7	81.8	53.6	58.4	72.6	44.2	51.8	67.3	36.4	50.3	67.5	33.1
June	74.5	90.1	58.9	66.4	82.0	50.9	59.4	76.1	42.7	57.4	76.8	38.1
July	79.1	96.3	61.9	72.3	89.3	55.3	66.0	84.7	47.3	63.6	85.8	41.5
August	77.5	94.5	60.5	71.2	88.5	54.0	64.6	83.5	45.7	62.2	84.4	39.8
September	73.5	89.7	57.3	66.9	83.5	50.4	59.0	76.9	41.2	56.8	78.3	35.3
October	65.3	79.7	50.8	58.4	72.9	44.0	49.5	64.5	34.4	48.4	67.6	29.3
November	53.9	64.7	43.1	47.2	58.1	36.3	38.4	48.5	28.4	38.3	52.5	23.9
December	46.7	55.0	38.4	42.0	51.7	32.3	31.8	39.9	23.6	31.5	43.6	19.5
Annual	62.6	75.6	49.7	55.5	68.9	42.2	47.2	60.9	33.5	46.1	62.9	29.3
Period of Record	1948-2004			1948-2004			1948-2004			1948-2002		

Source: Western Regional Climate Center, 2004

4.3 PRECIPITATION

Annual precipitation varies throughout the drainage area, ranging from 20 to 25 inches on the valley floor to about 100 inches in the higher mountains, and averages about 45 inches over the watershed above Oroville Dam. Winter precipitation usually falls as rain up to the 5,000 foot elevation and as snow at higher elevations, but some storms produce rain up to the highest elevations of the basin and snowfall occurs as low as the valley floor at rare intervals. About 90 percent of the runoff producing precipitation occurs during the winter months of November through April. The areal distribution of normal annual precipitation is shown on Plate 7. The mean monthly distribution at selected stations is given in Table 3.

TABLE 4

MEAN MONTHLY PRECIPITATION								
Month	Marysville (57 ft)		De Sabla (2720 ft)		CanyonDam (4560 ft)		Portola (4850 ft)	
	Inches	%	Inches	%	Inches	%	Inches	%
January	4.37	20.4%	12.75	19.2%	7.4	19.1%	4.13	18.8%
February	3.53	16.4%	10.81	16.3%	6.34	16.4%	3.34	15.2%
March	2.93	13.7%	8.98	13.5%	5.21	13.5%	3.03	13.8%
April	1.61	7.5%	4.93	7.4%	2.6	6.7%	1.34	6.1%
May	0.64	3.0%	2.28	3.4%	1.54	4.0%	1.09	5.0%
June	0.23	1.1%	0.89	1.3%	0.74	1.9%	0.58	2.6%
July	0.04	0.2%	0.1	0.2%	0.18	0.5%	0.36	1.6%
August	0.08	0.4%	0.28	0.4%	0.32	0.8%	0.35	1.6%
September	0.33	1.5%	1.09	1.6%	0.71	1.8%	0.53	2.4%
October	1.27	5.9%	3.65	5.5%	2.2	5.7%	1.18	5.4%
November	2.82	13.1%	8.74	13.2%	4.87	12.6%	2.36	10.7%
December	3.61	16.8%	11.88	17.9%	6.52	16.9%	3.73	16.9%
Average Annual	21.46	100%	66.37	100%	38.65	100%	22.02	100%
Maximum Annual	1983		1983		1983		1996	
Minimum Annual	1976		1976		1976		1976	
Period of Record	1948-2004		1948-2004		1948-200		1919-2004	
Source: Western Regional Climate Center, 2004								

4.4 SNOWFALL

Winter snowfall above 5,000 feet elevation normally accumulates until the first of April when increasing temperatures mark the beginning of the snowmelt season. Snow falling at lower elevations usually melts within a relatively short time. Snow course data are collected at 25 locations within the Feather River Basin by Pacific Gas and Electric Company, California Department of Water Resources, the East Lake Ranger District, and the Eagle Lake Ranger District as part of the California Cooperative Snow Survey program. Basin snowpack data for six representative snow courses are presented in Table 4. The locations of the snow courses are shown on Plate 8.

TABLE 5

SNOW SURVEY DATA (Water Equivalent - Inches)							
Snow Course	AVERAGE					MAXIMUM	MINIMUM
	1-Jan	1-Feb	1-Mar	1-Apr	1-May	(Date)	(Date)
Lower Lassen Peak (Elev 8250 ft.) (POR 1930-2000)	33.4	48.2	62.8	78.7	80.8	162.1 3/27/1995	6.4 1/1/1987
Mount Dyer #1 (Elev 7100 ft) (POR 1930-2000)	9.6	14.5	19.4	25	23	71.7 5/1/1983	0 Multiple
Rowland Creek (Elev 6700 ft) (POR 1950-2000)	6.9	11.8	15.4	17.7	13.3	43.8 4/1/1952	0 Multiple
Eureka Lake (Elev 6200 ft) (POR 1939-2000)	n/a	19.5	28	31.6	21.7	72.9 4/1/1952	0 Multiple
Letterbox (Elev 5600 ft) (POR 1940-2000)	17.8	25.8	37.3	48.4	40.6	106.5 4/1/1952	0 Multiple
Chester Flat (Elev 4600 ft) POR 1930-2000)	3.7	7.5	9	6.4	1.6	29.1 4/1/1952	0 Multiple
Source: California Department of Water Resources, California Data Exchange Center, 2003							

4.5 EVAPORATION AND WIND

The average historical evaporation at Lake Oroville is listed in Table 5. Pan evaporation was measured with a class "A" pan. Peak wind velocities in California are generally associated with winter-type storm fronts, whereas the strongest sustained winds occur in the summer with maximum sunshine. The prevailing wind direction in the lower Feather River Basin is from the south and southeast during the months of April through September, and from the north during the months of October through December. A continuous recording ground level anemometer was recently installed at Oroville Dam. Table 7 is a compilation of the mean and peak monthly wind velocities for Beale Air Force Base and the Red Bluff Airport.

TABLE 6

HISTORICAL MONTHLY PAN EVAPORATION LAKE OROVILLE	
MONTH	MEAN EVAPORATION (in)
January	1.2
February	2.02
March	3.59
April	5.36
May	7.96
June	10.1
July	11.99
August	10.86
September	8.36
October	5.36
November	2.12
December	1.17
Annual Total	70.09

Source: DWR Bulletin 73-79, Nov 1979 (Period of Record WY1959-WY1979). DWR and University of California Statewide Integrated Pest Management Program (Period of Record WY198l-WY2002)

TABLE 7

MEAN AND PEAK MONTHLY WIND VELOCITIES				
Month	Beale Air Force Base		Red Bluff Airport	
(mph)	Mean (mph)	Peak Gust (mph)	Mean (mph)	Peak Gust
January	5	59	9	47
February	5	62	9	55
March	6	51	10	60
April	6	53	10	47
May	6	43	9	45
June	6	44	9	41
July	5	38	8	39
August	5	35	8	35
September	5	48	8	43
October	3	53	8	48
November	5	64	8	54
December	5	67	8	49
Annual	5	67	9	60

Source: Climatic Wind Data for the United States, 1998, NCDC, Period of Record not specified.

4.6 STORMS AND FLOODS

The Feather River Basin lies on the seaward face of the Sierra Nevada which rises directly across the path of storms moving inland from the Mid-Pacific Ocean. The low barrier of the Coast Range which intervenes between the ocean and the Sierra Nevada is pierced by the large San Francisco Bay Gap westward from the Feather River Basin so that considerable volumes of moist maritime air reach the basin at low elevations.

The most important storms affecting this area are cyclonic wave disturbances along the polar front that usually originate in the vicinity of the Aleutian Islands. The normal trajectory of the waves along this front is to the south and east from the Pacific Ocean to the west coast. In the summertime, this frontal zone is located far to the north and the accompanying precipitation seldom reaches as far south as California. During the summer the air which reaches the region is generally stable and thunderstorms are rare. During the wintertime, from October to April, the frontal zone moves southward and the cyclonic wave disturbances move over California.

The annual precipitation is concentrated almost entirely during the winter storm season from November through March. Precipitation normally falls as snow above the 5,000 foot level. However, during extremely warm winter storms rain has fallen over the entire basin melting some of the snow and at times stripping most of the snowpack from the basin. By the end of the winter most of the area above 5,000 feet is covered by a compact snowpack that often averages more than 10 feet in depth over large areas. Occasionally, depths reach 30 feet. Because of this deep snowpack in the higher areas, storm rainfall therein is largely absorbed in the mass of the snow and appreciable storm runoff from such areas is prevented.

Studies of storms and floods of record indicate that critical flood producing conditions on the Feather River Basin will occur only during the winter season when there may be a prolonged series of general storms covering the entire basin. Storm precipitation amounts are typically distributed aerially in the same general pattern as normal annual precipitation amounts, although there are large departures from this rule. On occasion a general storm series may last 2 to 5 days. During such stormy periods, soil saturation occurs, infiltration capacities decline, and the natural and artificial storage within the basin is progressively filled.

Outside the winter season, storms are less severe, cover only a small portion of the basin at a time, and are so widely separated in time that basin storages have an opportunity to replenish, resulting in lower basin runoff. Thunderstorms lasting up to three hours can occur over small areas at higher elevations from late spring through early fall. The resulting runoff is characterized by high peaks of short duration with low volumes. For small tributaries, peak flows from thunderstorms can approach those that occur during major winter rain floods, but flows on the main stem are barely affected.

Floods in the Feather River Basin are typical of those occurring on the other Sierra Nevada streams. Floods are rather frequent and of two general types, winter rain floods and spring snowmelt floods. However, only rain floods, resulting from intense rainfall over the foothills and mountains during the winter season, cause serious flooding because the highest rate of snowmelt runoff is well below that corresponding to the damaging stage of the river.

Rain floods have a high peak discharge, are flashy, and are generally only a few days in duration. When antecedent rainfall has resulted in saturated ground conditions or when the ground is frozen, the volume of runoff can be much greater and flooding more severe. These floods may occur in rapid succession with secondary peaks occurring before flows from the preceding floods have completely receded.

Snowmelt floods can be expected any time from April through July. They are characterized by lower peak flows, long durations, and comparably large volumes of runoff. The snowmelt flood potential varies according to the depth and areal extent of the snowpack and temperature. The highest rates of snowmelt runoff usually occur during years with an unusually deep snowpack. High flows are sustained during May and June when rising temperatures cause the snowpack to melt. The top five historic snowmelt inflow flood events are shown in table 9.

4.7 RUNNOFF CHARACTERISTICS

Runoff occurs primarily during the months of November through June. Maximum flows between the months November and April are the result of direct runoff from intense precipitation augmented occasionally by melting snow (USACE, 1958). Runoff during the months of April through June is primarily from snowmelt. Such runoff generally does not result in flood-producing flows, but is ordinarily adequate to fill reservoir space maintained empty during the winter months for flood control. During late summer and early fall, runoff diminishes and streamflow is sustained by springs and drainage of lakes, reservoirs, and areas of effluent seepage (USACE, 1958). Greatest water demands occur during the months June through September. Thus, in years of normal or above normal snowmelt, flood control operation does not interfere with the filling of the reservoir for subsequent water deliveries.

Runoff accumulates rapidly in the upstream tributary areas where the flows are confined within the natural narrow canyon stream channels and the floods produced are of high intensity but relatively short duration. Flood peaks on the streams in the basin above Oroville Dam are often impaired and delayed by numerous upstream check dams, diversions and reservoirs.

Significant runoff occurs after the ground approaches saturation. Thereafter, successive storms would produce runoff with lower loss rates unless enough time expires between storms for the basin to dry out. Loss rates in the basin vary with the wetness of the ground and the intensity of the rainfall plus snowmelt. Constant loss rates, estimated for eight floods between 1940 and 1955, are presented in the March 1958 office report, Flood Control Hydrology, Feather River Basin, California. Constant loss rates were found to range from 0.06 in/hr to 0.13 in/hr.

Annual runoff volume since project completion has been highly variable, and has ranged from a minimum of 752,000 acre-feet in water year 1977 to a maximum of 8,857,000 acre-feet in water year 1983. The extremes represent 18 and 210 percent, respectively, of the 36-year average runoff of 4,227,000 acre-feet. Mean monthly unregulated runoff at Oroville Dam is presented in Table 8.

TABLE 8

MEAN MONTHLY UNREGULATED RUNOFF FEATHER RIVER AT OROVILLE DAM		
MONTH	TOTAL MONTHLY RUNOFF (1000 AF)	PERCENT OF ANNUAL RUNOFF
JANUARY	509	11.2
FEBRUARY	571	12.6
MARCH	705	15.5
APRIL	739	16.3
MAY	670	14.7
JUNE	349	7.7
JULY	159	3.5
AUGUST	104	2.3
SEPTEMBER	89	2
OCTOBER	106	2.3
NOVEMBER	196	4.3
DECEMBER	350	7.7
ANNUAL	4,547	100.0

The official operation record of Oroville Dam is maintained by the State of California. Operation of Oroville Dam began in October 1967. Daily historical operation data including inflow, outflow, storage and top of conservation are available at the California Data Exchange Center (CDEC) on the web at http://cdec.water.ca.gov/reservoir.html.

4.8 CLIMATE CHANGE

4.8.1. PURPOSE

This section presents a discussion of the potential impact of climate change for the Sutter basin feasibility study (SBFS) hydrology.

4.8. 2. GENERAL

Two possible trends associated with climate change that may affect the SBFS study area are a change in sea level and the shift in Sierra Nevada runoff patterns..

Recent research indicates continued or accelerated rise in global mean sea level height (sea level change) based on decades (and in some cases centuries) of measurements. Climate change has been identified as a likely cause of the increase in global sea level height by many researchers but is still subject to spirited debate. However, the reality of the observed rise in global sea level height at project specific locations and local vertical land movement needs to be adequately addressed by projects in and near coastal areas regardless of the causes (USACE, 2011A).

Also, studies have shown that increasing temperatures associated with climate change are causing a shift in the runoff patterns of Pacific slope watersheds with a large snowmelt component. The runoff shifts for those watersheds include increased runoff in winter, less snowmelt in summer, and earlier runoff in the spring (USACE, 2011B).

4.8.3. SEA LEVEL CHANGE

The discussions of sea-level analysis has been removed to the hydraulic analysis appendix.

4.8.4. IMPACT OF CLIMATE CHANGE ON RUNOFF

A sensitivity study of the potential impact of climate change on runoff was completed. A separate technical memorandum documents that effort in "Sensitivity of Alternative Selection to Climate Change", dated 03January2013 (USACE, 2013).

The procedure used hydrologically was to adopt the percent change in 3-day flood flow at discrete locations in the Sacramento river basin from a paper by Tapas Das (Das, 2011). Those percent changes in 3-day flows were applied to the unregulated flow frequency curves to shift the frequency of future flows to a more frequent occurrence. The future unregulated flows were then input to the economics model were transform curves from the existing without project condition transformed the unregulated flow to regulated flow. The economics model then assessed the ranking of project alternatives based on three future climate scenarios as defined in the Das paper representing wetter and dryer future conditions.

The conclusion of that sensitivity study was that the impact of climate change will not change the selection of draft alternatives for the Sutter Basin Feasibility Study. Table 9 shows the final ranking of alternatives, showing that alternative SB-7 remains in first position. The results indicate that the ranking of the alternatives on the basis of net annual benefits is not sensitive to the climate change scenarios.

TABLE 9.

Rankings of Alternatives Based Upon Equivalent Net Annual Benefits by Climate Scenario

Alternative	NCAR (Driest Condition)	Existing Condition	GFDL (Wettest Condition)
SB-1	8	8	6
SB-2	2	2/3	5
SB-3	4	4	4
SB-4	7	7	8
SB-5	5	5/6	7
SB-6	6	5/6	3
SB-7	1	1	1
SB-8	3	2/3	2

5. Historic Flooding

Historic unregulated flows and volumes for the Feather River at Oroville for the five largest rain floods of record, based on 3-day volumes, are listed in Table 10. Unregulated flows and volumes for the Feather River at Oroville for the five largest snowmelt season (April through July) floods of record based on 3-day volumes are shown in Table 11. A discussion of the 1955, 1964, 1986, and 1997 floods follows.

TABLE 10

HISTORIC RAIN FLOOD INFLOWS FEATHER RIVER AT OROVILLE DAM			
DATE	PEAK a/ (cfs)	UNREGULATED 1-DAY VOLUME (acre-feet)	UNREGULATED 3-DAY VOLUME (acre-feet)
Jan- 1997	302,000	620,600	1,454,800
Feb- 1986	275,000	430,500	1,112,800
Dec- 1964	250,000	354,100	984,100
Mar- 1907	230,000	370,900	894,500
Dec- 1955	203,000	360,100	874,200

Source: USCAE 1999, and CDEC, Period of Record WY 1902- WY 2003
Excerpted fom Oroville DRAFT 2005 WCM a/ Peak flows impaired due to upstream regulation

TABLE 11

HISTORIC UNREGULATED SNOWMELT SEASON INFLOW FLOODS OF RECORD FOR THE FEATHER RIVER AT OROVILLE DAM		
WATER YEAR	1-DAY VOLUME (acre-feet)	3-DAY VOLUME (acre-feet)
1995	491,000	4,263,000
1982	425,000	3,156,000
1915	362,000	2,940,000
1911	308,000	4,368,000
1963	290,000	1,685,000
Source: USACE, CDEC, Period of Record WT 1902 - WY 2003 Excerpted from Oroville DRAFT 2005 WCM Snowmelt season begins April 1st		

During the week preceding Christmas 1955, northern and central California was subjected to one of the greatest floods in the area's history. The intense flood-producing precipitation covered an area of about 100,000 square miles, which represents over sixty percent of the gross area of the state. By December 15, the Feather River Basin was moderately wet from preceding storms, the snowline was at about 4,000 feet, and there was about 36 inches of snow above 7,000 feet. During the first cold phase of the storm, from the 15th to the 20th, about 10 inches of precipitation fell on the basin, as rain below about 5,500 feet and as snow above that elevation. The snowline retreated about 500 feet in elevation, but snow depths at 7,000 feet elevation increased to about 75 inches. After the 21st, temperatures and wind velocities increased greatly and the rainfall extended to the highest point in the basin. The snowline retreated about 700 feet in elevation and snow depths decreased about 18 inches at all elevations, contributing to heavy runoff from most of the basin below above 7,000 feet. Extensive flooding occurred throughout the basin. At Shanghai Bend, south of Yuba City, the west levee of the Feather River failed at about midnight on the 23rd. Water from this break entered Yuba City and flooded about ninety-five percent of the city. In the residential areas, the depth of flooding varied from a few inches to over 12 feet. Because the flooding occurred so quickly, and in the middle of the night, practically none of the contents of homes and businesses could be saved. About 12,000 people were evacuated from the Yuba City area for a period varying from a few days to several months. It was reported that 38 people lost their lives in this area as a result of the flood.

On December 23, 1955, a peak flow of 203,000 cfs and a gage reading of 76.5 feet above streambed occurred at the gaging station in the Feather River Canyon a few miles east of Oroville. An estimated peak discharge of 230,000 cfs occurred during the great flood of March 1907. However, in December 1955, upstream reservoirs, which did not exist in 1907, stored 137,000 acre-feet of floodwater between December 21 and December 28. It is estimated had Oroville Dam existed, the inventoried damages, losses, and costs below the dam site of about $50,000,000 and the loss of human lives could have been prevented. Such a reduction in flood

flows in the Feather River would also have relieved the threat to the remaining portion of the levee system.

The flood of December 1964 - January 1965 resulted from a winter rainstorm that followed a meteorological pattern typical of other flood-producing storms over the basin. Heavy precipitation occurred in the preceding 60 days over the general area, with up to 5 inches of rain recorded at some valley stations. The storm came in four distinct waves. The first wave, which occurred during 18-20 December, was cold, and deposited 2-3 inches of snow in the mountains down to the 3,000 foot level. The following wave brought rising temperatures and heavy rains up to 6,000 feet elevation. Within the 4-day period, 20-23 December, about 13 inches of rain fell. The warm winds and rain melted most of the new snow accumulated during the initial storm. Another cold wave occurred during 26 December - 4 January, and brought rain to lower elevations and snow in the mountain. The final wave of this storm series occurred on 4-6 January when 3 to 10 inches of precipitation fell on the Feather and Yuba River Basins. Inflow to Oroville Reservoir peaked at 250,000 cfs. Flow at Oroville was attenuated by the partially constructed dam to a maximum outflow of 158,000 cfs.

The storms of February 1986 severely affected northern California and northwestern Nevada. Heavy precipitation reached record levels in many locations. The heaviest precipitation occurred 200 miles north to 100 miles south of a line from San Francisco to Sacramento to Lake Tahoe. Over much of this area the precipitation ranged between 100 to 350 percent of normal February Precipitation. In the Feather River Basin, the heavy rains began on February 12 and continued through February 21. With the continued rain and storm runoff, storage increases at Oroville from February 13 through February 23 were 640,300 acre-feet or approximately seventy percent of the space available at the beginning of the flood.

Several reservoirs above Oroville contributed to incidental flood flow retention. Collectively, these reservoirs stored 408,000 acre-feet during the flood. The maximum release from Oroville Dam was 147,400 cfs on February 18 and 19. The Feather River at Gridley gage recorded a peak flow of approximately 150,000 cfs on February 19 compared to the past Oroville Dam peak flow of 90,100 cfs on January 15, 1980. Flows on the Feather River below the dam equaled but did not exceed the design flows of the downstream levees. However, on February 20, a levee break occurred on the south bank of the Yuba River at the towns of Linda and Olivehurst causing extensive residential and commercial damage.

Flooding in early January 1997 resulted when a series of three subtropical storms followed a cold storm and one of wettest Decembers on record. Prior to the late December storms, rainfall was already well above normal throughout the Sacramento and San Joaquin River basins. Then, several days before Christmas 1996, a cold storm from the Gulf of Alaska brought snow to low elevations in the Sierra Nevada foothills. The first of three subtropical storms hit Northern California on December 29, 1996, with less than expected precipitation totals. On December 30, the second storm arrived. The third and most severe storm hit late December 31 and lasted through January 2. The snowpack at lower elevations, melted when the trio of warmer storms hit. However, not much snowpack loss was observed at snow sensors over 6,000 feet in elevation in the northern Sierra. Precipitation totals at lower elevations in the Central Valley were not unusually high in contrast to extreme rainfall in the upper watersheds. Extreme precipitation in

the Sierra Nevada resulted in record flows in both the Sacramento and San Joaquin River basins. Several gaging stations used to measure the water level in streams and rivers recorded the largest peaks in the history of their operation during this series of storms. Based on 3-day volume, inflows to Lake Oroville were the largest on record. The estimated peak bi-hourly inflow was 302,000 cfs and occurred on 1 January 1997. The maximum release from Lake Oroville was 160,000 cfs. Oroville came close to reaching design capacity as only 27 percent of the flood management reservation pool remained.

The eastern levee of the Feather River failed on the evening of January 3, 1997, near the town of Arboga, California. Within 24 hours of the initial failure, the levee breach had reached over 800 feet in length. Floodwaters inundated 12,000 acres, damaging over 700 structures. Although the area was primarily agricultural, many of the damaged structures were concentrated along Country Club Road and in the town of Arboga. In total, approximately 600 residential structures were within the flooded area. This area had a wide range of flooding depths, with maximum depths about 20 feet (structures totally covered) in the south near the levee break to minimal depths in the north near the Yuba County Airport.

6. Hydrologic Analysis

In support of the Comprehensive Study (USACE, 2002), the Water Management Section of the Sacramento District, USACE, has developed synthetic 50-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent chance exceedence flood events. These seven synthetic exceedence frequency events will provide a basis for defining existing conditions and eventual alternatives analysis and plan formulation. In this sense, this hydrology study will serve as a cornerstone for future Comprehensive Study investigations.

The methodology used by the Water Management Section of the USACE, in performing the Comprehensive Study, including: 1) updated natural flow frequency curves for locations within the basins; 2) a retrospective of historic floods that have impacted Central Valley rivers and the synthetic flood runoff centerings developed to represent flood events of a specific exceedence frequency; and 3) construction of seven synthetic exceedence frequency flood hydrographs.

The synthetic hydrology, as presented in the Comprehensive Study, was created to be "Comprehensive" in nature. Without further investigation, its development offers only enough detail in the storm centerings, local-flow contributions, and ungaged stream contributions to be applied in pre-feasibility applications (USACE, 2002). The models developed for the Comprehensive Study analysis were created with the following assumptions and limitations:

- The data are stationary.
- The natural flow frequency curves are strictly rainflood frequency curves. Snowmelt runoff is not directly incorporated into the analysis.
- Centering hydrographs are predicated on flood runoff, not precipitation. The approach was driven entirely by historic flow data; precipitation never entered into any portion of the methodology.
- Storm runoff centerings were formulated based on the Composite Floodplain concept.

- The unregulated frequency curves computed for the Comprehensive Study were created by following procedures outlined in Bulletin 17B.
- Travel times and attenuation factors (Muskingum Coefficients) are fixed for all simulated exceedence frequencies.
- Mainstem unregulated flow frequency curves were designed to quantify the total flows that the basins produced in rainfloods, not the average natural flows expected at mainstem locations during any of the synthetic exceedence frequency storm events.
- Patterns for synthetic floods are formulated based on historic storms.

Ultimately, results from the Comprehensive Study hydrologic investigation will feed into other models and drive parameter development for related aspects of the study. The results of the Comprehensive Study have been fed into hydraulic models that have refined the flow routing throughout the Sacramento River basin. The hydrologic data is still considered the best available data for areas as large as the Sutter basin. The results will be of use in feasibility studies to come, such as the Sutter basin feasibility study.

6.1 STORM CENTERING AND MODELING PROCEDURE

The hydrology for the feasibility study will be based upon the storm centering method described in the Comp Study. A storm centering is the simulation of the effect of storms that are positioned (centered) over particular locations in a watershed to produce flow rates of specific frequencies at those locations. In the Comp Study, a suite of storm centerings were used in developing synthetic hydrology for the Sacramento and San Joaquin watersheds to emulate the diverse spectrum of floods that can occur from different combinations of concurrent storms on tributaries, accounting for orographic influences and other factors that influence regional rainfall runoff events. The synthetic hydrology as presented in the Comp Study represents the best available data for the large flood sources (Sutter Bypass and Feather River) of the Sutter Basin Feasibility Study. The hydrology has also been used for several other feasibility studies in the region, such as the American River Common Features, Yuba River, and Marysville studies.

The synthetic hydrology of the Comp Study was based upon a transformation of unregulated hydrologic conditions to regulated conditions. This was accomplished by developing balanced unregulated hydrographs based upon historical patterned storm events, resulting in hydrographs representing the varying flood durations. These balanced hydrographs were then transformed to regulated hydrographs using an HEC-5 reservoir operations model of the system. The HEC-5 model, also developed and calibrated for the Comp Study, simulates reservoir operations and produces regulated flow (USACE, 1996). Resulting hydrographs were obtained from the HEC-5 model at ‘handoff’ points and modeled in more hydraulic detail using a UNET unsteady hydraulic model. The Sacramento and San Joaquin Comp Study UNET model, developed and calibrated for the Comp Study, is designed to simulate unsteady flow through a network of open channels, weirs, bypasses, and storage areas (USACE, 2002C).

The Comp Study UNET model downstream of the latitude at the City of Colusa has been replaced for the Sutter Basin Feasibility Study with an HEC-RAS unsteady model. Hydrographs were extracted from the Comp Study UNET model at two locations (a United States Geological

Survey (USGS) gage, Sacramento River at Colusa, and a California Department of Water Resources (DWR) gage, Butte Slough at Meridian) and transferred to the HEC-RAS model. The two locations represent the entire flow passing the latitude at the City of Colusa. All model assumptions, flow, and routings upstream from these two locations are from the Comp Study (USACE, 2002). There were several simulations that were done for the Comp Study, however for the Sutter Basin Feasibility Study hydraulic model, the UNET model results from a levee overtopping only and no failure simulation were used.

6.2 DESIGN RAINFALL ANALYSIS

The interior drainage analysis required rainfall depth-duration-frequency tables derived from California Department of Water Resources (DWR) gage data. The data is available on the world-wide-web at: http://www.water.ca.gov/floodmgmt/hafoo/csc/climate_data/ (NOAA, 2011). The Nicolaus and Yuba City gages were selected based on their location , elevation, and period of record. Design storm depths for these gages are provided in Table 12.

TABLE 12

Design Storm Depths [inches].						
	Period of Record	Gage Elevation	100-Year		200-Year	
Rainfall Gage	[year]	[feet]	24-Hr	96-Hr	24-Hr	96-Hr
Nicolaus	91	47	3.38	6.77	3.67	7.4
Yuba City	46	60	3.88	7.33	4.2	8.01
Sutter Buttes [a]	n/a	n/a	4.23	8.46	4.59	9.25

[a] Rainfall depths over the Sutter Buttes were calcuated as 125% of the Nicolaus gage depths.

All subbasins south of Yuba City were assigned storm depths from the Nicolaus gage. The remainder of the subbasins were assigned storm depths according to the Yuba City gage with the exception of the subbasins within the Sutter Buttes. The Sutter Buttes typically receive higher rainfall amounts than the surrounding valley due to orographic effects and were treated as a unique rainfall zone. NOAA atlas 14 point rainfall depths (NOAA, 2011) were evaluated for both the Sutter Buttes and the surrounding valley. From this analysis, it was estimated that the Sutter Buttes typically receive about 25% more rainfall than the surrounding area. Therefore, in the absence of a rainfall gage in the Sutter Buttes, design rainfall depths for this region were estimated as 25% higher than those for the Nicolaus gage.

The 24-hour storm was patterned according to a SCS Type I temporal distribution as recommended in the Sutter County Design Standards (Sutter County, 2005). The 24-hour storm duration was chosen to stress the study area from a peak rainfall intensity and peak flow standpoint.

The 96-hour temporal distribution used was developed for the Sutter Basin region (California- Region 5) as part of the NOAA Atlas 14 Precipitation-Frequency Study for California (NOAA, 2011). The 96-hour storm, although a greater volume, is a less intense storm than the 24-hour storm and was analyzed to stress the study area from a volume standpoint.

The 24-hour and 96-hour temporal distribution patterns are provided in the Sutter Butte Flood Control Agency (SBFCA) Interior Drainage Analysis, dated February 2012, in graphical and table formats.

6.3 WIND WAVE ANALYSIS

The wind wave analysis has been moved to the hydraulic analysis appendix.

7. Analysis for Unregulated Flow Frequency Curves

7.1 GENERAL ANALYSIS

Unregulated frequency curves were developed at key mainstem and tributary locations in both the Sacramento and San Joaquin River basins. Unregulated frequency curves plot historic points and statistical distributions of unimpaired flows (no reservoir influence). Curves display volumes or average flow rates for different time durations over a range of annual exceedence probabilities. These curves can be used to translate: 1) hydrographs to frequencies (i.e., in 1997, the 3-day natural inflow to Oroville Dam, Sacramento River was roughly 209,000-cfs, which translates to a 1.6-percent chance exceedence event); and 2) frequencies to flood volumes (i.e., according to the curves, the 3-day natural inflow to Oroville Dam associated with an annual 10-percent chance exceedence event is approximately 105,000 cfs). After a curve is developed, the runoff volume for any of the seven synthetic exceedence frequency flood events can be obtained from the plot for that curve's specific location.

7.2 UNREGULATED FREQUENCY ANALYSIS

The unregulated frequency curves computed for the Comprehensive Study were created by following procedures outlined in Bulletin 17B, Guidelines for Determining Flood Flow Frequency, U.S. Department of the Interior, dated March of 1982. This report directs Federal agencies to use the procedures included therein for all "planning activities involving water and related land resources." Bulletin 17B requires the use of a Pearson Type III distribution with log transformation of the data (Log Pearson Type III distribution) as the method to analyze flood flow frequency.

In this report, charts containing frequency curves display two types of information. The frequency curve itself is one of these. The curve is derived from a statistical analysis of the recorded data after it has been transformed to log values. The mean, standard deviation and skew of the log-transformed data, are computed for the stream gage or reservoir. The data are screened for high and low outliers and if found, adjustments to the statistics are computed as outlined in Bulletin 17B. In addition, the resulting statistics are reviewed and sometimes adjusted or smoothed to account for sampling error differences among the various durations, or after comparison with similar gages in the watershed or region. The second type of information found on each frequency curve is the plot of the historical events given their estimated frequency. To determine its location on the frequency paper, the peak of each annually recorded event or peak

flow value is given a hypothetical frequency based upon its assigned plotting position using a Log Pearson Type III distribution. In some instances, visual examination of the unregulated frequency curves contained in this report reveal a significant difference between the statistical frequency curve and the imaginary curve that would be formed if a pencil line were hand-drawn through the historical data points. For some curves in this report in which the characteristic described above was apparent, further examination was made. In addition, a few frequency curves were re-computed using alternative distributions such as Gumble type III or lognormal. The result was that the other distributions did not result in an improved fit. Bulletin 17B directs the use of a Log Pearson III Distribution unless compelling and substantive evidence can be found that other distributions are more appropriate.

Development of the unregulated frequency curves for the tributaries required daily natural flow data for all target locations. Data were obtained from USACE archives or computed by routing daily change in storage from upstream reservoirs and adding this routed value to the gage record at the location of interest. Most required storage time series were available through USGS publications. Other data were obtained directly from Central Valley and federal water agencies, including U.S. Bureau of Reclamation, U.S. Geological Survey, Oroville-Wyandotte Irrigation District, South Sutter Water District, Placer County Water Association, Nevada Irrigation District, Surface Water Data Inc., Southern California Edison, Sacramento Metropolitan Utility District, and Pacific Gas and Electric.

Data from tributaries were routed to downstream locations for use in constructing mainstem "index" frequency curves. The frequency curves that characterize the total flows through the mainstem index locations represent "at-latitude" flows (i.e., any and all diverted or channelized flows that pass through a particular gage's geographic latitude). Muskingum routings with travel times (in hours) and reach-specific attenuation factors were used to transport daily hydrographs through the basins, as shown in Table 13 for the Sacramento River Basin. Travel times and attenuation factors (Muskingum Coefficients) were obtained from past studies, through communication with local water agencies, or through comparisons of historic flood data. If no information was available from these sources, variables were estimated based on length of reach, average slope, and other channel characteristics. All river routings were assumed to be conservative (routings were simulated with indefinitely large channels); no flow was lost in overbank areas during transit.

TABLE 13

MUSKINGUM ROUTING PARAMETERS FOR SACRAMENTO RIVER BASIN INDEX POINTS				
Source	From	To	Travel Time (Hours)	Muskingum Coefficient
Sacramento River	Shasta Dam	Keswick	2	0.4
Sacramento River	Keswick	Clear Creek	3	0.4
Clear Creek	Whiskeytown Dam	Mouth	2	0.4
Sacramento River	Clear Creek	Cow Creek	2	0.1
Cow Creek	Gage near Millville	Mouth	1	0.2
Battle Creek	Gage below Coleman F.H.	Mouth	1	0.2
Sacramento River	Battle Creek	Bend-Bridge	3	0.1
Sacramento	Bend-Bridge	Ord Ferry	18	0.2
Mill Creek	Gage near Los Molinos	Ord Ferry	14	0.2
Elder Creek	Gage near Paskenta	Ord Ferry	20	0.2
Deer Creek	Gage near Vina	Ord Ferry	14	0.2
Thomes Creek	Gage at Paskenta	Ord Ferry	20	0.2
Big Chico Creek	Gage near Chico	Ord Ferry	6	0.2
Stony Creek	Black Butte	Ord Ferry	11	0.2
Sacramento	Ord Ferry	Moulton Weir	13	0.2
Sacramento	Moulton Weir	Colusa Weir	3	0.2
Sacramento	Colusa Weir	Tisdale Weir	9	0.2
Sacramento	Tisdale Weir	Knights Landing	7	0.2
Sacramento	Knights Landing	Fremont Weir	2	0.2
Ord Ferry Overflow	Ord Ferry	Highway 162	32	0.1
Butte Creek	Gage at Chico	Highway 162	7	0.2
Butte Creek and Ord Ferry Overflow	Highway 162	Moulton Weir	10	0.1
Moulton Weir Spill	Sacramento River	Butte Creek	4	0.1
Butte Basin Flow	Moulton Weir/Butte Creek	Colusa Weir	4	0.1
Butte Basin Flow	Colusa Weir	Butte Sink	16	0.1
Butte Basin Flow	Butte Sink	Tisdale Weir	8	0.1
Sutter Bypass/Tisdale I	Tisdale Weir	Fremont Weir	20	0.1
Feather River	Oroville	Gridley	3	0.2
Feather River	Gridley	Honcut	1	0.17
Feather River	Honcut	Yuba City	4	0.17
North Yuba River	Bullards Bar Dam	Englebright	3	0.15
Yuba River	Deer Creek	Dry Creek	2	0.15
Yuba River	Dry Creek	Marysville	1	0.15
Yuba River	Marysville	Mouth	1	0.15
Feather River	Yuba River	Bear River	8	0.35
Bear River	Wheatland	Mouth	5	0.35
Feather River	Bear River	Nicolaus	2	0.35
Feather River	Nicolaus	Fremont Weir	4	0.2
Sacramento River	Verona	Sacramento Weir	5	0.2

This procedure was not intended to reflect the natural dynamics of the Central Valley, where large flood flows often discharge to out-of-bank areas and are lost or greatly attenuated. The unregulated flow frequency curves were designed to quantify the total flows that the basins produced in rain floods throughout the period of record, rather than the average natural flows expected at mainstem locations during any of the seven synthetic exceedence frequency storm events.

Historical data were plotted using moving averages of the daily time series for 3-, 5-, 7-, 10-, 15-, and 30-day duration natural flow at all points of interest. Wintertime maxima were picked from the moving average for each water year. All snowmelt-driven events were screened out from these duration maxima; screened events were replaced with the highest rainflood, or rainfall driven, maxima experienced during that water year, which included any rain-on-snow events occurring during the obvious rainflood season of a particular annual record. Values were sorted, ranked, and graphed with median plotting positions. Statistics were computed for these samples of annual rainfloods with USACE statistical analysis tools (FFA and REGFREQ). Sample mean, standard deviation, and skew were computed and, in some cases, smoothed to better represent the values for each duration. The Pearson Type III Distribution with log transformation of the data and final statistics were used to construct best-fit curves for all durations and were plotted on the same graph as the historic values for each location.

Unregulated frequency curves were prepared for 43 tributary locations and 8 mainstem locations. In all cases, curves were developed or updated to reflect post-1997 flood hydrology. For any location, the amount of runoff volume produced during simulation of any one of the seven synthetic exceedence frequency flood events can be read off of the family of best-fit curves or computed directly from the final statistical distribution of each duration.

Flood volumes at mainstem index locations represent the sum of volumes contributed by all upstream tributaries, but do not offer any information regarding how each tributary provides to the whole. In this sense, these index curves can provide exceedence frequency targets, in terms of volumes, at mainstem locations for any of the seven synthetic exceedence frequency flood patterns that involve a number of upstream tributaries. During the development process, it was assumed the effects of increased urbanization occurring throughout the period of record were insignificant on the timing of runoff within the watersheds of the Sacramento and San Joaquin rivers. For a further investigation of this assumption, please reference the "Watershed Impact Analysis" done by HEC (USACE, 2002).

The approach formulated and described above was driven entirely by historic flow data. Each year of record included the influence of snowmelt, infiltration, interception, precipitation distribution, timing of runoff, storm development characteristics, and physical basin attributes for that annual rainflood event. Historic flow data records provided a sufficient sample of flood events to characterize hypothetical flood volumes and tributary-system relationships.

No synthetic precipitation events were required. In fact, precipitation never entered into any portion of the methodology.

Design flows and regulated flow-frequency tabular values are shown below in Table 14. The mainstem storm centering for the Sacramento River used for the Sacramento River below Colusa, and the Sutter Bypass is at the latitude of Sacramento. The tributary storm centering for the Feather River below Oroville Dam is centered at Shanghai bend. The frequency curves for the locations of the Sacramento River at Colusa and the Feather River at Shanghai Bend are shown as plates 9 and 10.

TABLE 14. Design Flows and Regulated Flows

Stream & Reach	1957 Authorized Design Flow (CFS)	Regulated Peak Flows (CFS)						
		50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Sacramento River								
Colusa to Tisdale Weir	66,000	44,000	48,000	50,000	53,000	55,000	59,000	68,000
Tisdale Weir to Sutter Bypass	30,000	28,000	30,000	31,000	32,000	34,000	36,000	41,000
Feather River								
Oroville to Honcut Creek	210,000	60,000	100,000	150,000	150,000	150,000	174,000	320,400
Honcut Creek to Yuba River	210,000	49,000	107,000	157,000	159,600	163,000	182,000	293,600
Yuba River to Bear River	300,000	71,000	192,000	256,000	281,000	283,000	360,000	534,000
Bear River to Sutter Bypass	320,000	78,000	211,000	288,000	321,000	336,000	409,000	574,000
Sutter Bypass								
Meridian to Wadsworth Canal	150,000	57,000	102,000	126,000	155,000	184,000	228,000	327,000
Wadsworth Canal to Tisdale Weir	155,000	58,000	103,000	127,000	156,000	185,000	229,000	327,000
Tisdale Weir to Feather River	180,000	71,000	117,000	141,000	163,000	197,000	237,000	329,000
Feather River to Sacramento River	380,000	141,000	283,000	393,000	436,000	490,000	581,000	799,000
Wadsworth Canal								
Tributary Specific Storm Centering	1,500	820	2,550	3,200	3,980	4,830	5,750	7,070
Cherokee Canal								
Nelson Shipee Road to Western Canal	8,500							
Western Canal to Afton Road	11,500	6,000	10,300	12,100	13,200	14,300	15,200	16,300
Afton Road to Gridley – Colusa Road	12,500							

Notes: data pulled from PBI Addendum 1 models which are the final models for the Sutter Basin Feasibility Study.
Design flows obtained from USACE drawing file 50-10-3334. Levee Channel Profiles, dated 15 March 1957.
Peak flow is the higher of the Sacramento or Shanghai Bend storm centering peak flows.
Wadsworth Canal and Cherokee Canal peak flows are from unregulated streams.
Peak flows for the 0.5% and 0.2% ACE flood events include effects from levee overtopping and may be reduced from the possible maximums.

7.3 UNREGULATED FREQUENCY CURVES FOR SACRAMENTO RIVER AT THE LATITUDE OF SACRAMENTO AND ORD FERRY

The unregulated frequency curve for the latitude of Sacramento is a tool that can be used to develop a mainstem storm centering. Mainstem centerings were designed to stress widespread valley areas. Index frequency curves were prepared at Ord Ferry and Sacramento in the Sacramento River Basin. These curves provide the hypothetical volumes that the basin will produce during simulations of each of the seven synthetic exceedence frequency flood events. The role of the mainstem centerings is to distribute these volumes back into the basin, tributary by tributary, in accordance with patterns visible in historic flood events. Once the volume is distributed it will be translated into hydrographs and routed through reservoir simulation models (Appendix C of the Comp Study) to produce the synthetic exceedence frequency regulated hydrographs at the two locations needed to construct floodplains throughout the Sacramento river system.

Mainstem centerings reflect a generalized flood pattern based on a number of historic events. Through the incorporation of multiple floods into one characteristic pattern, relationships between tributaries become more stable and the influence of powerful, but isolated, storm cells are downplayed.

The frequency curve for the latitude of Sacramento is shown as plate 11. Flow frequency curves are generated at a specific location, usually a gage location. However, for a river basin a large as the Sacramento River basin, a synthetic storm centering approach is required to correctly portray the discharge probability at locations away from the storm center. Table 15 below shows the percent chance exceedence for selected locations throughout the Sacramento River basin with a storm center at Ord Ferry, while table 16 shows the percent exceedance for a centering at the latitude of Sacramento. A flow-frequency table computed from the statistics shown in the Ord Ferry frequency curve is shown in Table 17 below, while the flows from the centering at the latitude of Sacramento frequency curve is shown in Table 18 below.

TABLE 15 Sacramento River Mainstem at Latitude of Ord Ferry

Synthetic Flood Centerings for Sacramento River Total Flow at Latitude of Ord Ferry							
Index Point	Percent Chance Exceedence						
	50%	10%	4%	2%	1%	0.50%	0.20%
Sacramento River at Shasta	82.08	16.91	5.71	2.41	1.25	0.65	0.28
Clear Creek at Whiskeytown	61.56	15.04	9.03	5.61	2.92	1.52	0.65
Cow Creek nr Millville	61.56	13.53	8.02	3.89	2.02	1.05	0.45
Cottonwood Creek nr Cottonwood	61.56	15.04	9.03	5.61	2.92	1.52	0.65
Battle Creek below Coleman FH	61.56	13.53	8.02	3.89	2.02	1.05	0.45
Mill Creek near Los Molinos	87.94	15.03	7.22	5.94	3.1	1.61	0.69
Elder Creek near Paskenta	87.94	19.33	12.5	10.1	5.26	2.74	1.17
Thomes Creek at Paskenta	87.94	19.33	12.5	10.1	5.26	2.74	1.17
Deer Creek near Vina	87.94	15.03	7.22	5.94	3.01	1.61	0.69
Big Chico Creek near Chico	87.94	15.03	7.22	5.94	3.01	1.61	0.69
Stony Creek at Black Butte	87.94	19.33	12.5	10.1	5.26	2.74	1.17
Butte Creek near Chico	87.94	15.03	10.2	8.42	4.39	2.28	0.97
Feather River at Oroville	87.94	19.33	9.62	8.42	4.39	2.28	0.97
Yuba River at New Bullards Bar	87.94	19.33	11.76	9.18	4.78	2.49	1.06
Yuba River at Englebright	87.94	19.33	11.76	9.18	4.78	2.49	1.06
Deer Creek near Smartsville	87.94	19.33	11.76	9.18	4.78	2.49	1.06
Bear River near Wheatland	87.94	19.33	12.03	10.1	5.26	2.74	1.17
Cache Creek at Clear Lake	87.94	19.33	18.05	12.63	6.58	3.42	1.46
North Fork Cache Creek at Indian Valley	87.94	19.33	18.05	12.63	6.58	3.42	1.46
American River at Folsom	87.94	19.33	14.29	12.63	6.58	3.42	1.46
Putah Creek at Berryessa	87.94	19.33	18.05	12.63	6.58	3.42	1.46

TABLE 16 Sacramento River Mainstem at Latitude of Sacramento

Synthetic Flood Centerings for Sacramento River Total Flow at Latitude of Sacramento							
Index Point	Percent Chance Exceedence						
	50%	10%	4%	2%	1%	0.50%	0.20%
Sacramento River at Shasta	84.42	17.03	8.09	4.41	2.21	1.13	0.44
Clear Creek at Whiskeytown	80.91	17.03	10.79	6.47	3.24	1.66	0.65
Cow Creek nr Millville	80.91	16.18	9.71	5.39	2.70	1.38	0.60
Cottonwood Creek nr Cottonwood	80.91	17.03	10.79	6.47	3.24	1.66	0.65
Battle Creek below Coleman FH	80.91	16.18	9.71	5.39	2.70	1.38	0.60
Mill Creek near Los Molinos	88.26	16.18	9.71	4.22	2.35	1.23	0.51
Elder Creek near Paskenta	88.26	19.42	10.79	4.85	2.70	1.38	0.58
Thomes Creek at Paskenta	88.26	19.42	10.79	4.85	2.70	1.38	0.58
Deer Creek near Vina	88.26	16.18	9.71	4.22	2.35	1.23	0.51
Big Chico Creek near Chico	88.26	16.18	9.71	4.22	2.35	1.23	0.51
Stony Creek at Black Butte	88.26	19.42	10.79	4.85	2.70	1.38	0.58
Butte Creek near Chico	66.70	13.63	6.08	2.75	1.38	0.71	0.30
Feather River at Oroville	53.60	11.78	4.42	2.41	1.20	0.62	0.24
Yuba River at New Bullards Bar	55.09	12.52	4.86	2.10	1.05	0.54	0.21
Yuba River at Englebright	55.09	12.52	4.86	2.10	1.05	0.54	0.21
Deer Creek near Smartsville	55.12	12.52	4.86	2.10	1.05	0.54	0.21
Bear River near Wheatland	53.60	11.13	4.42	2.10	1.05	0.54	0.21
Cache Creek at Clear Lake	52.19	12.52	6.95	4.45	2.22	1.14	0.45
North Fork Cache Creek at Indian Valley	52.19	12.52	6.95	4.45	2.22	1.14	0.45
American River at Folsom	55.09	12.52	4.86	2.51	1.26	0.64	0.25
Putah Creek at Berryessa	52.19	12.52	6.95	4.45	2.22	1.14	0.45

TABLE 17

Unregulated Flow Frequency for the "Ord Ferry" storm centering							
Avg flow[2](cfs) for given duration and AEP[3]							
1/AEP[3]	2	10	25	50	100	200	500
Duration (days[1])	0.5	0.1	0.04	0.02	0.01	0.005	0.002
1	102,000	234,000	317,000	386,000	460,000	541,000	657,000
3	81,000	184,000	247,000	299,000	354,000	414,000	499,000
7	65,000	145,000	193,000	232,000	272,000	315,000	376,000
15	49,000	103,000	131,000	153,000	174,000	196,000	225,000
30	38,000	76,000	97,000	112,000	127,000	143,000	163,000

TABLE 18

Unregulated Flow Frequency for the "at latitude of Sacramento" storm centering							
Avg flow[2](cfs) for given duration and AEP[3]							
1/AEP[3]	2	10	25	50	100	200	500
Duration (days[1])	0.5	0.1	0.04	0.02	0.01	0.005	0.002
1	157,000	399,000	561,000	700,000	853,000	1,023,000	1,275,000
3	144,000	357,000	498,000	617,000	749,000	894,000	1,108,000
5	132,000	320,000	444,000	547,000	661,000	786,000	969,000
7	122,000	297,000	410,000	506,000	611,000	726,000	894,000
15	97,000	223,000	299,000	361,000	426,000	496,000	595,000
30	76,000	164,000	213,000	252,000	292,000	334,000	390,000

7.4 UNREGULATED FREQUENCY CURVES FOR FEATHER RIVER AT SHANGHAI BEND

7.4.1 Hypothetical Storm Pattern Generation

The intent of this hydrologic analysis is to prepare a hypothetical storm pattern and flood hydrographs that can be fed into reservoir system and hydraulic models for each frequency event (10-, 2-, 1-, and 0.2-percent chance exceedences). In order to define floodplains for this particular reach of the Feather River, synthetic storms centered over this area were developed. The Comprehensive Study includes a number of synthetic storms that produce large floods along the Feather and Yuba rivers, including storms centered at Oroville Dam on the Feather River, Marysville on the Yuba River, and at the Latitude of Sacramento (USACE, 2002). However, none of these storms were centered at locations along the Feather River within this study area. Therefore, hypothetical storms were developed where the most upstream and downstream locations of the study reach (Feather River at Shanghai Bend and the Sacramento River at Latitude of Verona) experience greater intensity than any other location within the Sacramento Valley.

Large floods at Shanghai Bend result from the combination of high flows from both the Yuba River and Upper Feather River. Historically, large events occurring at Shanghai Bend have resulted from rare events occurring on the Upper Feather River (above Oroville) and also on the Yuba River, with one of these rivers having a slightly rarer event than the other. For example, in 1997 a slightly less frequent event occurred at Oroville than on the Yuba River at Marysville, and in 1965 Marysville experienced a less frequent event than Oroville. However, in both of these years, large floods occurred at Shanghai Bend. Because of the possibility that either scenario could happen, two different hypothetical storm patterns were produced. These storm patterns are shown in Tables 19 and 20.

TABLE 19

Feather River Above Shanghai Bend Storm Centering With a Specific Centering on the Yuba River							
Index Point	**Percent Chance Exceedence**						
	50%	**10%**	**4%**	**2%**	**1%**	**0.50%**	**0.20%**
Sacramento R at Shasta	101.01	20.20	8.08	5.77	2.89	1.44	0.58
Clear Cr at Whiskeytown	344.83	68.97	27.59	19.70	9.85	4.93	1.97
Cow Cr nr Millville	196.08	39.22	15.69	11.20	5.60	2.80	1.12
Cottonwood Cr nr Cottonwood	344.83	68.97	27.59	19.70	9.85	4.93	1.97
Battle Cr blw Coleman FH	196.08	39.22	15.69	11.20	5.60	2.80	1.12
Mill Cr nr Los Molinos	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Elder Cr nr Paskenta	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Thomes Cr at Paskenta	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Deer Cr nr Vina	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Big Chico Cr nr Chico	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Stony Cr at Black Butte	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Butte Cr nr Chico	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Feather R. at Oroville	54.95	10.87	4.35	2.17	1.06	0.53	0.21
Yuba R. at New Bullards Bar	50.00	10.00	4.00	2.00	1.00	0.50	0.20
Yuba R nr Marysville	50.00	10.00	4.00	2.00	1.00	0.50	0.20
Deer Cr nr Smartsville	125.00	25.00	10.00	5.00	2.50	1.25	0.50
Bear R nr Wheatland	125.00	25.00	10.00	5.00	2.50	1.25	0.50
Cache Cr at Clear Lake	153.85	30.77	12.31	6.15	3.08	1.54	0.62
Cache Cr at Indian Valley	153.85	30.77	12.31	6.15	3.08	1.54	0.62
American R at Folsom	76.34	15.27	6.11	3.05	1.53	0.76	0.31
Putah Cr at Berryessa	153.85	30.77	12.31	6.15	3.08	1.54	0.62

Note – The seven frequency storms centered at Shanghai Bend and Verona are the bold values located in the column headers. The concurrent frequency values for each index location are given below each column header. For example, a 2.89% chance exceedence event occurs on the Sacramento River above Shasta Dam during the 1% chance exceedence event centered at Shanghai Bend and Verona.

TABLE 20

Unregulated Flow Frequency for Feather River at Shanghai Bend storm centering							
Avg flow[2](cfs) for given duration and AEP[3]							
1/AEP[3]	**2**	**10**	**25**	**50**	**100**	**200**	**500**
Duration (days[1])	**0.5**	**0.1**	**0.04**	**0.02**	**0.01**	**0.005**	**0.002**
0.0416	93,600	282,800	408,900	513,600	626,300	746,900	918,300
1	73,600	222,600	321,800	404,200	492,900	587,900	722,800
3	56,600	172,200	249,400	313,600	382,800	457,000	562,400
7	39,900	115,800	165,200	205,700	249,000	295,000	359,900
15	29,300	77,600	106,100	128,400	151,200	174,600	206,100
30	22,100	54,900	73,600	88,000	102,600	117,300	137,000

There are only subtle differences between these two storm patterns. These differences lie within the index locations on the Feather and Yuba rivers. For storm centering A, exceedence frequency values generated at Shanghai Bend and the Latitude of Verona are the same as the frequency assigned to the Yuba River. However, for storm centering B, the Yuba River experiences a more frequent event, and the Feather River at Oroville is assigned the same exceedence frequency value that is produced at Shanghai Bend and the Latitude of Verona. In other words, storm centering A has more emphasis on the Yuba River, and storm centering B has more emphasis on the Feather River.

In developing these storm centerings, the guidelines for preparation of mainstem centerings developed for the Comprehensive Study were followed (USACE, 2002). Shanghai Bend and the Latitude of Verona are the bull's eyes of the storm. That is, no other location within the Sacramento River Basin experiences a larger flood than at Shanghai Bend and the Latitude of Verona for the seven hypothetical storms (10-, 2-, 1-, and 0.2- percent chance exceedences). First, the distribution of storm intensity for the Upper Feather and Yuba River basins was developed. Initial exceedence frequency values were assigned to the Yuba River and Feather River index locations. Hydrographs were then constructed at these tributary locations and routed through the system to Shanghai Bend. Duration maxima (peak, 1-, 3-, 7-, 15-, and 30-day) were computed for the hydrographs at Shanghai Bend and compared with the average flows from the frequency curves. The initial pattern was then increased or decreased and the comparison process was repeated until results agreed reasonably with the unregulated rain flood frequency curves.

Once this portion of the pattern was set, the same process was followed for the Latitude of Verona index location. The storm pattern for the rest of the tributary index locations were based upon the average of the Feather and Yuba River storm centerings generated for the Comprehensive Study [#]. This pattern was iteratively adjusted by a fixed percentage until the duration maxima (1-, 3-, 7-, 15-, and 30-day) computed at the Latitude of Verona agreed reasonably with the unregulated rain flood frequency curve at this index location.

The frequency curves used in this process were obtained from the Comprehensive Study (USACE, 2002), except for the Shanghai Bend unregulated flow frequency curve. This curve was adopted from the 1999 FEMA report entitled, "Rain Flood Flow Frequency Analysis, Feather and Yuba Rivers" (USACE, 2002). No adjustments were made to any of the frequency curves except for the peak curve for Shanghai Bend. According to Robert Collins, District Hydrologist, the peak mean for the unregulated flow frequency curve at Shanghai Bend was proportioned based on the relationship of the peak and 1-day means at Oroville, since no peak unregulated data at Shanghai Bend was available. The frequency curve for the Feather River at Shanghai Bend with the modified statistics is presented in Plate 12.

It was determined through a comparison of stages from hydraulic models using as input the hydrology from the various storm centerings that the Feather-Yuba storm centering at Shanghai Bend and the mainstem storm centering at the latitude of Sacramento produced the highest stages. Therefore only those two storm centerings were kept for the analysis of Sutter basin flood risk management.

7.5 UNREGULATED FREQUENCY CURVES FOR CHEROKEE CANAL AT RICHVALE

7.5.1 Purpose:

The hydrology presented in this hydrology appendix for the Butte County portion of the Sutter Basin focuses on the Cherokee Canal, which is a potential source of flooding in the northern portion of the feasibility study area. The hydrology includes the development of flood frequency estimates and 30-day balanced hydrographs for the n-year (50-, 20-, 10-, 4.0-, 2.0-, 1.0-, 0.5-, and 0.2-) percent chance synthetic flood events on the Cherokee Canal from Cottonwood Creek to Afton Road.

7.5.2 Study Area:

The Cherokee Canal, located in Butte County, is tributary to Butte Creek. The Cherokee Canal watershed includes the total drainage above the Cherokee Canal, an artificial channel that flows southwesterly to lower Butte Creek. The watershed is bounded by the Feather River watershed to the east and southeast, by Butte Creek and its tributaries to the north and west, and by Wadsworth Canal drainage to the south. The three primary tributaries to Cherokee Canal are Dry Creek, which, with its tributary, Clear Creek, flows out of the Sierra Nevada foothills, and Cottonwood and Gold Run creeks, which flow west from Table Mountain.

The Cherokee Canal drainage area covers approximately 94 square miles. Its elevation varies from about 70 feet on the Cherokee Canal to about 2,200 feet in the headwaters of Dry Creek. The most heavily urbanized area in the watershed is the incorporated city of Paradise, where the headwaters of Dry and Clear creeks are located. Land use on the valley floor is mostly agricultural, with rice fields predominating. Native vegetation covers the foothills. Plate 14, the general map, shows the boundaries of the upper Cherokee Watershed and the Cherokee Canal watercourse from the headwaters down to the confluence with Butte Creek. Plate 15 shows the area's topography and a more detailed map of the upper Cherokee Canal drainage.

7.5.3. Background:

Between 1959 and 1960 the Corps of Engineers constructed the Cherokee Canal flood control project from Butte Sink up to Dry Creek. The Federal Flood Control Act of 1944 authorized the construction of the Cherokee Canal as part of several flood control projects on Sacramento River tributaries. The objectives of the Cherokee Canal flood control project were to provide flood protection and to control inflow of sediment into the canal. According to the Cherokee Canal Design Memorandum, dated 15 November 1958, the Cherokee Canal Levee Project included levee construction and channel improvement on the Cherokee Canal and its principal tributaries. The project, as designed, would provide flood protection to 22,000 acres of improved agricultural land, highways, railroads, and irrigation canals. The project begins at the Lower Butte Basin and runs northeasterly to high ground about 13 miles north of Biggs, for a total distance of approximately 22 miles. The design capacity for Cherokee Canal was 8,500 cfs from the upstream end of the canal down to the confluence with Cottonwood Creek, 11,500 cfs from Cottonwood Creek down to Afton Road (the Biggs Princeton Highway), and 12,500 cfs from

Afton Road to the downstream end of the canal. The design capacity reaches are identified on Plate 15.

7.5.4. Stream Gage and Recent Flood History:

A streamflow gaging station was established on the Cherokee Canal at Butte City Road Bridge (State Highway 162). The General Map, Plate 14, shows the location of this streamflow gage, "Cherokee Canal near Richvale," California DWR station A02984. Records for this station have been collected from water year 1961 to present. Flow and stage records are available back to 1976 on the Department of Water Resources Water Data Library website(DWR, 2010). Table 21 lists the five highest flows of record for the Cherokee Canal gaging station. See Section 6.3 for information on the October 1962 high flow event and Section 7.1 for information on other high flow events on the Cherokee Canal.

Table 21

Tabulation of High Peak Flows For Cherokee Canal Gage (DWR Station A02984)	
Peak Flow (cfs)	Date
15,200	13-Oct-62
11,000	13-Jan-69
10,000	11-Mar-89
9,750	21-Jan-64
9,460	24-Dec-83

During the first ten years of the project, several high flows reached or exceeded warning stage at the gage. The high flows deposited sediment from the upstream mining debris in the canal; brush and willows growing in the canal fixed the sediment deposits in place.

On 11 March 1989, a levee break occurred on the left bank of Cherokee Canal just upstream of Nelson-Shippee Road Bridge. The break was caused by overtopping, due to backwater from debris blocking the bridge opening. Design capacity of the canal at this location was 8,500 cfs. Apparently, the levee break resulted from an overnight flood on 11 March that carried enough debris to block the bridge opening and produce a peak flow of 10,000 cfs downstream at the Richvale gage. [#]

During the January 1995 flood, a waterside levee slip occurred on the left levee of Cherokee Canal about 300 feet north of State Highway 162, the location of the "near Richvale" gaging station (Plate 15). The slip was covered with sandbags and plastic to prevent levee failure, which would have flooded several farm houses and the USDA Rice Experimental Station 9USACE, 1995). The observed peak flow at the gage for this event was 8,220 cfs.

The Department of Water Resources removed sediment from various reaches of the Cherokee Canal in 1988, 1989, 1990, and 1996. Occasional high flows down Dry Creek continue to deposit sediment in the Cherokee Canal. Sediment accumulation and vegetation in the canal have reduced its channel capacity such that at some locations the Cherokee Canal channel capacity has been reduced between 37 percent and 44 percent of the original 11,500 cfs design capacity [#].

7.5.5 Hydraulic Analysis – General:

The hydrologic analysis in this appendix uses a hypothetical flood pattern to compute balanced flood hydrographs for an 8-flood synthetic series (50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2% event floods), which will be used in a hydraulic routing model along a critical reach of the Cherokee Canal for a levee break analysis. This critical reach of the canal extends from the Western Canal Levee, at the confluence of Cottonwood Creek, down to the Biggs Extension, about a mile upstream of the Richvale gaging station. The reach is being analyzed to test for a potential left bank levee break that could cause flooding in the town of Biggs to the south. The analysis also includes a test of response time needed to repair a breach in the levee. If the levee is not repaired in a timely manner, later flood waves could increase the flooding to the south. For that reason, the synthetic flood series is 30 days in duration. Hydrographs at the Richvale gaging station are equivalent to those for the critical levee reach as well as for the Cherokee Canal down to Afton Road, the lower end of the hydraulic model. Plate 15 shows the extent of the Cherokee Canal hydraulic model, from Afton Road up to the downstream end of Cottonwood Creek.

7.5.6 Flow Frequency Analysis:

The streamflow gage, Cherokee Canal near Richvale (DWR gage A02984) currently has 46 years of record available, from 1961 to 2006. More recent gaged data are still preliminary. The gage is located at Butte City Road Bridge, 2.1 miles south of Richvale. Flows at the gage are similar to those along the Cherokee Canal reach being analyzed upstream, from the Cottonwood Creek confluence to the Biggs Extension canal. No additional flow enters the canal downstream of the Cottonwood Creek confluence. Daily flows at the gage are available for the period of record; hourly flows are available for water years 1982 to 2006, as well as for the floods of October 1962, January 1964, December 1964, January 1965, and January 1969. DWR Northern District provided a table of annual peak flows for the period of record. Data for the Cherokee Canal near Richvale gage are from (USACE, 2002).

7.5.7 Results and Conclusions:

The unregulated flow frequency of the Cherokee Canal at Richvale is presented in Table 18 below, and on plate 16 at the end of the report. Table 22 lists the peak, and volume flows for the 8-flood series from the flow frequency curves. Plate 17 shows a graphical representation of the 5-day waves for the 8-flood series hydrographs. For this study, it was assumed that the peak flows listed in Table 18 are able to remain in-channel down the Cherokee Canal.

TABLE 22

Peak and Duration Flow Rates for the Synthetic 8-Flood Series Hydrographs							
Percent Exceedence Flood Event	Peak Flow (cfs)	1-Day Flow (cfs)	3-Day Flow (cfs)	5-Day Flow (cfs)	10-Day Flow (cfs)	15-Day Flow (cfs)	30-Day Flow (cfs)
50%	5,900	3,040	1,960	1,540	1,070	869	600
20%	8,700	4,460	2,860	2,260	1,570	1,270	879
10%	10,300	5,280	3,390	2,670	1,860	1,510	1,040
4%	12,100	6,190	3,980	3,130	2,180	1,770	1,220
2%	13,200	6,870	4,360	3,430	2,390	1,940	1,340
1%	14,300	7,310	4,700	3,700	2,580	2,090	1,440
0.50%	15,200	7,780	5,000	3,940	2,750	2,220	1,540
0.20%	16,300	8,340	5,360	4,220	2,950	2,380	1,650

7.5.8. Hydrologic Uncertainty:

EM 1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies," (USACE, 1996), requires use of risk and uncertainty procedures in the evaluation of flood damage reduction studies. An unbroken record of 46 years of stream gage data (1961 to 2006) is available for the DWR station Cherokee Canal near Richvale (DWR gage A02984) that fits a known statistical distribution such as log Pearson III. Based on a review of the flow record and methodology, it is recommended that the systematic record length of 46 years be used as the equivalent record length in the analysis of project performance. The final statistics associated with this record length for the Cherokee Canal near Richvale are:

Mean (Log) = 3.7484
Adopted Standard Deviation = 0.224
Adopted Skew = -0.7

7.6 UNREGULATED FREQUENCY CURVES FOR WADSWORTH CANAL

Wadsworth Canal is an artificial channel that carries rainy season and agricultural runoff from the northeast part of Sutter County south to the Sutter Bypass. The drainage area covers the eastern slopes of the Sutter Buttes, northeastern Sutter County north of the East and West Interceptor canals, and a portion of southern Butte County west of Feather River. The tributaries contributing to Wadsworth Canal are: the West Interceptor Canal and its tributary, Sutter City Lateral; and the East Interceptor Canal with its tributaries (from east to west): Live Oak Slough, RD 777 Lateral 1, Snake River with its tributary, Morrison Slough, and Sand Creek. The drainage area, primarily agricultural, covers about 91 square miles.

The elevation varies from about 54 feet at the upper end of Wadsworth Canal to over 2100 feet on South Butte, the headwaters of the West Interceptor Canal drainage. Aside from Sutter Buttes, the topography of the Wadsworth drainage is relatively flat. The channel capacity of

Wadsworth Canal is 1,500 cfs. During a period of high runoff, the water fills Wadsworth Canal to capacity, then ponds behind the interceptor canals until there is room in Wadsworth Canal to accommodate the ponded water.

The California Department of Water Resources operates two stage gages on Wadsworth Canal:

A0-5927 Wadsworth Canal Near Sutter, Lower Station, and
A0-5929 Wadsworth Canal Near Sutter, Upper Station.

At times, backwater from the Sutter Bypass affects the stage-discharge relationship.

The Wadsworth unregulated frequency curve was developed based on DWR gage A05929, Wadsworth Canal Upper gage. The period of record is 01Oct1939 to 30Sep1996. Annual 1-day maximum flows are available for WY 1939 to WY 1974. Daily data is available from 01Oct1975 to 30Sep1996. The gage was discontinued after WY 1996. A table of peak unregulated flows and volumes for the Wadsworth Canal is shown below in table 23. The flow-frequency curve is shown on plate 18.

TABLE 23

Unregulated Flow at the Wadsworth Canal Upper Gage								
1/AEP	2	5	10	25	50	100	200	500
Duration (days)	0.5	0.2	0.1	0.04	0.02	0.01	0.005	0.002
Peak	817	1,607	2,254	3,197	3,983	4,833	5,750	7,067
1	743	1,390	1,874	2,523	3,024	3,533	4,049	4,740
3	592	1,122	1,522	2,062	2,480	2,906	3,340	3,923
7	455	853	1,151	1,551	1,860	2,173	2,492	2,919
10	400	741	994	1,332	1,591	1,853	2,119	2,474
30	249	434	566	738	867	995	1,124	1,293

7.7 VERIFICATION OF UNREGULATED FLOWS AT INFLOW AND HANDOFF POINTS FOR HYDRAULIC ROUTING

7.7.1. PURPOSE

The purpose of this section is to specify flow hydrographs for use as Sutter Basin Feasibility Study hydraulic model boundary conditions. The Sutter Basin Study Area and hydraulic model hydrologic boundary conditions are illustrated in Plate 19.

7.72. BACKGROUND

A system wide hydrology study of the Sacramento San Joaquin basin was completed in 2002. The study, titled Sacramento San Joaquin Comprehensive Study formed the basis of multiple flood risk management studies throughout the Sacramento and San Joaquin Basins. Several of these studies completed refinements to the hydrologic modeling. Hydrology for the Sutter Basin Feasibility Study is based on the latest hydrologic studies.

7.73. SUTTER BASIN FEASIBILITY STUDY HYDRAULIC MODEL

The Sutter Basin Study Area and HEC-RAS hydraulic model domain are illustrated in the attached Plate 19. The HEC-RAS model is a 1-dimensional unsteady model. The model includes 16 inflow type boundary locations which require hydrograph inputs for 1/2, 1/10, 1/25, 1/50, 1/100, 1/200, and 1/500 AEP flood event simulations.

Due to the size of the tributary area, the hydraulic model is run for two different hydrologic storm-centerings to determine the critical scenario (peak stage and/or flow) at internal model locations. The Sacramento (SAC) storm centering represents a storm centered over the upper Sacramento River watershed with lesser concurrent rainfall/runoff from the Feather/Yuba watershed. The Shanghai Storm Centering (SHY) represents a storm centered over the Feather/Yuba river watershed with lesser concurrent rainfall/runoff from the Sacramento River Basin. Analysis of each storm-centering requires a complete suite of hydrographs (16) for the model boundary conditions. A detailed description of the storm centering procedure is described in the 2002 Comprehensive Study technical documentation (USACE, 2002). The selection of the Sacramento and Shanghai storm centerings from the 25 storm centerings evaluated in the comprehensive study is described in a memorandum for file dated 10 December 2010.

7.74. HYDROGRAPHS

A single DSS file with hydrographs for each of the model boundary locations was provided as a digital attachment as HEC-DSS filename “Sutter_FS_Hydrographs.dss”. Tables are provided in the memorandum to describe the refinements made to the boundary conditions used during plan formulation of conceptual and preliminary alternatives.

A tabulation of the period of record and the peak unregulated flows within the study reaches is shown in table 24. The plates following the references of this report show the frequency curves and notes pertaining to the frequency curve creation.

TABLE 24

Period of Record and Peak Un-Regulated Flows								
Stream and Reach	Period of Record	Un-Regulated Peak Flows (cfs)						
		1/2	1/10	1/25	1/50	1/100	1/200	1/500
		0.5	0.1	0.04	0.02	0.01	0.005	0.002
Sacramento River								
Colusa to Tisdale Weir	76	111,000	257,000	328,000	406,000	484,000	566,000	681,000
Tisdale Weir to Sutter Bypass	76	169,000	423,000	625,000	756,000	928,000	1,143,000	1,360,000
Feather River								
Oroville to Honcut Creek	94	47,000	136,000	201,000	253,000	311,000	374,000	464,000
Honcut Creek to Yuba River	94	51,000	144,000	211,000	267,000	328,000	394,000	489,000
Yuba River to Bear River	94	84,000	250,000	365,000	459,000	561,000	670,000	827,000
Bear River to Sutter Bypass	94	90,000	265,000	391,000	491,000	599,000	714,000	878,000
Sutter Bypass								
Butte Slough to Wadworth Canal	76	56,700	101,300	126,300	254,800	182,400	225,400	327,400
Wadsworth Canal to Tisdale Weir	76	57,400	103,200	128,900	157,800	186,000	229,400	332,100
Tisdale Weir to Feather River	76	101,200	259,400	342,200	429,100	516,900	607,800	1,215,200
Feather River to Sacramento River	76	169,100	422,600	624,900	755,800	928,200	1,143,400	1,359,700
Wadsworth Canal								
East - West Interceptor to Sutter Bypass								
Concurrent with Sacramento Storm Centering	56	420	1,240	1,300	1,480	1,520	1,550	1,600
Tributary Specific Storm Centering	56	820	2,550	3,200	3,980	4,830	5,750	7,070
Cherokee Canal								
Nelson Shipee Road to Western Canal	-							
Western Canal to Afton Road	46	6,000	10,300	12,100	13,200	14,300	15,200	16,300
Afton Road to Gridley-Colusa Road	-							

Note: Peak un-regulated flows include the effects of headwater reservoir regulation
Note: Peak Un-Regulated flows are the higher of the Sacramento or Shang Shanghai Bend Storm Centerings
Note: The period of record is used in HEC-FDA to establish the confidence limits for the unregulated and regulated flows. The period of record shown above was taken from the unregulated flow-frequency curves that are shown as plates following the references in this report.

8. Reservoir Simulation Model (HEC-5) Routing

The Hydrologic Engineering Center's HEC-5 software (Simulation of Flood Control and Conservation Systems), Version 8.0 (USACE, 1998), was used to route the synthetic tributary flood hydrographs through the reservoir system on the Sacramento River - Basin for analysis of floodplain and channel hydraulics. The Reservoir Simulation Model User's Guide, (USACE, 2003), documents the reservoir model assumptions and methodology for routing the flood hydrographs through two reservoir system models, the headwater reservoirs model, and the lower basin reservoirs model. The reservoir system models routed tributary flows for the entire Sacramento basin; however, the only hydrographs needed for this study are those upstream of and at Hamilton City. The synthetic unregulated hydrographs constructed for Shasta Dam and Valley tributary locations from the Hamilton City flood centering series were input to the reservoir system models to simulate regulated hydrographs at mains tern points on the Sacramento River, including Hamilton City. The Shasta Dam hydrographs were routed through the HEC-5 headwater reservoirs model, to simulate results from regulation by reservoirs upstream of Shasta Dam for the synthetic flood series. The headwater reservoirs are listed on Table 20, and their relative locations shown in the schematic on Plate 20. The simulated regulated inflow hydrographs to Lake Shasta and the downstream tributary hydrographs were then input to the lower basins reservoir model. The schematic on Plate 21 shows the relationship of the reservoirs and the east- and westside tributaries downstream on the Sacramento River.

TABLE 25

LIST OF RESERVOIRS IN THE SACRAMENTO RIVER BASIN ABOVE ORD FERRY						
Reservoir	**Drainage**	**Owner**	**Gross Pool Storage (ac-ft)**	**Drainage Area (sq.mi.)**	**Began Operation**	**Purpose**
Britton (Pit No. 3)	Pit River	Pac Gas & Electric Co	34,600	4700	1925	Water Supply & Hydropower
Pit No.6	Pit River	Pac Gas & Electiic Co	15,700	5020	1905	Water Supply & Hydropower
Pit No. 7	Pit River	Pac Gas & Electric Co	34,000	5170	1965	Water Supply & Hydropower
McCloud	McCloud River	Pac Gas & Electric Co	35,300	380	1965	Hydropower
Shasta	Sacramento, McCloud & Pit.	US Bureau of Reclamation	4,552,000	6665	1945	Flood Management
Whiskeytown	Clear Creek	US Bureau of Reclamation	241,100	201	1963	Water Supply
East Park	Little Stony Creek	US Bureau of Reclamation	51,000	102	1910	Water Supply
Stony Gorge	Stony Creek	US Bureau of Reclamation	50,350	735	1928	Water Supply
Black Butte	Stony Creek	USACE	143,700	741	1963	Flood Management

Modeled Reservoirs in the Feather and Yuba River Basins				
Reservoir	**Tributary**	**Owner**	**Storage Capacity (ac-ft)**	**Drainage Area (sq mi)**
Feather River				
Mountain Meadows	Hamilton Creek	PGE	24,800	158
Almanor	NFk Feather Creek	PGE	1,308,000	503
Butt Valley	Butte Creek	PGE	49,800	86.2
Antelope	Indian Creek	DWR	22,566	71
Bucks Lake	Bucks Creek	PGE	103,000	29.5
Frenchman	Last Chance Creek	DWR	55,477	82
Lake Davis	Big Grizzly Creek	DWR	83,000	44
Little Grass Valley	SFk Feather River	OWID	93,010	27.3
Sly Creek	Lost Creek	OWID	65,050	23.9
Oroville	Feather River	DWR	3,538,000	3,611
Yuba above Marysville				
New Bullards Bar	NFk Yuba River	YCWA	960,000	489
Jackson Meadows	MFk Yuba River	NID	52,500	37.11
Bowman	Canyon Creek	NID	64,000	28.91
Fordyce	Fordyce Creek	PGE	48,900	30
Spaulding	SFk Jackson Creek	PGE	74,773	118
Scotts Flat	Deer Creek	NID	49,000	20
Merle Collins	Dry Creek	BVID	57,000	72.3

TABLE 26

Oroville Release Schedule		
Actual or Forecasted Inflow (Whichever is Greater) (cfs)	Flood Control Space Used (acre-ft)	Required Releases (cfs)
0 – 15,000	0 – 5,000	Power demand
0 – 15,000	Greater than 5,000	Inflow
15,000 – 30,000	0 – 30,000	Lesser of 15,000 or maximum inflow
0 – 30,000	Greater than 30,000	Maximum inflow for flood
30,000 – 120,000	N/A	Lesser of maximum inflow or 60,000
120,000 – 175,000	N/A	Lesser of maximum inflow or 100,000
Greater than 175,000	N/A	Lesser of maximum inflow or 150,000

TABLE 27

New Bullards Bar Release Schedule		
Actual Inflow (cfs)	Flood Control Space Used (ac-ft)	Required Releases (cfs)
0 – 50,000	0 – 170,000	Inflow
50,000 – 120,000	0 – 170,000	Inflow
Greater than 120,000	0 – 170,000	Inflow up to 180,000
Note – Emergency spillway release diagram used when the combination of the rate of rise and pool elevation dictate.		

TABLE 28

Downstream Flow Target Reductions			
Reservoir (cfs)	Downstream Location (cfs)	Target Flow	Reduced Target Flow
Oroville	Yuba City	180,000	174,000
	Below Yuba R. Confluence	300,000	280,000
	Below Bear R. Confluence	320,000	312,000
New Bullards Bar	Marysville	120,000/180,000	106,000/154,000

9. RESERVOIR OPERATIONS MODELING (HEC-ResSim)

Methodology

Reservoir routing for the Feather River system was accomplished using both HEC-5 and the ResSim modeling package produced by the Hydrologic Engineering Center (USACE, 2007). HEC-5 models were constructed for the entire Sacramento River Basin for the Comprehensive Study. A ResSim model for the Feather-Yuba system has been completed by HEC. The spatial extent of this model is shown in Plate 22. ResSim was used to model the Feather River system from Oroville down to Nicolaus. The Comprehensive Study HEC-5 model was used to model the Sacramento River system down to the confluence with the Feather River (Verona). Output hydrographs from both of these models were used as input into the hydraulic models which cover the majority of the main river system (Feather and Sacramento rivers). Hydrograph input locations to the hydraulic model include:

- Feather River below Oroville Dam
- Honcut Creek
- Yuba River at Englebright
- Deer Creek on the Yuba River
- Dry Creek on the Yuba River
- Bear River at Wheatland
- Dry Creek on the Bear River
- Sacramento River at Vina Bridge
- Big Chico Creek
- Stony Creek
- Butte Creek
- Cache Creek
- Putah Creek

The intent of the HEC-5 to ResSim model conversion was to replicate the results of the Comprehensive Study HEC-5 models using ResSim; therefore, all hydrologic routing parameters and methods, starting storage assumptions, and operational rules found in the Comprehensive Study HEC-5 models were incorporated into the ResSim model. All of the reservoirs included in both the headwater and lower basin Comprehensive Study HEC-5 models for the Feather and Yuba River basins are included in this ResSim model (see Table 25 for a complete listing of these reservoirs).

Model Changes

A number of modifications were made to the ResSim model delivered to the Sacramento District by HEC prior to use in the Lower Feather Floodplain Mapping Study. The Comprehensive Study starting storage assumptions for the headwater reservoirs listed in Table 20 were based on the average reservoir storages prior to the December-January 1997, March 1995, and February 1986 flood events. In a floodplain mapping study, storage capability below the normal pool elevation of dams operated primarily for purposes other than flood control should not be considered because the availability of

such storage is uncertain. Therefore, the storages for all but two of the headwater reservoirs were set to gross pool. The storage for both Bucks Lake and Lake Almanor has never exceeded gross pool. Therefore, the maximum storage that has occurred at the lakes for months of December-March was used as the starting storage.
Slight modifications were also made to the ramp-up criteria scripted for Oroville. The Water Control Plan for Oroville specifies a release schedule that is a function of both flood spaced used and actual/forecasted inflow (Table 26).

The original ResSim model developed by HEC did not incorporate the forecasted inflow component of this release schedule. For example, releases would be restricted to 60,000 cfs until an actual inflow exceeded 120,000 cfs. At this time releases would begin to ramp up to the next specified flow value in the schedule (100,000 cfs for this example). In reality, releases would begin to ramp up to 100,000 cfs much earlier than this if a forecasted inflow greater than 120,000 cfs was known. All events greater than the 10% flood have peak flows greater than the largest value in the release schedule (175,000 cfs); so, for these events, Oroville releases were modeled to allow releases to ramp up freely to the maximum objective flow of 150,000 cfs at a rate of 5,000 cfs per hour. This situation is better understood by reviewing tables 26, 27 and 28 above.

Another change to the ResSim model involved travel times. Total travel time from Oroville Dam down to Yuba City was increased from 8 hours to 16 hours, which is consistent with the published travel times used by the Department of Water Resources and is in better agreement with what has been observed.

Lastly, changes were made to the model to incorporate a forecast uncertainty component to the local flow. The original models assumed complete certainty in local flow contributions downstream of a reservoir. This assumption yields high operational efficiency when operating for downstream flow criteria. In reality, however, local flow contributions could be greater or less than what was forecasted. Because of the possibility that local flows could be more than what is forecasted, reservoir releases are typically less than what the calculated releases would be based on the forecasted information. The magnitude of forecast uncertainty can vary from basin to basin and also from storm to storm. The Corps standard is to incorporate a 20% uncertainty in local flow contributions when operating for downstream flow targets. This uncertainty percentage was modeled in ResSim by reducing all downstream flow targets by 20% of the local flow contributing to that specific location. These modifications are listed in Table 28.

Model runs were also simulated assuming complete certainty in local flow contributions for all frequency events. Results from both scenarios were compared for each flood event. The scenario producing the larger of the two flows was selected for the hydraulic analysis. Generally, the complete certainty scenario was selected for events in which the reservoirs were able to satisfy downstream flow criteria, and the 20% uncertainty scenario was selected for those events in which the downstream flow criteria were exceeded.

RESULTS

Discussion of results will focus on the area in which the synthetic storms are centered, the Feather-Yuba system, even though the spatial extent of the storms covered the entire Sacramento River Basin.

Yuba River Basin

Seven reservoirs were modeled within the Yuba River Basin. New Bullards Bar, located on the North Fork of the Yuba River, is the only reservoir that has dedicated flood space. New Bullards Bar, which contains 170,000 acre-feet of flood space, operates to flow targets at Marysville. The flow criteria at Marysville is 180,000 cfs except when the Feather River is experiencing high flows. When the flows in the Feather River upstream of the Yuba River confluence are high, the flow target at Marysville is reduced to 120,000 cfs. This adjustment is made to assure that 300,000 cfs is not exceeded at the confluence of the Yuba River with the Feather River. New Bullards Bar is able to maintain its objective flow of 50,000 cfs for all events through the 2-percent chance exceedence event. For events larger than the 2-percent chance exceedence event, New Bullards Bar outflow exceeds 50,000 cfs. However, the 300,000 cfs flow target at the confluence is still met for the 1-percent chance exceedence event. See Table 29 for a summary of peak flows.

TABLE 29

Effects of Headwater Regulation

Location	Annual Percent Chance Exceedence	Unregulated Peak Flow (cfs)	Regulated Peak Flow (cfs)	% Peak Reduction Due to Regulation
MF + SF of Yuba	10%	38,800	34,100	12.2
	2%	76,400	68,500	10.3
	1%	96,200	87,300	9.3
	0.2%	149,200	137,000	8.2
Deer Creek	10%	4,900	4,600	5.9
	2%	8,700	8,200	5.9
	1%	10,100	9,500	5.9
	0.2%	13,000	12,400	4.9
Dry Creek	10%	4,900	4,600	5.9
	2%	8,700	8,200	5.9
	1%	10,100	9,500	5.9
	0.2%	13,000	11,600	10.9
Oroville Inflow	10%	153,700	135,900	11.6
	2%	284,100	253,100	10.9
	1%	349,600	311,500	10.9
	0.2%	520,300	464,600	10.7

Notes:
% Peak Reduced = ((Maximum Unregulated Inflow)-(Maximum Regulated Inflow))/(Maximum Unregulated Inflow) X 100%
Values are from model simulations of the Feather River Storm Centering A

TABLE 30

Regulated Peak Flows by Hydrologic Routing					
% Chance Exceedance	Feather R. at Oroville	North Yuba R. at New Bullards Bar Dam	Yuba R. at Marysville	Feather R. at Shanghai Bend	Feather R. At Nicolaus
10	100,000	44,400	92,400	200,000	219,000
2	150,000	50,000	150,000	293,000	323,000
1	150,000	66,100	155,000	296,000	323,000
0.2	327,000	150,000	313,000	607,000	668,000

Note - Values at downstream locations are a result of Muskingum hydrologic routing which assumes infinite channel capacity and neglects backwater effects and channel geometry. Hydraulic model output will differ from these results.

The other six reservoirs modeled in the Yuba Basin, known as headwater reservoirs, are much smaller and do not have any dedicated flood space. Even though the model simulations began with the majority of the reservoirs at gross pool, effects of peak attenuation for many locations along the Yuba River was still evident due to surcharge effects (Table 27). Average peak flows along the Middle and South forks of the Yuba River were attenuated by 8.8% for the 1-, 0.5-, and 0.2-percent chance exceedence events.

Feather River Basin

A total of 9 headwater reservoirs were modeled in the watershed above Oroville. Only 20% of the natural flow hydrograph at Oroville was routed through these headwater reservoirs. However, these reservoirs still had a significant impact on attenuating flows into Oroville (Table 27). Average peak inflows to Oroville were reduced by 10.8% for the 1-, 0.5-, and 0.2-percent chance exceedence events.

Oroville Reservoir has a maximum flood space reservation of 750,000 acre-feet, and is required to maintain flow targets at multiple downstream locations. It is also required to maintain flows at or below 180,000 cfs above the Yuba River confluence, 300,000 cfs below the Yuba River confluence, and 320,000 cfs below the Bear River confluence. These criteria were met for all events except the 0.5% chance exceedence event. In these two events releases specified by the Emergency Spillway Release Diagram (ESRD) were triggered. See Table 28 for a summary of peak flow results.

10.0 BEAR RIVER MODEL

10.1 Purpose of Study

The hydrologic analysis described in this section is for the Bear River (a tributary to the Feather River in Northern California). The hydrology developed in this report will be used to support the Sutter Basin feasibility study on the Bear River mainstem and its lower tributaries including Yankee Slough, UP Intercept Canal, and Dry Creek.

10.2 Scope of Study

This study covers the unincorporated areas of Sutter and Yuba Counties, California within the Bear River Watershed. A detailed map of the study area is shown on Plate 26. Products derived include the 10-, 2.0-, 1.0-, and 0.2-percent chance exceedence flood hydrographs for the Bear River at Wheatland, Yankee Slough at Swetzer Road, UP intercept canal at Plumas Lake and Dry Creek at the Best Slough split and Jasper Lane. The above index points coincide with the upstream end of the levees on each stream. Determining interior runoff behind the levees was not within the scope of this hydrologic analysis.

10.3 Basin Description and Reservoir Regulation

The Bear River Basin is located on the western slope of the Sierra Nevada Mountains. The basin is bounded on the north by the Yuba River Basin and has its confluence with the Feather River about 15 miles south of Marysville. The Bear River drains approximately 550 square miles of mountain, foothill, and valley areas. Elevation varies from 6,000 feet to 60 feet above sea level. A topographic map is shown on Plate 27.

Vegetation at the uppermost elevations, where high mean annual rainfall occurs, is covered with dense forest. Much of the Bear River watershed above Wheatland consists of rolling hills vegetated by grass and oak trees. Grazing is the main use for this land. The Dry Creek watershed consists mainly of rolling hills used for grazing or pasture. Beale Air Force Base, located in the middle of the Dry Creek watershed, is urbanized but only constitutes a small percentage of the total land use. The UP Intercept watershed consists of a mix of pasture, irrigated cropland (including rice farming), and urban areas. The main land-use in the Yankee Slough watershed is irrigated cropland.

There are three major reservoirs on the Bear River. New Camp Far West, constructed in 1963, is the most downstream reservoir, has a drainage area of 283 square miles, and is located in the low foothills. The dam is operated by South Sutter Water District for power, irrigation, and recreation. It has a 300 foot long ungated spillway and storage capacity is 104,000 acre-feet. The next reservoir is located 18 miles upstream at Lake Combie. This reservoir is relatively small and only has about 5,000 acre-feet of storage capacity. Rollins Reservoir is the uppermost major reservoir in the watershed, was completed in 1965, and drains the uppermost 104 square miles of the watershed. It has a 300 foot long ungated spillway and a storage capacity of 66,000 acre-feet. This dam is operated by the Nevada Irrigation District. All three reservoirs are operated to fill and spill as early in the rain season as possible; therefore, the only flood control provided is for early season storms that occur while the reservoirs are filling and surcharge storage during spillway flow. The Comprehensive Study in 2001 modeled the Bear River watershed with an HEC-5 Reservoir Model that included Camp Far West and Rollins Dams. Lake Combie was not modeled since storage capacity is minimal. The Comprehensive Study HEC-5 model of the watershed indicates that the reservoirs attenuate the natural peak flow at Bear River at Wheatland

by about 11% during the 1% chance exceedence event. This attenuation is due to reservoir surcharge during uncontrolled spillway flow.

10.4 Principal Flood Problems

General rainstorms cause flooding on the mainstem of the Bear River and the larger local tributaries. Due to the relatively low elevation of most of the watershed, snowmelt runoff in the spring does not cause flooding. Localized cloudburst storms would only cause high flows on the smaller drainage basins such as the Linda-Olivehurst area and Yankee Slough. Some melting of the snowpack does occur during general rainstorms such as the January 1997 flood event.

10.5 Flood Protection Measures

Levees have been built along Bear River, Yankee Slough, Dry Creek, Best Slough and the UP Intercept Canal. Except for one reach on upper Yankee Slough (right bank), these levees are part of the Sacramento Flood Control Project. They are maintained by local reclamation districts. The three major upstream reservoirs on the Bear River only provide incidental storage that helps to attenuate the peak of major flood events or store floodwater early in the season before the reservoirs have filled.

10.6 Study Results of Hydrologic Analysis

Peak flood discharges for the 10-, 2.0-, 1.0-, and 0.2-percent chance exceedence events were obtained by using a HEC-HMS (USACE, 2010) rainfall-runoff model that was developed for the Bear River Basin and its tributaries. The subbasin delineation for this model is shown on Plate 31. Table 32 lists peak flows when storms are centered over the specific areas above the outlet point.

TABLE 31

TABLE 1: SUMMARY OF PEAK DISCHARGES					
FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. mi)	PEAK DISCHARGE (CFS EXCEEDENCE FREQUENCY			
		10%	2.0%	1.0%	0.2%
Bear River	292				
At Wheatland		25500	39400	44300	54700
Dry Creek					
Above Best Slough Split	82	9510	13700	15600	19800
At Jasper Lane	101	7470	10900	12500	15900
Best Slough					
Below Dry Creek Split	NA	3330	4810	5460	6920
UP Intercept Canal					
At Plumas Lake	87.2	2780	5060	6290	9630
Olivehurst Canal					
At Plumas Lake	9.46	706	1040	1190	1550
Yankee Slough					
At Swetzer Road	28.4	926	1950	2480	4050

TABLE 32

TABLE 2: SUMMARY OF COINCIDENT PEAK DISCHARGES					
FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. mi)	PEAK DISCHARGE (CFS EXCEEDENCE FREQUENCY			
		10%	2.0%	1.0%	0.2%
Bear River					
At Wheatland	292	25500	39400	44300	54700
Dry Creek					
Above Best Slough Split	82	6990	10500	12000	15500
At Jasper Lane	101	5850	8850	10200	13200
Best Slough					
Below Dry Creek Split	NA	2450	3670	4220	5440
UP Intercept Canal					
At Plumas Lake	87.2	2640	4890	6090	9390
Olivehurst Canal					
At Plumas Lake	9.46	594	900	1040	1360
Yankee Slough					
At Swetzer Road	28.4	761	1720	2220	3760

In addition to computing storm centerings at the above locations, coincident discharges for local tributaries during a centering on the mainstem of the Bear River were computed. Table 30 lists

coincident peak discharges at tributary index points when the Bear River at Wheatland gage is experiencing a specific frequency event. Coincident peaks are to be used when specific centerings on the Bear River mainstem are being evaluated.

The Comprehensive Study (USACE, 2002) calculated 1- through 30-day duration frequency curves for the Bear River at Wheatland. The curves were adopted for this study. A peak flow frequency curve was also created for this analysis. Unregulated peak flow values for the Wheatland gage exist for 1929 to 1963, while unregulated flows for the 1- through 30-day durations as calculated by the Comprehensive Study exist for 1929 to 1998. This data was input into HEC's Regional Frequency Computation Program (USACE, 1992). The program derives peak flow statistics based on correlation with the other durations. The 1-day skew was adopted for the peak curve. The adopted peak flow curve along with the other durations derived by the Comprehensive Study are shown in Plate 29. Table 33 displays the unregulated peak flow frequency values adopted for this study.

TABLE 33

Table 8: **Unregulated** Bear River at Wheatland	
Peak Flow in CFS	Percent Chance Exceedence
61100	0.2
54700	0.5
49600	1.0
44000	2.0
36100	5.0
29700	10.0

10.7 Coincident Flow on the Feather River

The Bear River hydrologic study conducted as part of the Lower Feather River FPMS computed design hydrographs assuming storms were centering on each tributary as shown in table 29. Then a second set of hydrographs were produced that assumed a storm centered on the Bear River at Wheatland, near the centroid of the basin, shown in table 30. The Sacramento – San Joaquin Comprehensive study and this feasibility study are using two storm centerings: one at the Feather River at Shanghai Bend, and the second at the latitude of Sacramento.

Therefore, the Bear River hydrographs from the Lower Feather River FPMS must be adjusted to match the Bear River at Wheatland flows for the Sacramento and Shanghai Bend storm centering used in this feasibility study. Ratios were computed as the Bear River Shanghai Bend or Sacramento centering peak flow divided by the Bear River hydrology study peak flow. These ratios were then applied to the hydrographs at the other locations including: Dry Creek, Best

Slough, UP intercept, and Yankee Slough, in the Bear River basin for which hydrographs were required in the hydraulic flood routings.

Note: the hydrograph for Dry Creek was not available in the Lower Feather FPMS or the Sacramento centering of the Comp Study. Therefore the hydrograph for Dry Creek for the Sacramento centering was derived from the Shanghai Bend centering by ratio of their peak flows.

The peak flows and ratios for the Bear River hydrology coincident storm centering, and the Comp Study Shanghai Bend and latitude of Sacramento centerings are shown in table 34.

TABLE 34

Table of Peak Flows and Ratios of Peak Flows for the Bear River								
AEP	1/2	1/10	1/25	1/50	1/100	1/200	1/500	Notes
Bear River at Wheatland								
Peak Flow	9251	26290	35828	43049	49201	54664	61972	Comp Study SAC centering
Peak Flow	6000	17100	27800	34600	41400	47700	55300	Shanghai-Yuba FPMS
Peak Flow	8500	25500	33500	39400	44300	49000	54700	Bear River Coincident Flow table
Ratio SAC-BR hydro	1.0884	1.0310	1.0695	1.0926	1.1106	1.1156	1.1330	Ratio of Comp Study SAC to Bear River Coincident peak flows
Ratio SHY-BR hydro	0.7059	0.6706	0.8299	0.8782	0.9345	0.9735	1.0110	Ratio of Comp Study SHY to Bear River Coincident peak flows
Ratio SAC - SHY	1.5419	1.5374	1.2888	1.2442	1.1884	1.1460	1.1207	Ratio of Comp Study SAC to SHY peak flows
Dry Creek at Jasper Lane								
	1700	4600	6200	7300	8300	9300	10500	Comp Study SAC centering
	1100	3000	4800	5900	7000	8100	9400	Shanghai-Yuba FPMS
	-	5850	-	8850	10200	-	13200	Bear River Coincident Flow table
Note: the hydrograph for Dry Creek was not available in the Lower Feather FPMS or the Sacramento centering of the Comp Study. Therefore the hydrograph for Dry Creek for the Sacramento centering was derived from the Shanghai Bend centering by ratio of their peak flows.								
Best Slough blw Dry Creek Split								
	1244	2521	3364	4015	4682	5293	6159	Comp Study SAC centering
	810	1640	2610	3230	3940	4620	5500	Shanghai-Yuba FPMS
	1140	2450	3150	3670	4220	4740	5440	Bear River Coincident Flow table
UP Intercept Canal								
	1089	2726	4084	5344	6765	8371	10644	Comp Study SAC centering
	710	1770	3170	4300	5690	7300	9500	Shanghai-Yuba FPMS
	-	2640	-	4890	6090	-	9390	Bear River Coincident Flow table
Yankee Slough								
	268	784	1312	1883	2471	3194	4258	Comp Study SAC centering
	170	510	1020	1510	2080	2790	3800	Shanghai-Yuba FPMS
	-	761	-	1720	2220	-	3760	Bear River Coincident Flow table

11. Interior Drainage Analysis

11.1. Background

The interior drainage analysis was performed by Peterson-Brustad Incorporated (PBI) a consultant to the Sutter Butte Flood Control Agency (SBFCA). The purpose of the SBFCA analysis was to serve as a submittal to FEMA in conformance with 44CFR65.10 requirements, and to support compliance with the State of California Urban Level of Protection criteria. A supplemental hydraulic analysis was also conducted to be used for the design of replacement levee culverts.

The modeling process consisted of using HEC-HMS to analyze 1% and 0.5% annual exceedance probability (AEP) rainfall-runoff and develop hydrographs at key concentration points in the interior of the Sutter basin, and using FLO-2D to analyze flood depths and boundaries.

A FLO-2D model with a 1,000-foot by 1,000-foot grid size was developed by Peterson Brustad, Inc. (PBI) for the U.S. Army Corps of Engineers' (USACE) Sutter Basin Feasibility Study and later modified to add key interior drainage channels and features. Hydrographs from HEC-HMS were input at concentration points into the FLO-2D model, and FLO-2D was used to route the floods, estimate residual floodplains, and estimate residual flood depths. In this instance, "residual" means floodplains which will exist following accreditation of all levees protecting the Sutter Basin, due to rainfall on the interior areas. These residual floodplains could later be modified through local land use changes or drainage improvement projects. The FLO-2D model and interior floodplain mapping will be discussed in the Hydraulics appendix.

The large grid size is expected to reveal areas of significant SFHA flooding, however, it should be noted that smaller areas of shallow flooding may be missed.

The design storm rainfall analysis was discussed above in section 6.2

11.1.2. Location

The study area includes approximately 340 square miles of Sutter and Butte Counties in Northern California. It is primarily bounded by the Feather River to the east and by the Sutter Bypass and Sutter Buttes in the west. Its southern boundary is at the confluence of the Feather River and the Sutter Bypass. The study area includes the cities of Live Oak, Gridley, Biggs, Yuba City, and the town of Sutter. Plate 30 shows the study area and its main features.

11.2. HEC-HMS MODELING

11.2.1. Model Development

11.2.1. Subbasin Delineation

The first step in developing the HEC-HMS model involved the delineation of drainage shed boundaries. Plate 30 provides an overview of the drainage sheds identified for this study. A total

of 16 main sheds covering approximately 340 square miles were identified within the interior drainage study boundary. The main sheds were further divided into a total of 77 subbasins as described below.

Live Oak Slough

The Live Oak Slough watershed includes 2 subsheds covering 16 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on drainage boundaries identified in the City of Live Oak Master Drainage Study (Live Oak, 2011), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Morrison Slough

The Morrison Slough watershed includes 2 subsheds covering 15 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on drainage boundaries identified in the City of Live Oak Master Drainage Study (Live Oak, 2011), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011). RD-777 The RD-777 watershed includes 3 subsheds covering 11 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on drainage boundaries identified in the City of Live Oak Master Drainage Study (Live Oak, 2011), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Snake River

The Snake River watershed includes 10 subsheds covering 32 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County, 2010), USGS DEMs (USGS, 2001), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Sutter

The Sutter watershed includes 3 subsheds covering 16 square miles and drains to the Sutter Bypass through DWR Pump Station #3. Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County, 2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Little Blue Creek

The Little Blue Creek watershed includes 2 subsheds covering 6 square miles and drains to the Sutter Bypass through DWR Pump Station #2 (O'Banion Pump Station). Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter

County, 2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Lower Snake River

The Lower Snake River watershed includes 4 subsheds covering 20 square miles and drains to the Sutter Bypass through DWR Pump Station #2 (O'Banion Pump Station). Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County,2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

West Interceptor Canal

One subshed covering 8 square miles flows from the Sutter Buttes directly into the West Interceptor Canal which drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on USGS DEMs (USGS, 2001), (DWR LiDAR data is not available over the Sutter Buttes) and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Sand Creek

The Sand Creek watershed includes 2 subsheds covering 9 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on USGS DEMs (USGS, 2001), DWR LiDAR data (DWR, 2011) and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Sutter City Canal

The Sutter City Canal watershed includes 2 subsheds covering 4 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on USGS DEMs (USGS, 2001), DWR LiDAR data (DWR, 2011) and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Live Oak Canal

The Live Oak Canal watershed includes 3 subsheds covering 15 square miles and drains to the Sutter Bypass through DWR Pump Station #2 (O'Banion Pump Station). Subsheds were delineated based on drainage boundaries identified in the West Yuba City Master Drainage Study (Yuba City, 2006) and the storm drain system outlined in the Sutter County Master Drainage Study (Sutter County, 1979).

Gilsizer Slough

The Gilsizer Slough watershed includes 9 subsheds covering 46 square miles and drains to the Sutter Bypass through DWR Pump Station #2 (O'Banion Pump Station). Subsheds were delineated based on drainage boundaries identified in the West Yuba City Master Drainage

Study (Yuba City, 2006) and the storm drain system outlined in the Sutter County Master Drainage Study (Sutter County, 1979).

Chandler

The Chandler watershed includes 2 subsheds that cover 16 square miles and drains to the Sutter Bypass through DWR Pump Station #1 (Chandler Pump Station). Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County, 2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

RD-823 (Hamatani Ranch)

The RD-823 watershed includes 2 subsheds covering 8 square miles and drains to the Feather River through a private pump station (Hamatani Ranch Pump Station). Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County, 2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Butte Sink

There are 11 subbasins in the northern portion of the study area that drain west to the Butte Sink. These subbasins total 94 square miles and were delineated based the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

East Biggs

The East Biggs subbasin totals 6.01 square miles. The Butte Canal makes up its western boundary and, based on a phone conversation with the director of the Joint Water Board, this section of the Butte Canal has the ability to capture storm runoff from this area. This subbasin was modeled, but its runoff was not conveyed beyond the Butte Canal boundary.

Feather River

Although most of the interior lands drain in a southwesterly direction away from the Feather River's west levee, there are 19 subsheds covering 25 square miles that drain directly to the Feather River through levee culverts or pump stations. These sheds are independent from the rest of the HEC-HMS model and were delineated to assist SBFCA in the design of replacement levee culverts. Sheds were identified based on DWR LiDAR data (DWR, 2011), the City of Live Oak Master Drainage Study (Live Oak, 2011), the West Yuba City Master Drainage Study (Yuba City, 2006), the Sutter County Master Drainage Study (Sutter County, 1979) and telephone conversations with City of Yuba City officials.

11.3.1.7. Pump Stations and Detention Ponds

Ten stormwater pump stations were included in the analysis (see Plate 30). Three DWR pump stations discharge stormwater to the Sutter Bypass. Capacities for these pump stations were obtained from the DWR Sutter Maintenance Yard (DWR, 2009).

One private pump station (Hamatani Ranch Pump Station) is identified in the Sutter County General Plan (Sutter County, 2010) and discharges to the Feather River. A utilities inventory (Flowserve Inc, 2010) conducted along the Feather River's west levee identified this pump station as a Byron Jackson 17HQH pump. Its pump capacity was obtained from a BJ 17HQH pump curve (Flowserve Inc, 2010).

Six pump stations that drain areas in and around Yuba City and discharge to the Feather River were included in the analysis. Five of these pumps are operated by the City of Yuba City. Capacities for these pumps and their associated detention ponds were estimated by the City of Yuba City. An additional pump station operated by the Gilsizer Drainage District also drains Yuba City. Pump and pond capacities for this pump station were obtained from the Gilsizer Drainage District. Ponds are pumped dry after each storm, so ponds were assumed empty at the start of each simulation.

Pump station data are summarized in Table 35.

Table 35. Pump station capacities.

Pump Station	Details
DWR PS#1	Total Capacity: 280 cfs 4 pumps @ 70 cfs each
DWR PS#2	Total Capacity: 786.6 cfs 6 pumps @ 131.1 cfs each
DWR PS#3	Total Capacity: 182.2 cfs 4 pumps @ 45.55 cfs each
Hamatani Ranch PS	Total Capacity: 9.3 cfs 1 pump @ 9.3 cfs
Yuba City Pump Station #1	Total Capacity: 6,820 gpm (15.2 cfs) 1 pump @ 1,950 gpm; 1 pump @ 770 gpm; 1 pump @ 4,100 gpm Pond Capacity: 9 Acre-Feet (AF)
Yuba City Pump Station #2	Total Capacity: 7,300 gpm (16.3 cfs) 2 pumps @ 3,000 gpm; 1 pump @ 1,300 gpm Pond Capacity: 46 Acre-Feet (AF)
Yuba City Pump Station #3	Total Capacity: 9,800 gpm (21.8 cfs) 3 pumps @ 40 horsepower each Pond Capacity: 68.9 Acre-Feet (AF)
Yuba City Pump Station #4	Total Capacity: 900 gpm (2.0 cfs) Pond Capacity: 15 Acre-Feet (AF)
Yuba City Seepage Pump Station	Total Capacity: 9,700 gpm (21.6 cfs) 1 pump @ 3,270 gpm; 1 pump @ 6,430 gpm Total Capacity: 47,500 gpm (105.8 cfs)
Gilsizer Drainage District Pump Station	2 pumps @ 10,000 gpm; 1 pumps @ 5,000 gpm; 1 pumps @ 22,500 gpm Pond Capacity: 70 Acre-Feet (AF)

[a] Estimated based on horsepower and capacities of similarly sized pumps in Yuba City.

11.3.3. Model Results

Once calibrated, the HEC-HMS model was run with the four design storm events described above in section 6.2. The simulations were extended several days beyond the storm event to ensure that hydrographs had time to return to low-flow conditions and runoff had time to travel to the model's outlet points. Table 36 and Table 37 provide a summary of peak flow and runoff volume results at several key locations in the study area.

In the absence of gage records, high water marks, or other physical tools for model verification, PBI verified results through discussions with several area officials from the City of Yuba City, Sutter County, and Gilsizer Drainage District, as well as with residents within the basin who recalled flooding that took place during the 1997 and 2006 events.

TABLE 36

Summary of peak flow results [cfs].					
Location	Drainage Area [sq.mi.]	100yr-24hr	100yr-96hr	200yr-24hr	200yr-96hr
Live Oak Slough					
at Highway 99	5.97	90	54	110	67
at East Interceptor Canal confluence	18.06	470	120	580	140
RD777 Canal					
at Sheppard Rd	4.66	330	150	410	180
Morrison Slough					
d/s of Sutter/Butte County Line	5.35	290	150	350	190
Snake River					
West Fork at Sutter/Butte County Line	3.87	210	160	250	180
East Fork at Sutter/Butte County Line	2.85	220	170	260	190
u/s of Clark Rd.	29.75	1,900	1,600	2,300	1,900
at Morrison Slough confluence	45.34	2,600	2,300	3,100	2,700
Interceptor Canal					
at RD777 Canal confluence	28.52	1,000	440	1,300	540
at Snake River confluence	74.95	3,700	2,900	4,400	3,400
at Wadsworth Canal entrance	95.44	4,900	4,100	5,900	4,800
Wadsworth Canal Outlet	96.12	4,900	4,200	5,900	4,900
Sutter Main Canal					
DWR Pump Station #3 Inflow	16.26	1,200	520	1,500	650
Little Blue Creek					
at Highway 20	1.43	91	53	110	60
Live Oak Canal					
at Highway 20	4.37	150	100	180	120
at Bogue Rd	10.01	440	220	530	280
Lower Snake River					
at Highway 20	3.08	400	120	480	140
at Little Blue Creek confluence	15.78	780	540	940	630
at Live Oak Canal confluence	31.91	1,600	1,000	2,100	1,200
Gilsizer Slough					
at Lincoln Rd.	6.85	380	380	430	420
at Bogue Rd.	8.36	510	460	560	500
at Oswald Rd.	14.04	700	510	820	560
at George Washington Blvd.	38.28	1,200	690	1,600	810
DWR Pump Station #2 Inflow	87.25	3,100	2,600	3,800	3,000
Chandler Main Drain					
DWR Pump Station #1 Inflow	10.68	540	460	680	520
RD-823 Main Drain					
at Highway 99	3.58	110	21	150	31
Hamatani Ranch Pump Station Inflow	7.63	210	180	270	210
Average Unit Peak Flows [cfs/acre]		0.08	0.05	0.1	0.06

Table 37

Summary of runoff volume results [acre-feet].					
Location	Drainage Area [sq.mi.]	100yr-24hr	100yr-96hr	200yr-24hr	200yr-96hr
Live Oak Slough					
at Highway 99	5.97	340	340	400	410
at East Interceptor Canal confluence	18.06	890	610	1,100	700
RD777 Canal					
at Sheppard Rd	4.66	330	610	390	700
Morrison Slough					
d/s of Sutter/Butte County Line	5.35	330	350	400	460
Snake River					
West Fork at Sutter/Butte County Line	3.87	390	1,100	440	1,200
East Fork at Sutter/Butte County Line	2.85	250	540	290	620
u/s of Clark Rd.	29.75	2,700	6,500	3,100	7,400
at Morrison Slough confluence	45.34	4,200	9,000	4,900	10,000
Interceptor Canal					
at RD777 Canal confluence	28.52	1,700	1,900	2,000	2,200
at Snake River confluence	74.95	6,100	11,000	7,100	13,000
at Wadsworth Canal entrance	95.44	7,800	15,000	9,200	17,000
Wadsworth Canal Outlet	96.12	7,800	15,000	9,200	17,000
Sutter Main Canal					
DWR Pump Station #3 Inflow	16.26	1,200	2,100	1,400	2,400
Little Blue Creek					
at Highway 20	1.43	140	380	150	420
Live Oak Canal					
at Highway 20	4.37	370	470	430	530
at Bogue Rd	10.01	770	930	900	1,100
Lower Snake River					
at Highway 20	3.08	250	520	290	600
at Little Blue Creek confluence	15.78	1,400	3,600	1,600	4,000
at Live Oak Canal confluence	31.91	2,700	5,600	3,100	6,400
Gilsizer Slough					
at Lincoln Rd.	6.85	980	1,700	1,100	1,900
at Bogue Rd.	8.36	1,200	2,100	1,300	2,300
at Oswald Rd.	14.04	1,400	2,300	1,500	2,500
at George Washington Blvd.	38.28	2,100	2,900	2,500	3,200
DWR Pump Station #2 Inflow	87.25	6,500	12,000	7,500	14,000
Chandler Main Drain					
DWR Pump Station #1 Inflow	10.68	940	1,900	1,100	2,100
RD-823 Main Drain					
at Highway 99	3.58	120	160	160	180
Hamatani Ranch Pump Station Inflow	7.63	520	1,300	600	1,400
Average Unit Runoff Volumes [AF/acre]		0.13	0.24	0.15	0.27

12. Analysis of Alternatives by Hydrology

The ring levee and J-levee (the levee) around Yuba City are the two alternatives that required additional hydrologic analysis. The fix-in-place, and other similar levee alternatives will not require a change in the hydrology effecting those alternatives.

For the preliminary screening, an estimate of the runoff within the levee was developed using the rational method of rainfall-runoff analysis. Rainfall depths were extracted from the design rainfall analysis by David Ford Consulting Engineers Inc (Ford) for this study. The Ford analysis is based on rainfall depth-area-duration statistics developed by Jim Goodrich, the former California State Climatologist, and kept up-to-date on the Department of Water Resources (DWR) web site. Areas within the levee were developed from Google Earth sketches of the proposed alternative alignment. The loss rate coefficient was calibrated to match the peak flows shown the West Yuba City master drainage study.

A mean daily flow rate of 918 cfs was estimated for the whole area inside the levee. The area used was 24.23sq.mi. within the levee. A 1-day, 10-year precipitation volume of 2.82 inches, and a rainfall-runoff coefficient of 0.5 was used. Pumps were sized based on this average flow rate. These estimates have been used in the study to this point. Refinements will be made as shown below.

The interior drainage analysis performed by Peterson-Brustad Inc (PBI) for SBFCA using HEC-HMS and FLO2D later determined the 100-year and 200-year 24-hour storm duration flow at two locations. The two locations are natural drainage outlets that must pass through the levee, and include Gilsizer Slough and Live Oak Slough. The discharge and volume at these two locations is shown in tables 33 and 34 to be: 440 and 530 cfs for the 24-hour, 100- and 200-year return periods respectively at Live Oak Slough. And, 1200 and 1600 cfs for the 24-hour, 100- and 200-year return periods respectively at Gilsizer Slough.

The pump size required must be determined in conjunction with an accompanying detention basin. The larger the detention basin, the smaller the required pump size. A detailed analysis of the interior drainage within the ring levee alternatives was done by PBI. In addition, pump sizes and detention basin sizes were calculated. Those results may be found in the Interior Drainage Analysis by Peterson-Brustad, Inc. (SBFCA, 2012).

13. Results

The results of the design rainfall analysis, the discharge probability of the Sutter Bypass and Feather River systems, the Cherokee and Wadsworth Canal systems, and of the Sutter basin interior areas tributary to the Wadsworth canal and the Sutter Bypass are shown above. For further information see the individual reports, Technical Memorandum, and Memorandum for Record.

14. Conclusions

This summary report provides information for the determination of a feasible project within the Sutter Basin, California. This is the complete hydrology appendix document for the Sutter Basin Feasibility Study Draft Report. The information summarized herein is detailed in technical memorandums, and memorandum for record. Those memos are cited in the text above and shown in the references below.

15. REFERENCES:

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Legend

- Sutter Basin Study Area
- Sacramento Basin
- Watershed Boundary
- Lake or Reservoir
- Designated Floodway
- River or Stream
- City

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

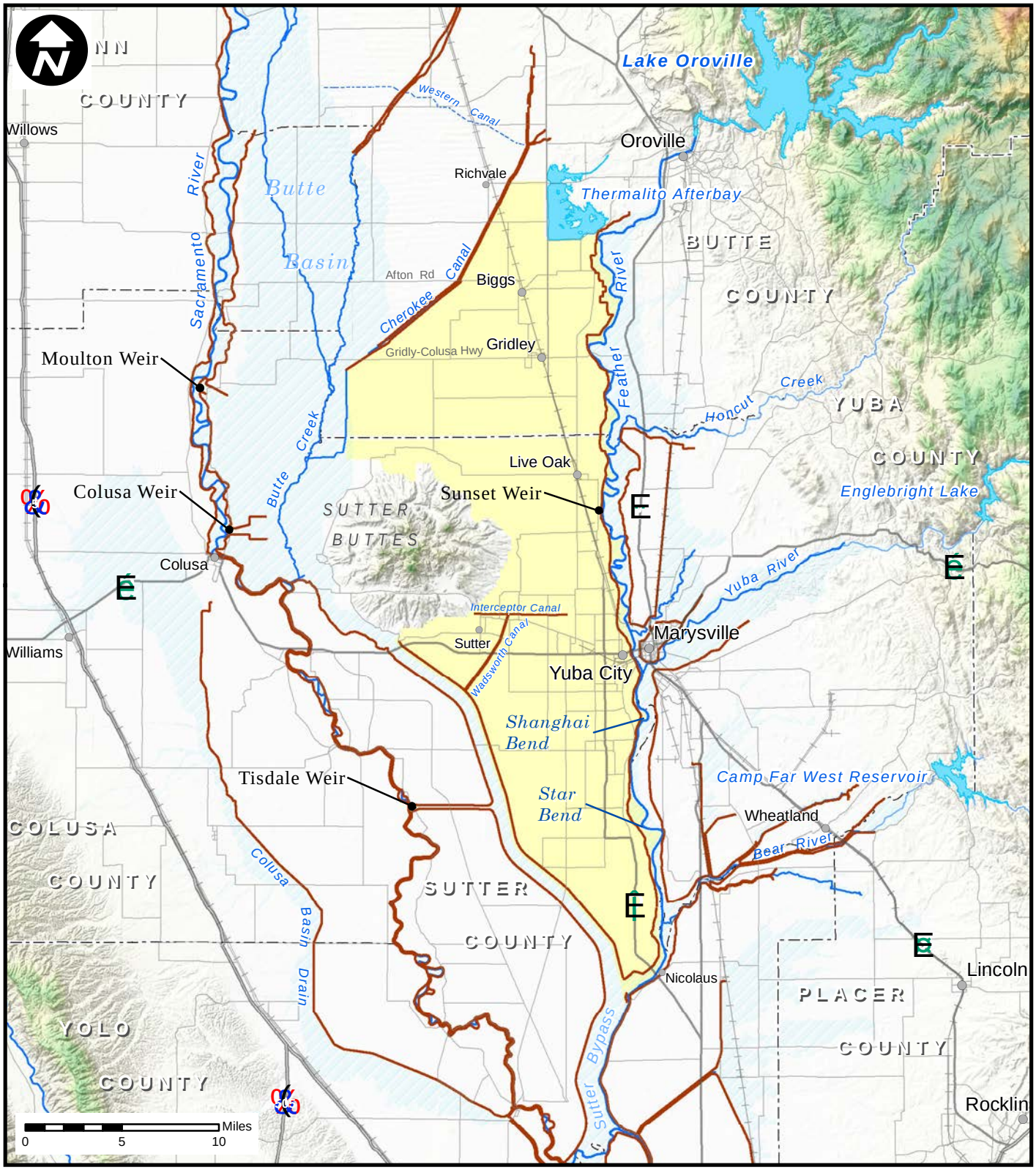
SACRAMENTO RIVER WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 1



Legend

- Study Area Extent
- Designated Floodway
- Lake or Reservoir
- River or Stream
- Federal Levee
- Highway
- Major Road
- Railroad
- County Boundary
- City or Town

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

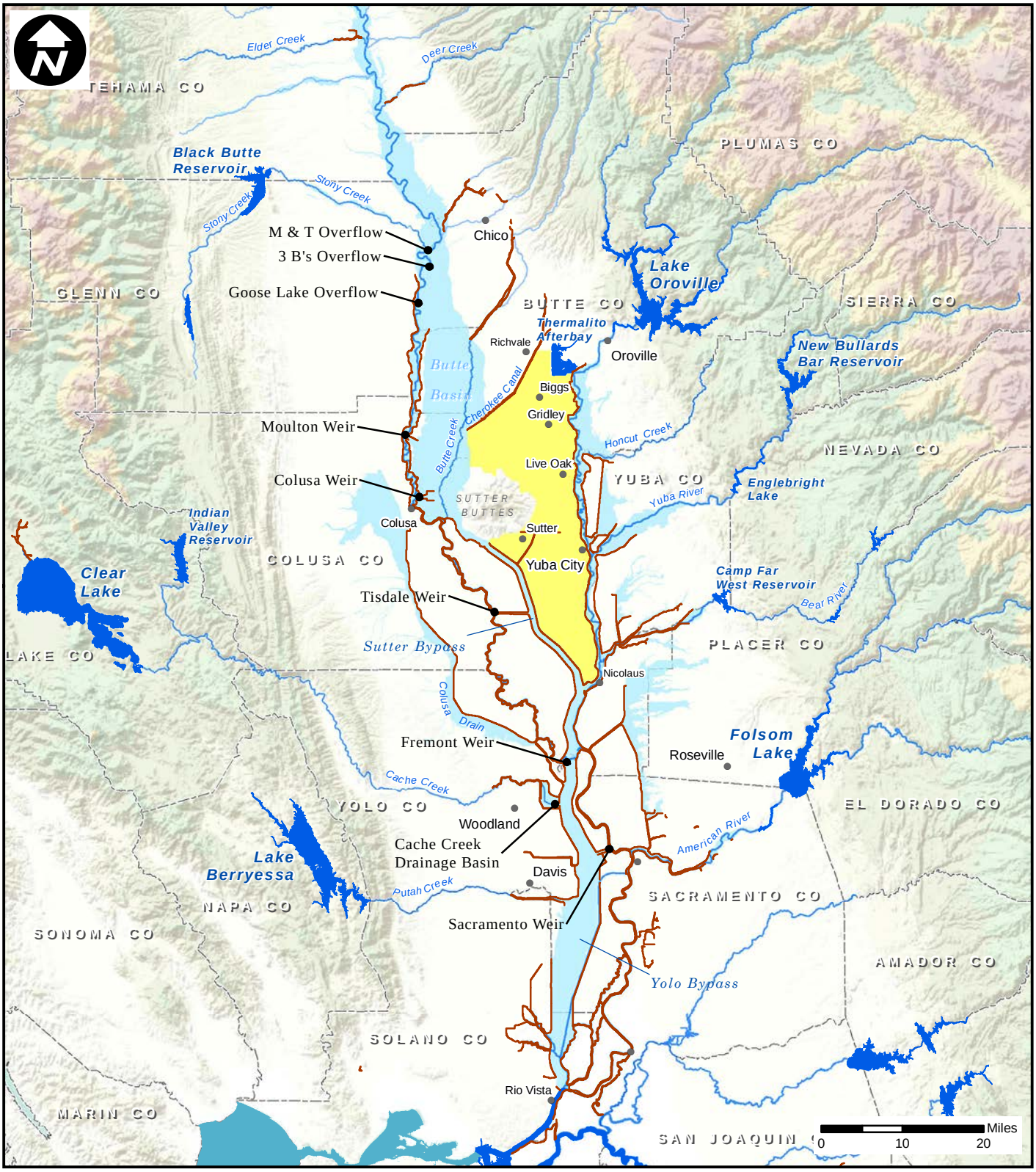
STUDY AREA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 2



Legend

- Study Area Extent
- Designated Floodway
- Lake or Reservoir
- River or Stream
- Federal Levee
- County Boundary
- City

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

SACRAMENTO RIVER FLOOD CONTROL PROJECT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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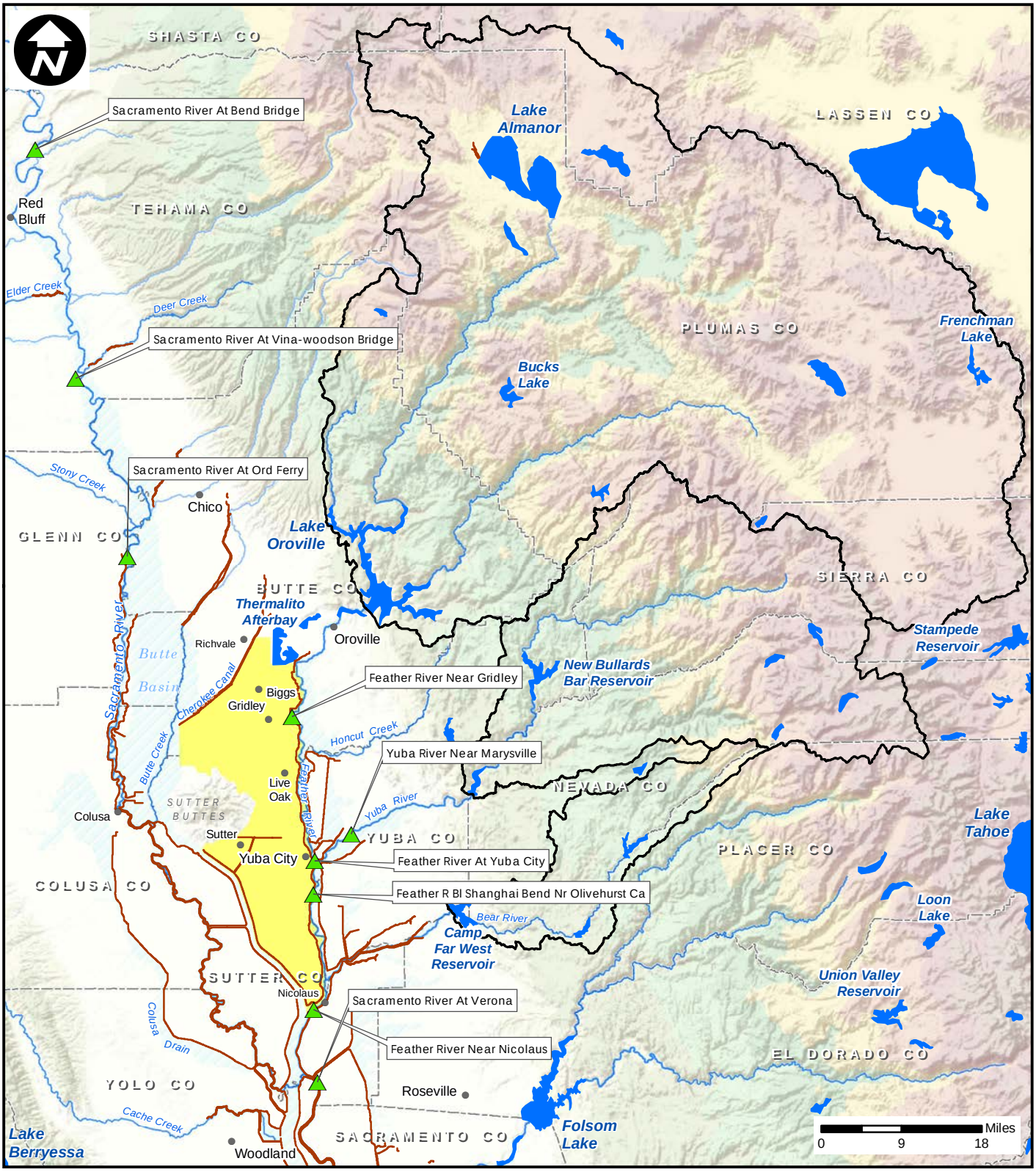
PLATE 3



Legend

- Stream Gage
- Study Area Extent
- Watershed Boundary
- Designated Floodway
- Federal Levee
- Lake or Reservoir
- River or Stream
- County Boundary
- City

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

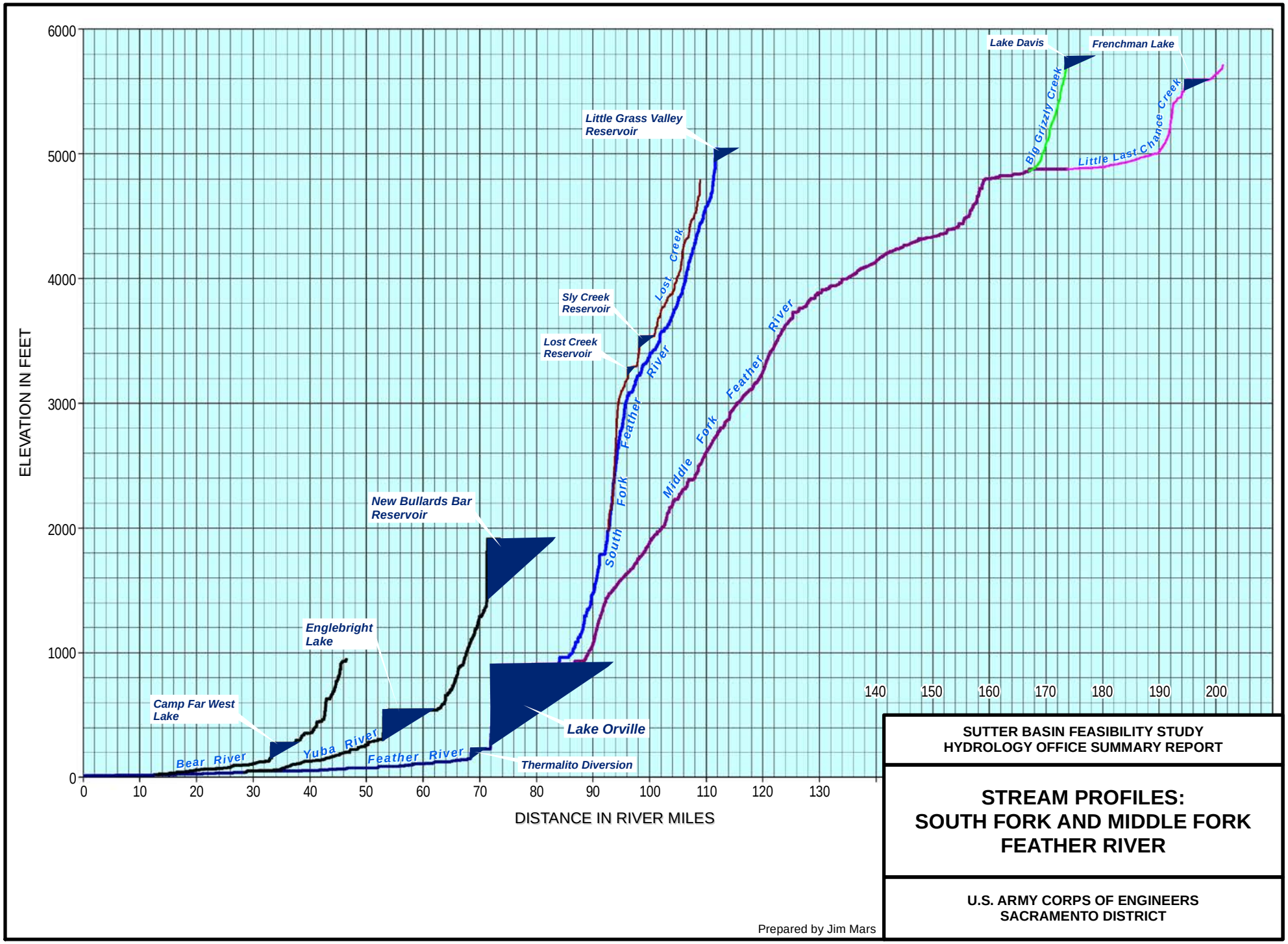
UPPER WATERSHED BASINS TOPOGRAPHY AND STREAM GAGES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 4



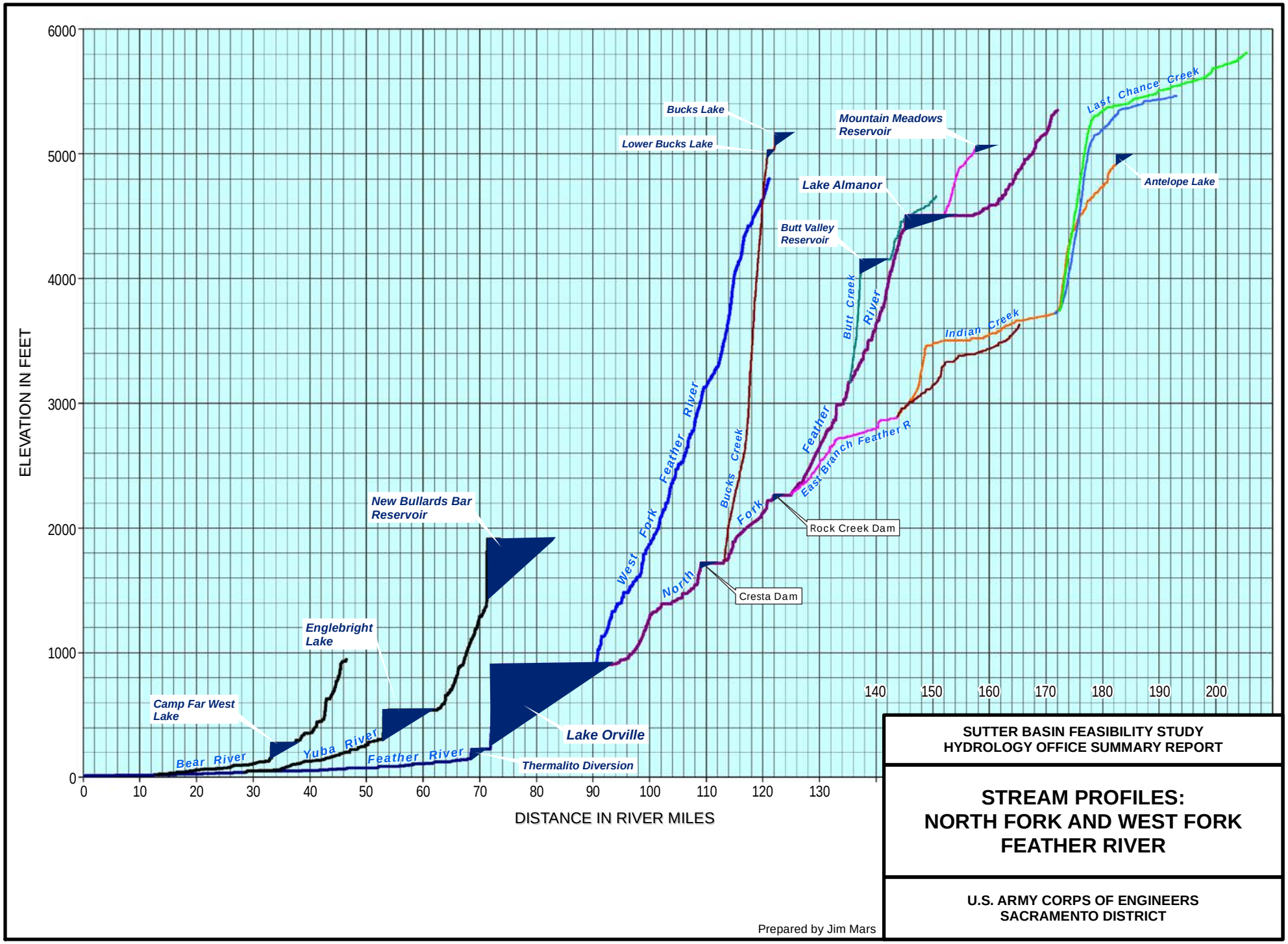
SUTTER BASIN FEASIBILITY STUDY
HYDROLOGY OFFICE SUMMARY REPORT

STREAM PROFILES: SOUTH FORK AND MIDDLE FORK FEATHER RIVER

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

NOV 2012

PLATE 5.1



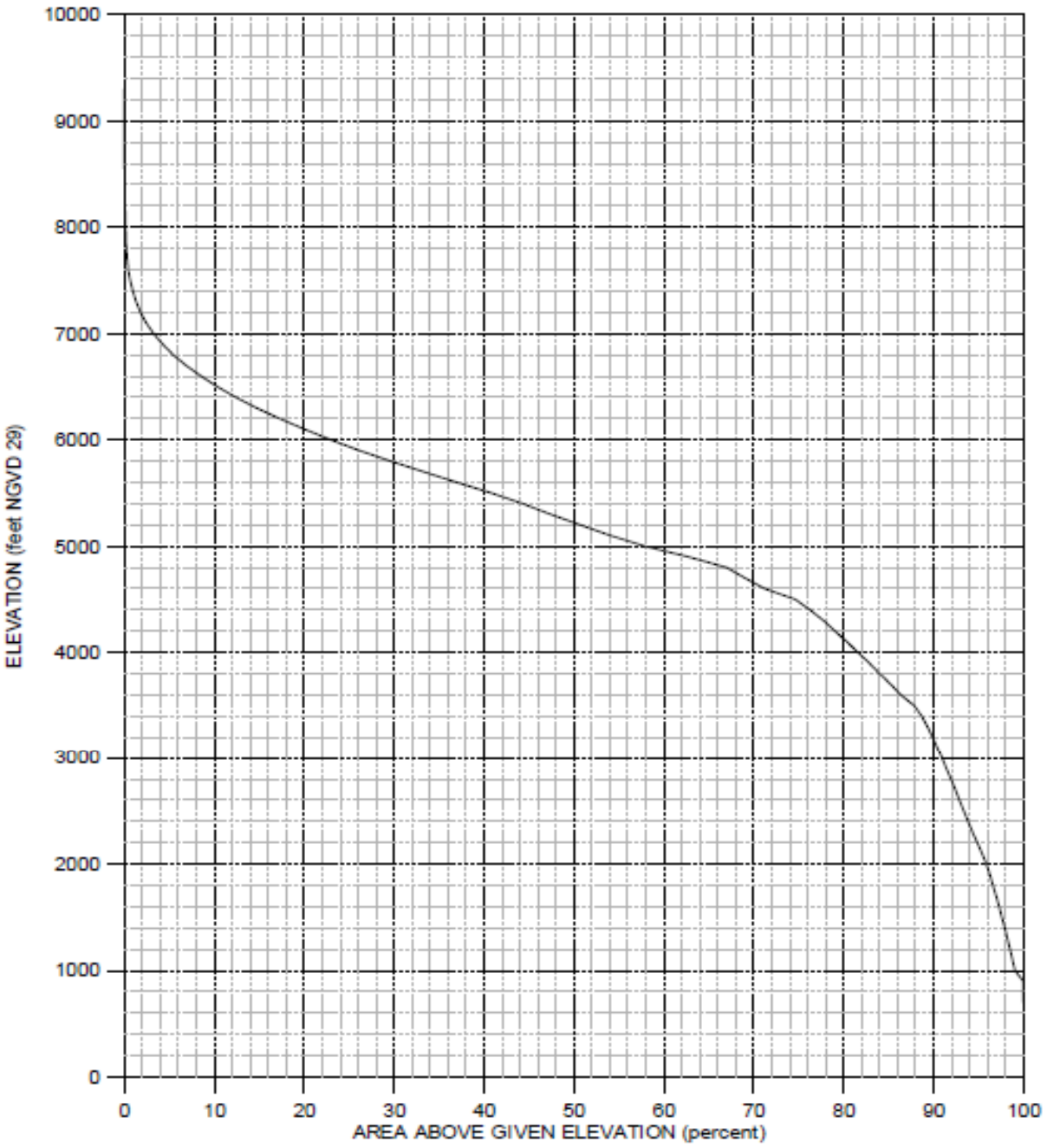
SUTTER BASIN FEASIBILITY STUDY
HYDROLOGY OFFICE SUMMARY REPORT

STREAM PROFILES: NORTH FORK AND WEST FORK FEATHER RIVER

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

NOV 2012

PLATE 5.2



NOTES:

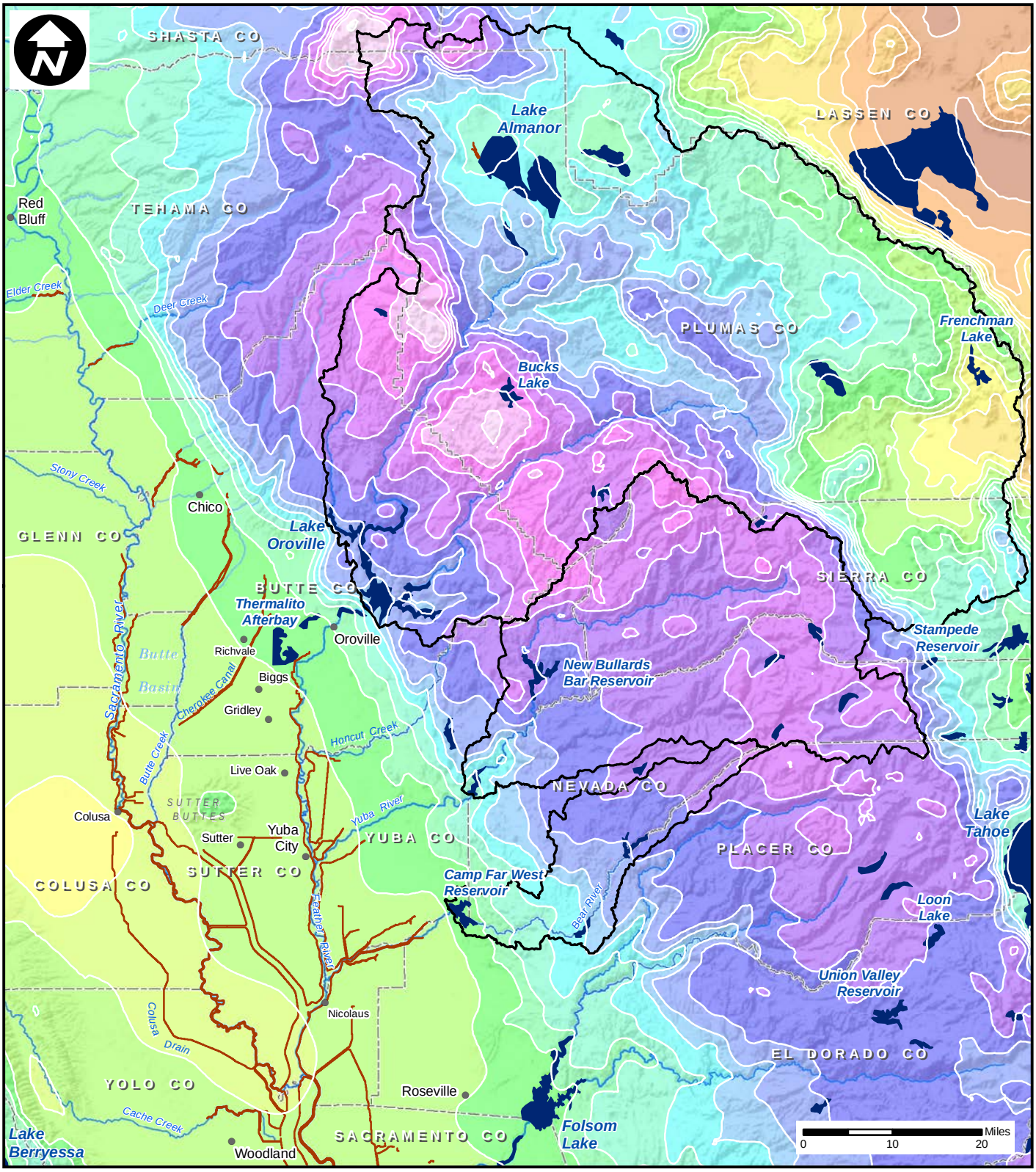
Watershed above Oroville Dam (3,602 square miles)

Source: Oroville Water Control Manual, Revised Feb 2005

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

AREA-ELEVATION CURVE

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Legend

- Watershed Boundary
- Federal Levee
- Lake or Reservoir
- River or Stream
- County Boundary
- City

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

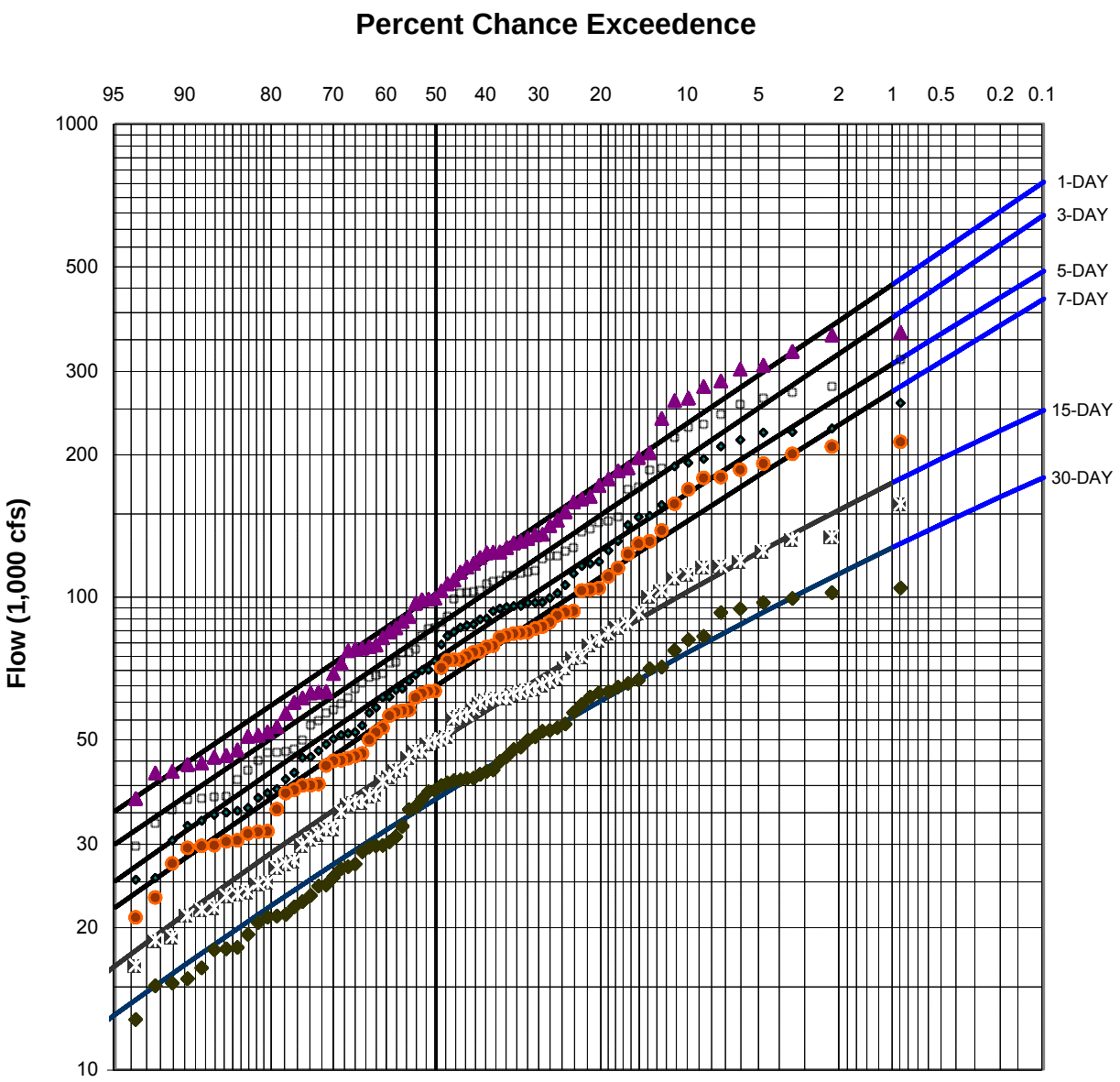
UPPER WATERSHED BASINS NORMAL ANNUAL PRECIPITATION AND CLIMATOLOGICAL GAGES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 7



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	5.009	0.281	0.0
3-day	4.939	0.281	0.0
5-day	4.866	0.279	-0.1
7-day	4.809	0.278	-0.1
15-day	4.680	0.267	-0.3
30-day	4.562	0.258	-0.3

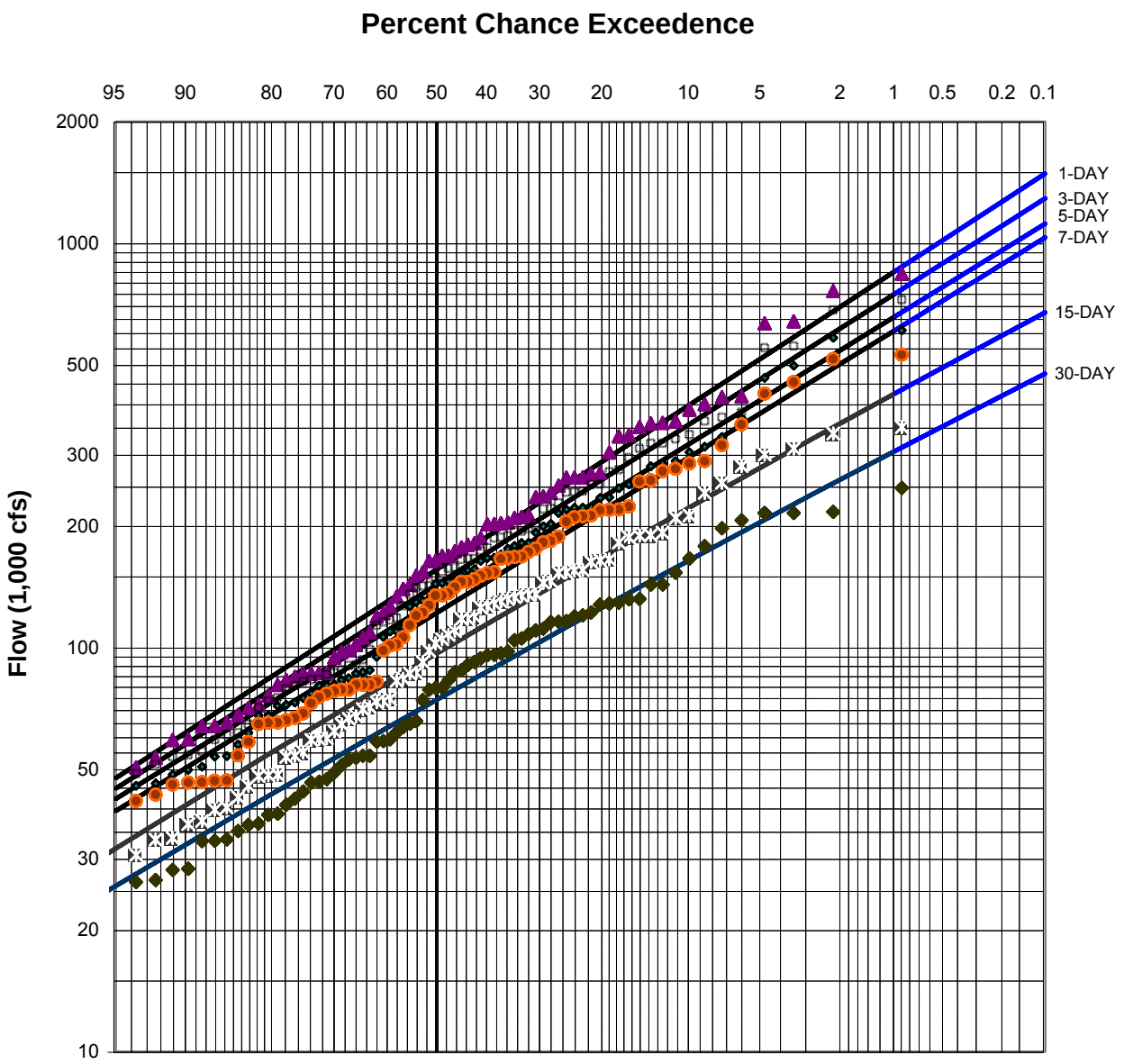
NOTES:

1. Adjusted USGS gage 11388700 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. WY 1977 censored as low outlier.
3. Median plotting positions.
4. Drainage area: approx. 12,050 sq. mi.
5. Period of record: 1922-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
SACRAMENTO RIVER AT ORD FERRY (LATITUDE)
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	5.196	0.316	0.0
3-day	5.158	0.308	0.0
5-day	5.120	0.301	0.0
7-day	5.088	0.300	0.0
15-day	4.983	0.287	-0.1
30-day	4.869	0.274	-0.2

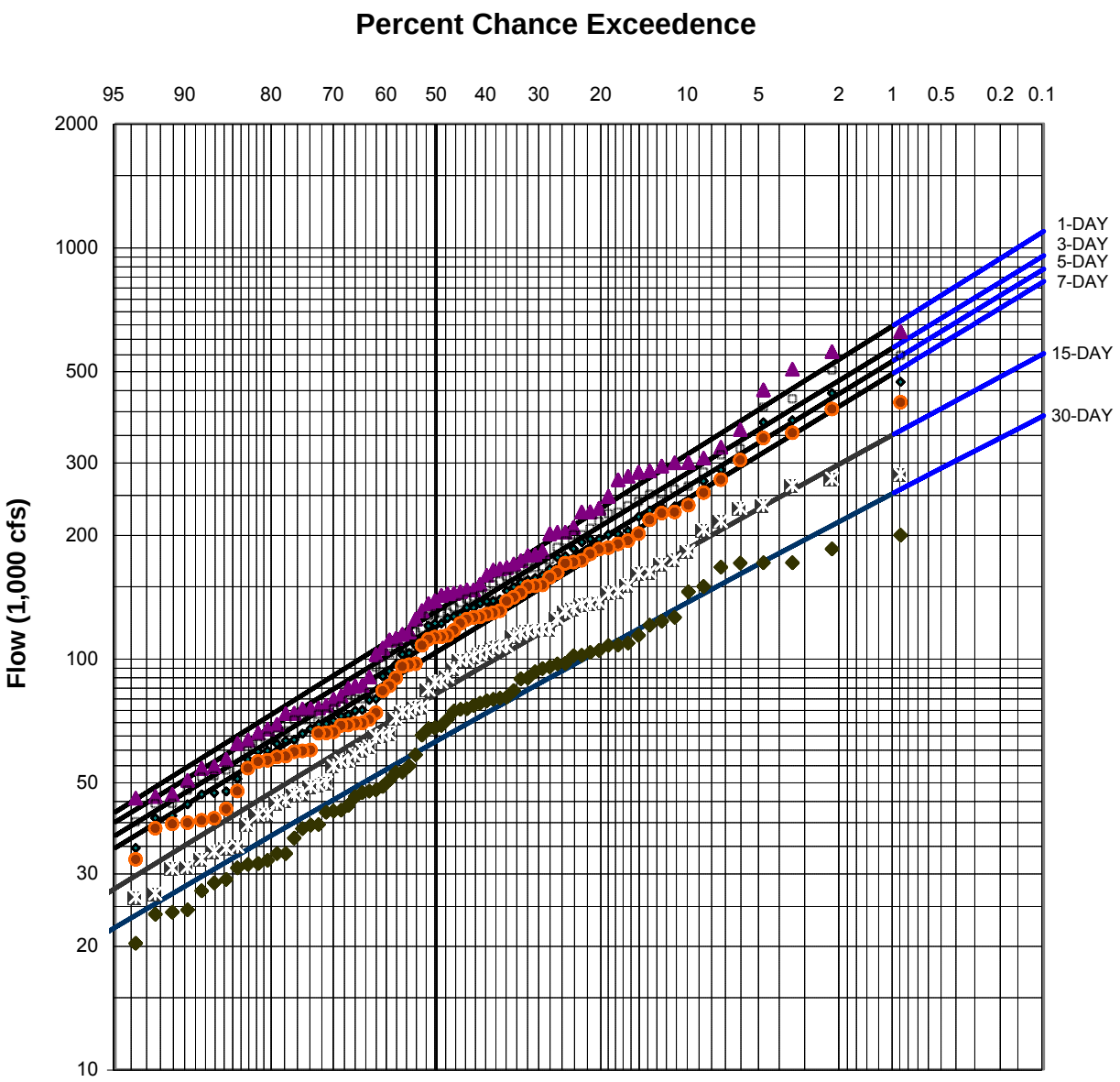
NOTES:

1. Adjusted USGS gage 11447500 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. WY 1977 censored as low outlier.
3. Median plotting positions.
4. Drainage area: approx. 26,150 sq. mi.
5. Period of record: 1922-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
SACRAMENTO RIVER AT SACRAMENTO (LATITUDE)
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	5.117	0.298	0.0
3-day	5.081	0.291	0.0
5-day	5.048	0.291	0.0
7-day	5.018	0.291	0.0
15-day	4.912	0.281	-0.1
30-day	4.796	0.269	-0.2

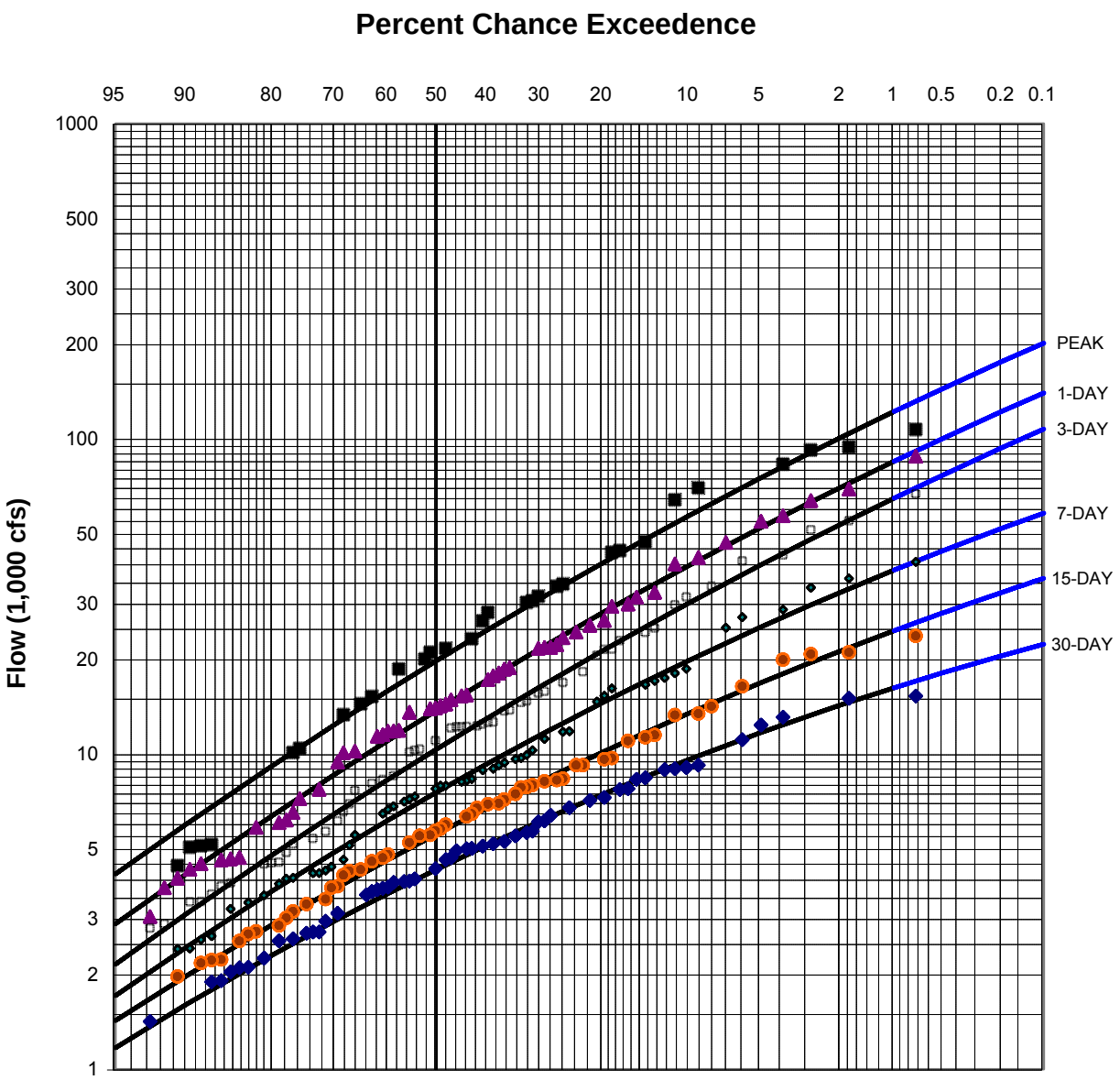
NOTES:

1. Adjusted USGS gage 11425500 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. WY 1977 censored as low outlier.
3. Median plotting positions.
4. Drainage area: approx. 21,251 sq. mi.
5. Period of record: 1922-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
SACRAMENTO RIVER AT VERONA (LATITUDE)
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
Peak	4.280	0.383	-0.3
1-day	4.122	0.383	-0.3
3-day	3.999	0.386	-0.3
7-day	3.858	0.357	-0.4
15-day	3.727	0.327	-0.4
30-day	3.611	0.306	-0.5

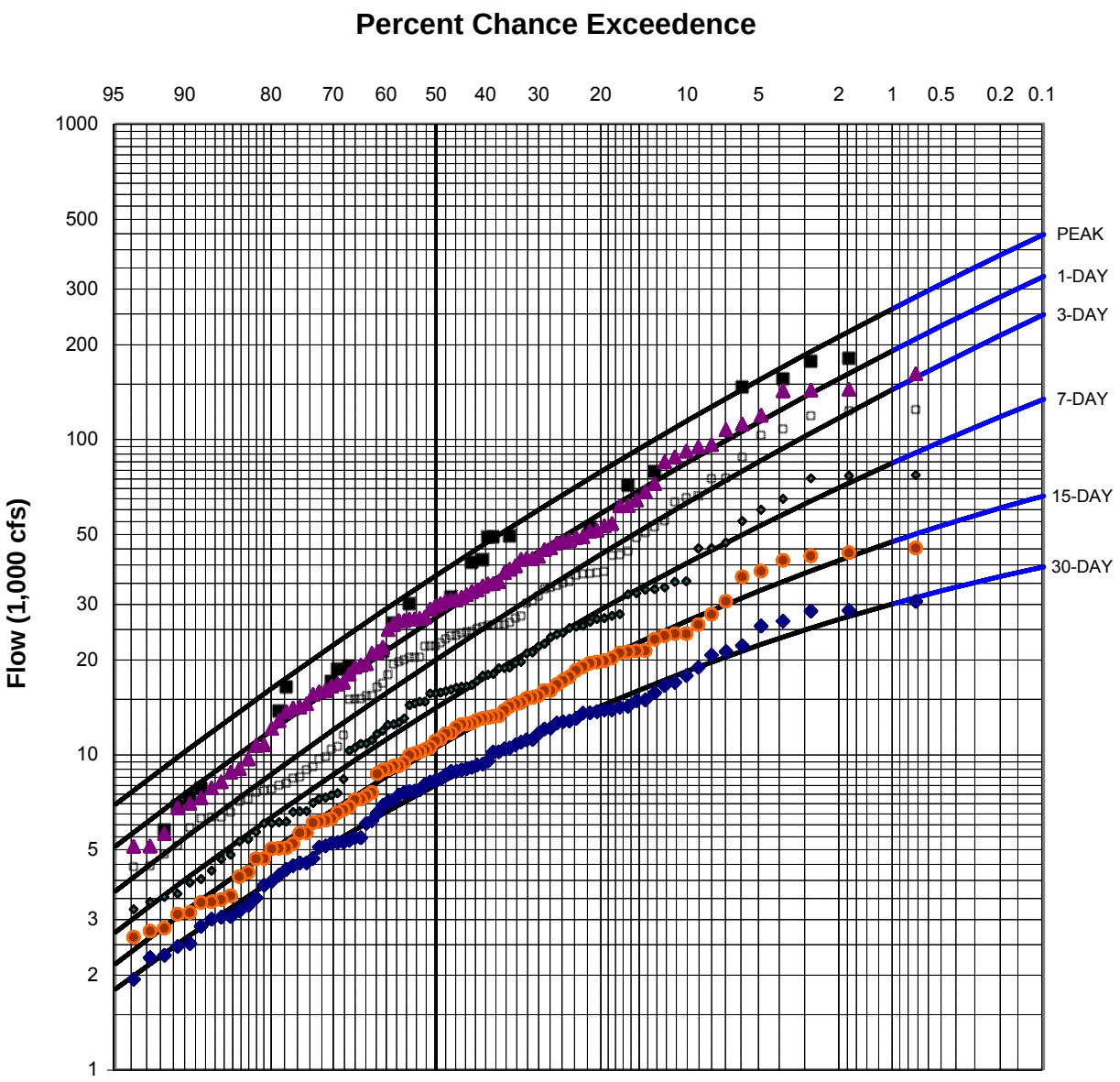
NOTES:

1. Statistics adjusted based on correlation with Yuba River near Marysville station (94 years).
2. Median plotting positions.
3. Drainage Area: 489 sq. mi.
4. Period of record: 1938-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
NORTH YUBA AT NEW BULLARDS BAR DAM
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
Peak	4.550	0.411	-0.3
1-day	4.417	0.411	-0.3
3-day	4.283	0.416	-0.3
7-day	4.125	0.394	-0.4
15-day	3.989	0.364	-0.6
30-day	3.867	0.337	-0.7

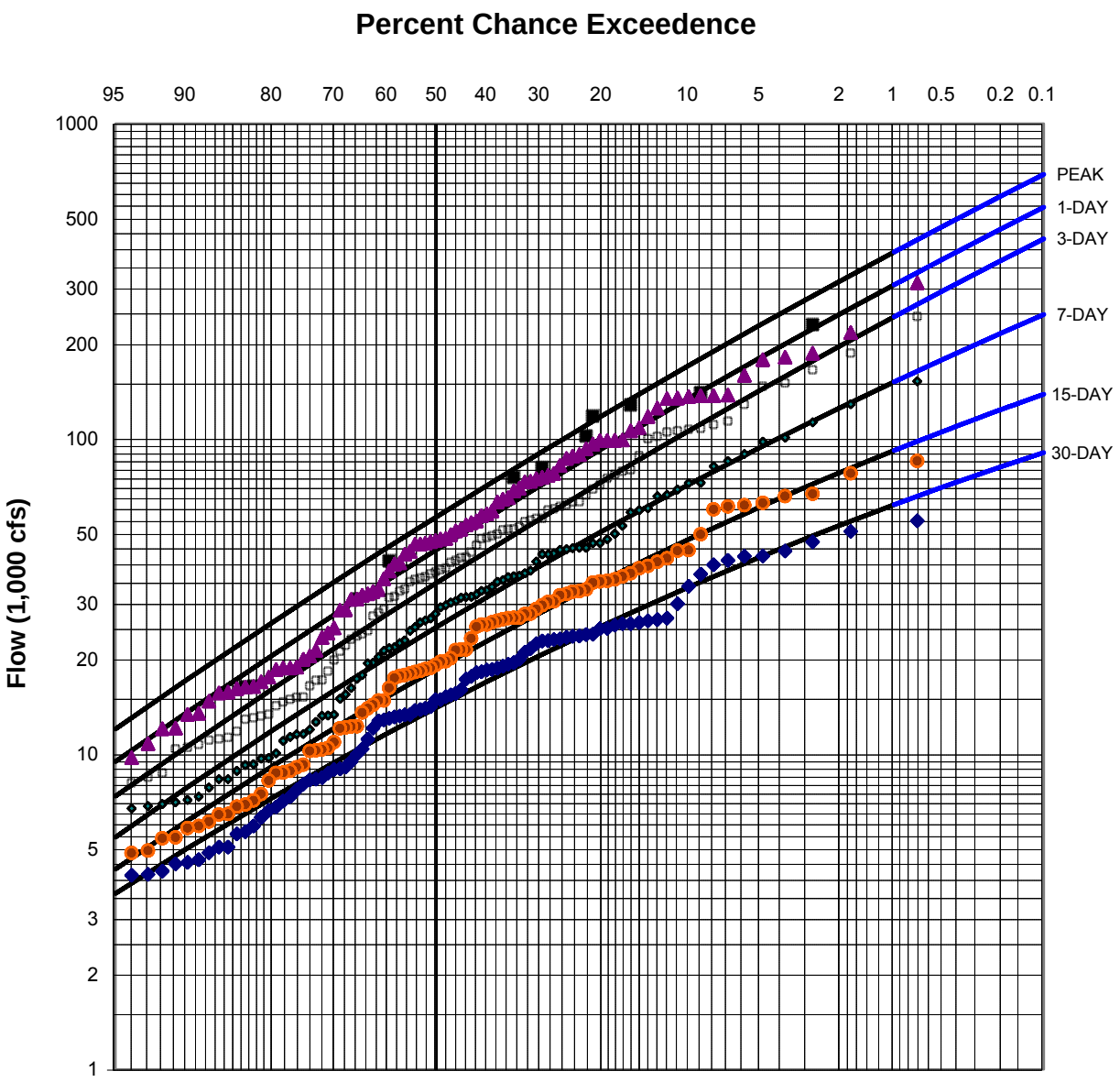
NOTES:

1. Median plotting positions.
2. Peak data available for 25 years of record.
3. Drainage area: 1,339 sq. mi.
4. Period of record: 1904-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
YUBA RIVER NEAR MARYSVILLE
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
Peak	4.743	0.390	-0.2
1-day	4.639	0.390	-0.2
3-day	4.533	0.392	-0.2
7-day	4.387	0.377	-0.3
15-day	4.250	0.351	-0.4
30-day	4.129	0.326	-0.4

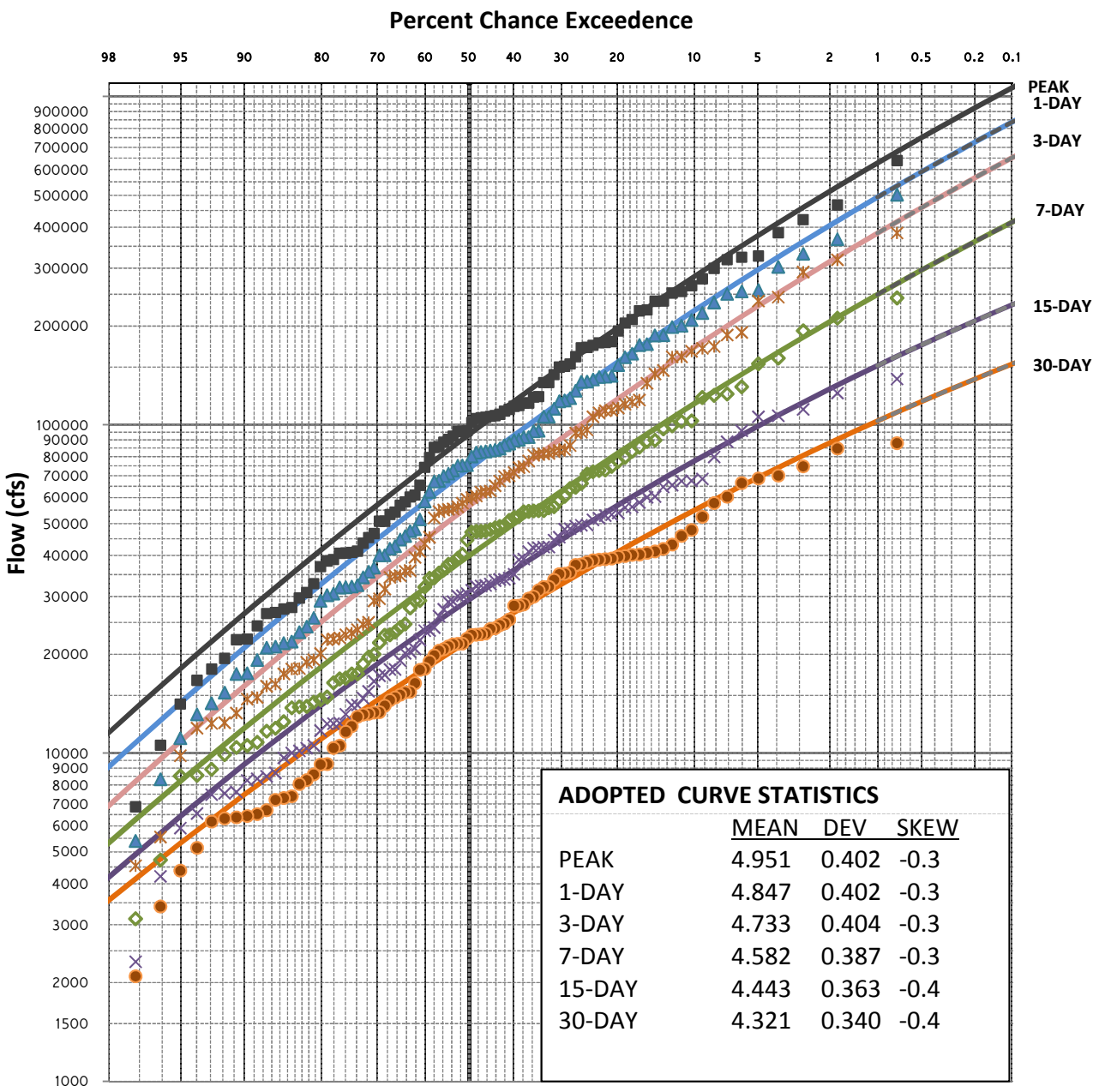
NOTES:

1. Median plotting positions.
2. Peak data available for 11 years of record.
3. Drainage area: 3,624 sq. mi.
4. Period of record: 1901-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
FEATHER RIVER AT OROVILLE DAM
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED CURVE STATISTICS

	MEAN	DEV	SKEW
PEAK	4.951	0.402	-0.3
1-DAY	4.847	0.402	-0.3
3-DAY	4.733	0.404	-0.3
7-DAY	4.582	0.387	-0.3
15-DAY	4.443	0.363	-0.4
30-DAY	4.321	0.340	-0.4

NOTES:

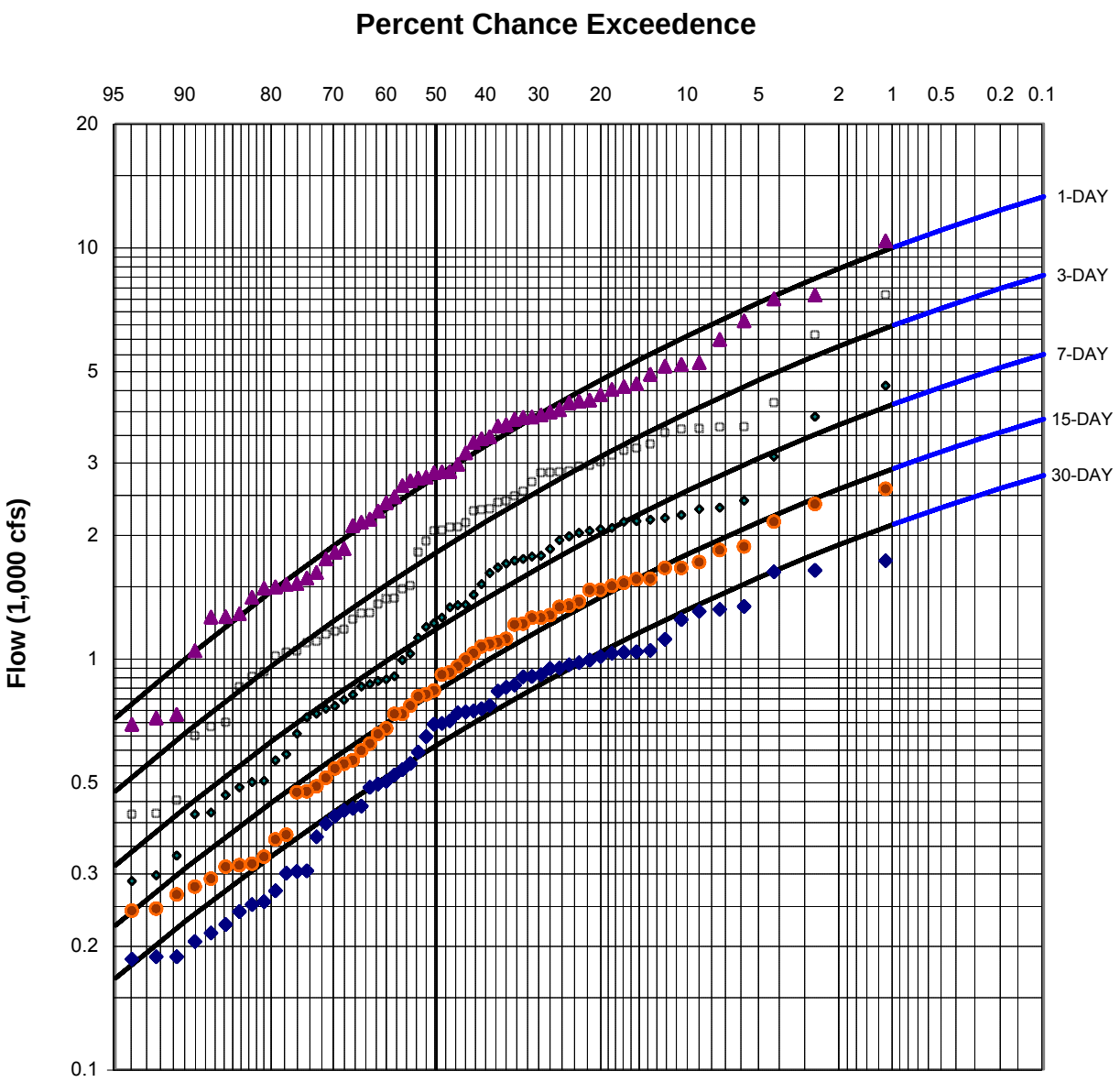
1. Median plotting positions.
2. Computed Probability
3. Drainage area: 5313 sq. mi.
4. 94 years of record (1904 to 1997)

MODIFIED BY BJW MAY 2002

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

RAINFLOOD FREQUENCY CURVES
FEATHER RIVER AT SHANGHAI BEND
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	3.414	0.311	-0.6
3-day	3.230	0.308	-0.6
7-day	3.044	0.305	-0.6
15-day	2.893	0.302	-0.6
30-day	2.761	0.300	-0.6

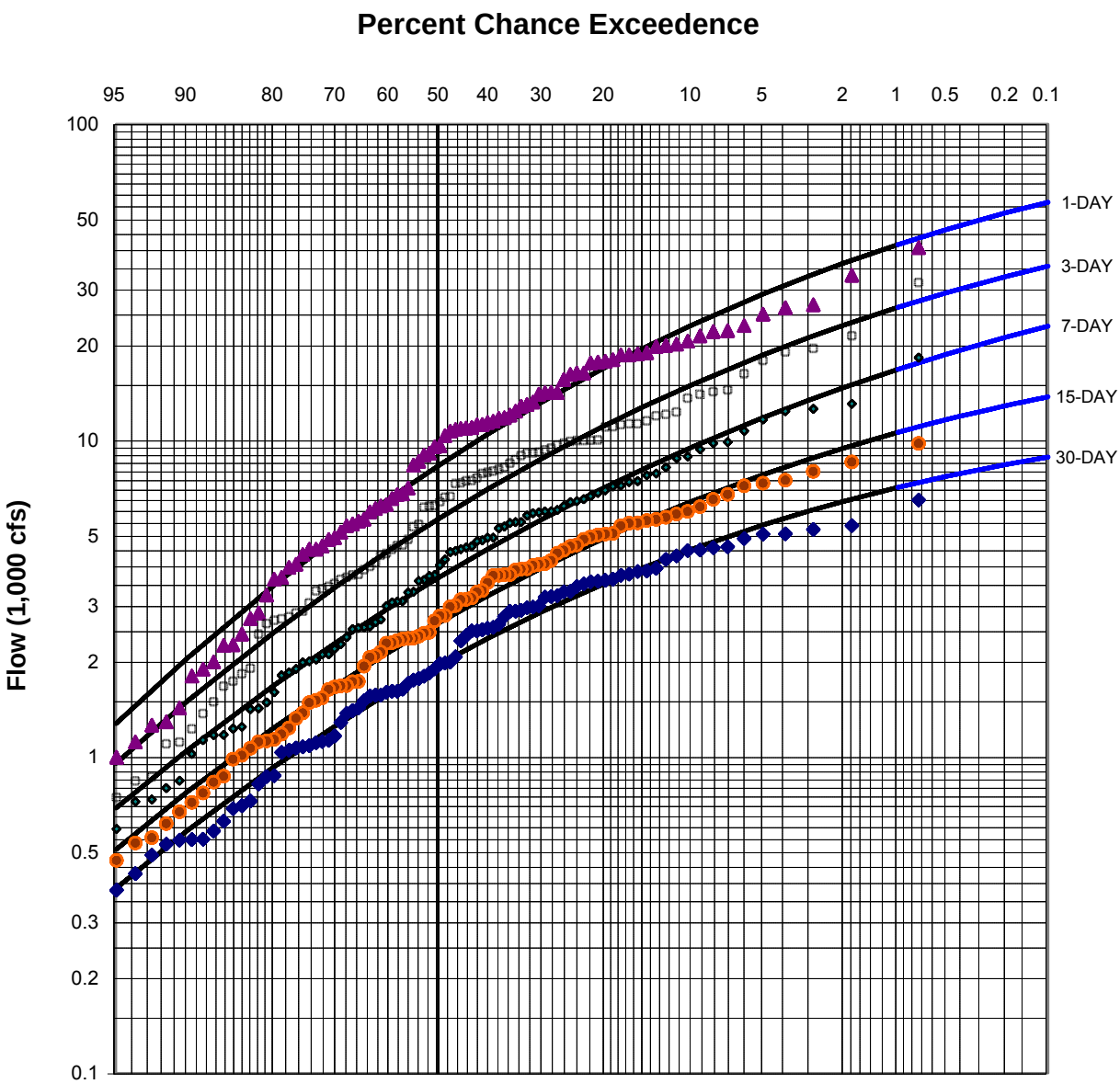
NOTES:

1. Adjusted USGS gage 11418500 to account for daily change in storage at upstream reservoir (potential channel, out-of-channel, or storage losses neglected).
2. WY 1977 censored as low outlier.
3. Median plotting positions.
4. Drainage area: 84.6 sq. mi.
5. Period of record: 1936-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
DEER CREEK NEAR SMARTVILLE
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	3.872	0.420	-0.7
3-day	3.707	0.399	-0.7
7-day	3.527	0.380	-0.7
15-day	3.379	0.367	-0.8
30-day	3.244	0.357	-0.9

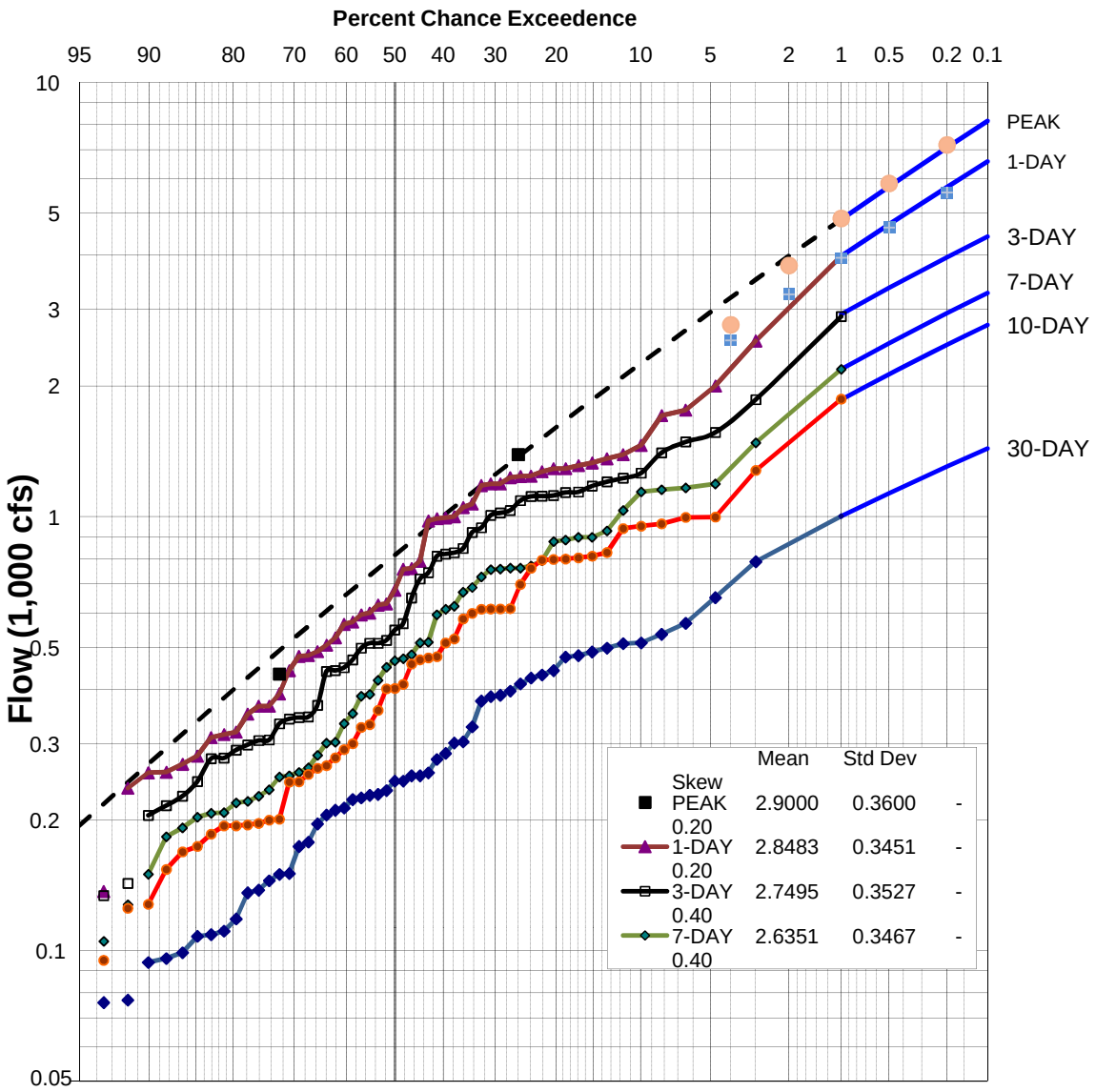
NOTES:

1. Adjusted USGS gage 11424000 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. Statistics adusted based on correlation with Van Trent (1906-27) and Yuba R at Smartville (1928).
3. Median plotting positions.
4. Drainage area: 292 sq. mi.
5. Period of record: 1906-1998.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
BEAR RIVER NEAR WHEATLAND
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Notes:

1. Recorded flows use median plotting positions for the 56 years of record from 1939 to 1996.
2. Drainage area about 96 sq. mi. for DWR Station A05929.
3. Modeled values from SBFCA HMS model June 2012 with precipitation reflecting The 1-, 3-, 7-, 10-, and 30-day data was plotted to extend the historical data up to the 0.1-percent exceedance frequency of the estimated best fit curve.
4. The peak flow curve was manually adjusted to best fit the historical and modeled data and the 1-day volume curve. Model Runs reflect 10 Year Flows in the Sutter Bypass with storm precipitation reflecting the frequency of the flows reflected on the flow volume frequency curve.
5. The plotted curves to the right of the 1-percent exceedance frequency are manually

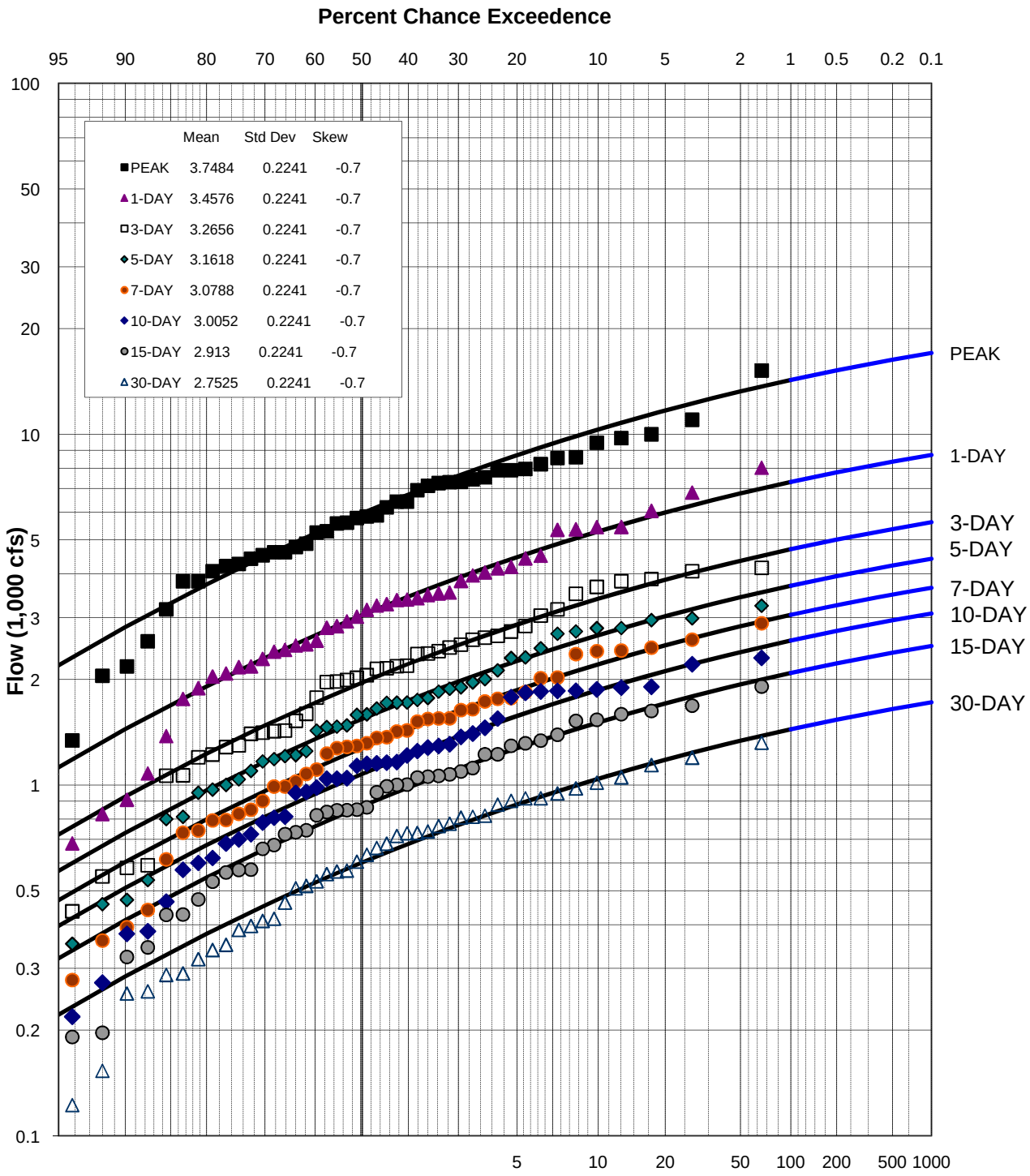
RAIN FLOOD FREQUENCY CURVES
UNREGULATED CONDITIONS

WADSWORTH CANAL NR SUTTER
SACRAMENTO RIVER BASIN.

WATER YEARS 1939 ~ 1996

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 17



NOTES:

1. WY 1977, 1972, 1990 are low outliers.
2. Median plotting positions
3. Drainage area about 94 sq. mi.
4. 46 years of record
5. DWR Station A02984

DEC 2008

SUTTER BASIN, CALIFORNIA

Sutter Basin Hydrology Study

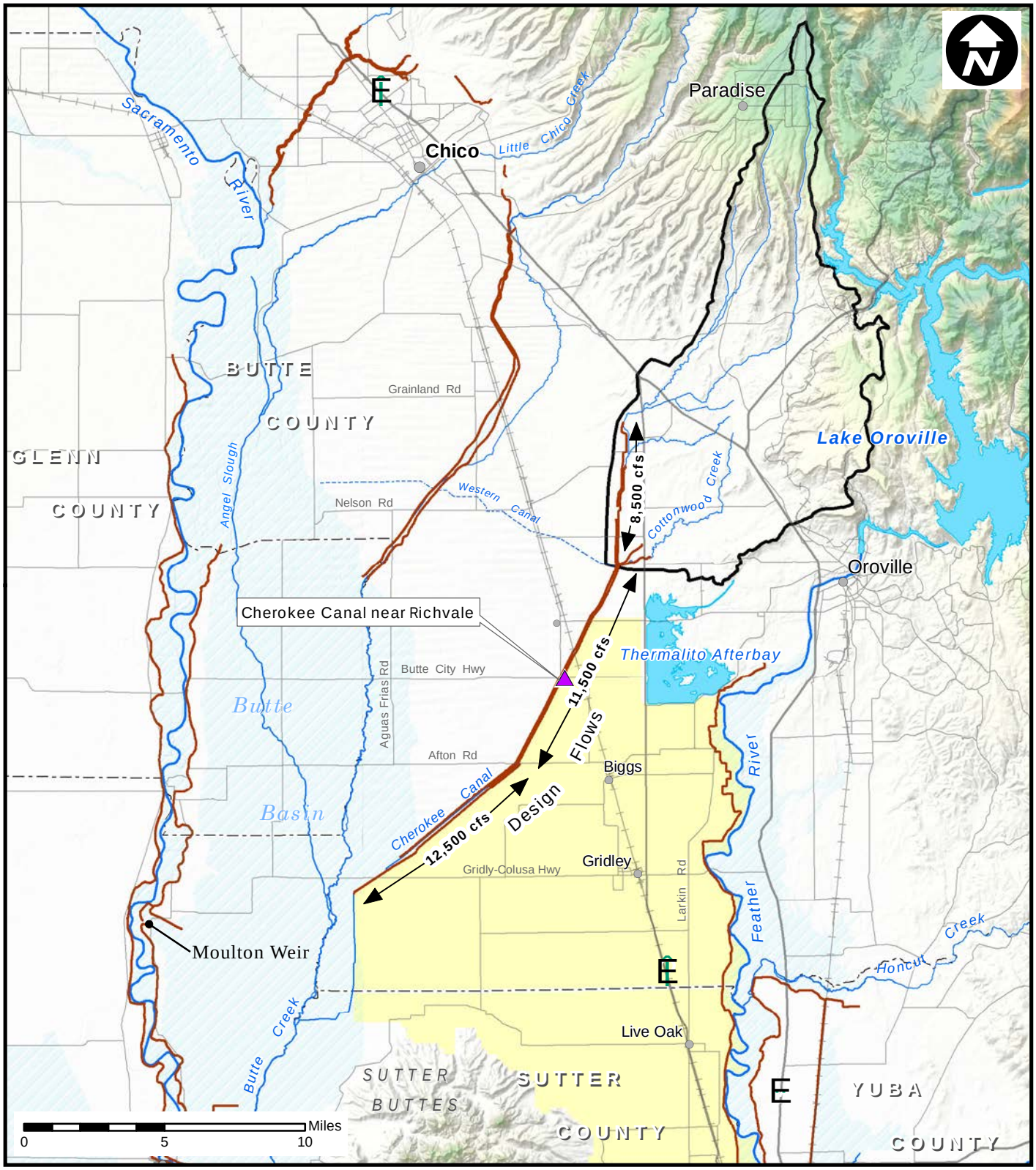
CHEROKEE CANAL NEAR RICHVALE, CA

RAIN FLOOD FREQUENCY CURVES

WATER YEARS 1961-2006

U.S. ARMY CORPS OF ENGINEERS

SACRAMENTO DISTRICT



Legend

- Stream Gage
- Sutter Basin Study Area
- Watershed Boundary
- Designated Floodway
- Lake or Reservoir
- River or Stream
- Federal Levee
- Highway
- Major Road
- Railroad
- County Boundary
- City or Town

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

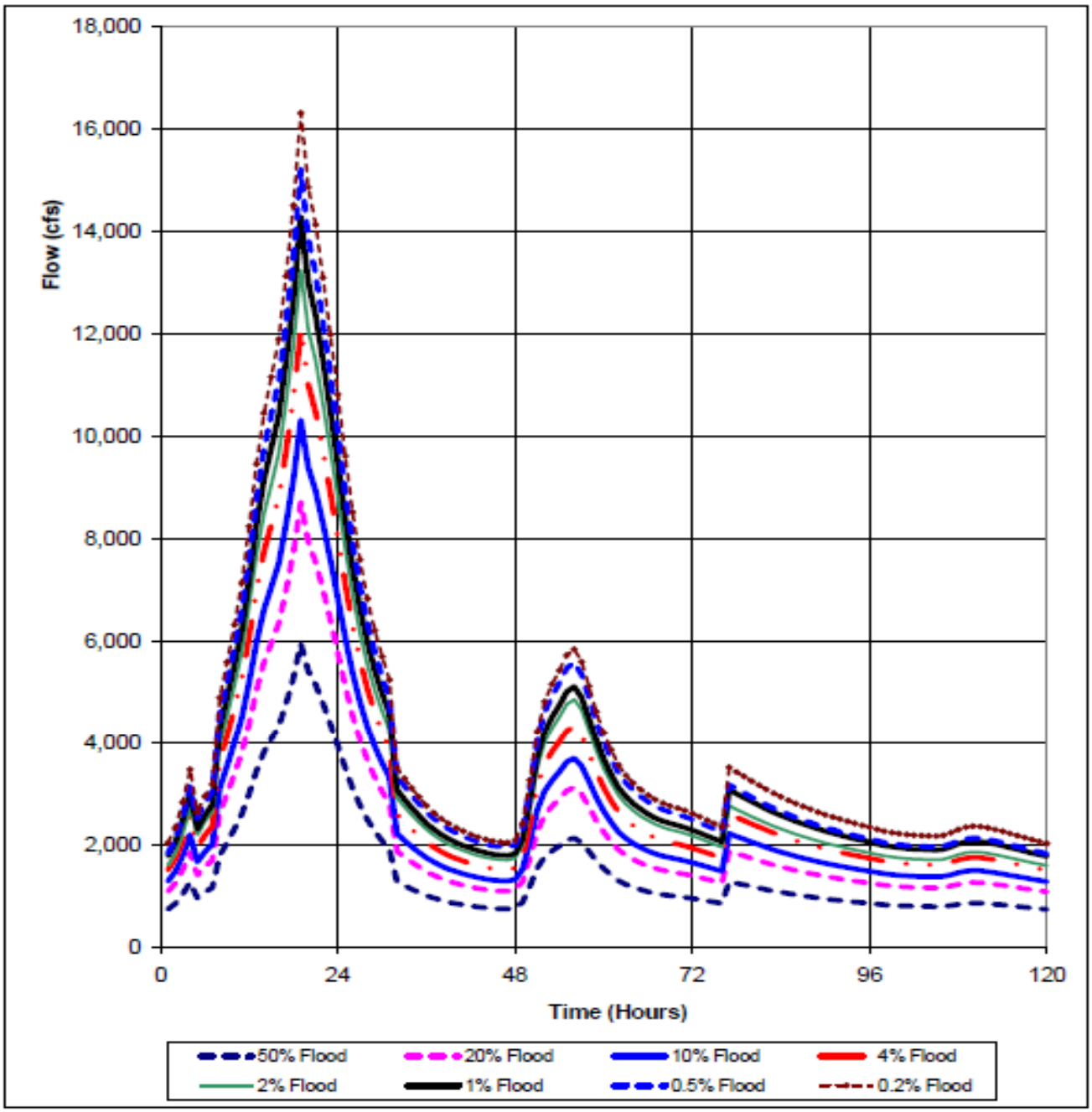
CHEROKEE CANAL WATERSHED AND TOPOGRAPHY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 19

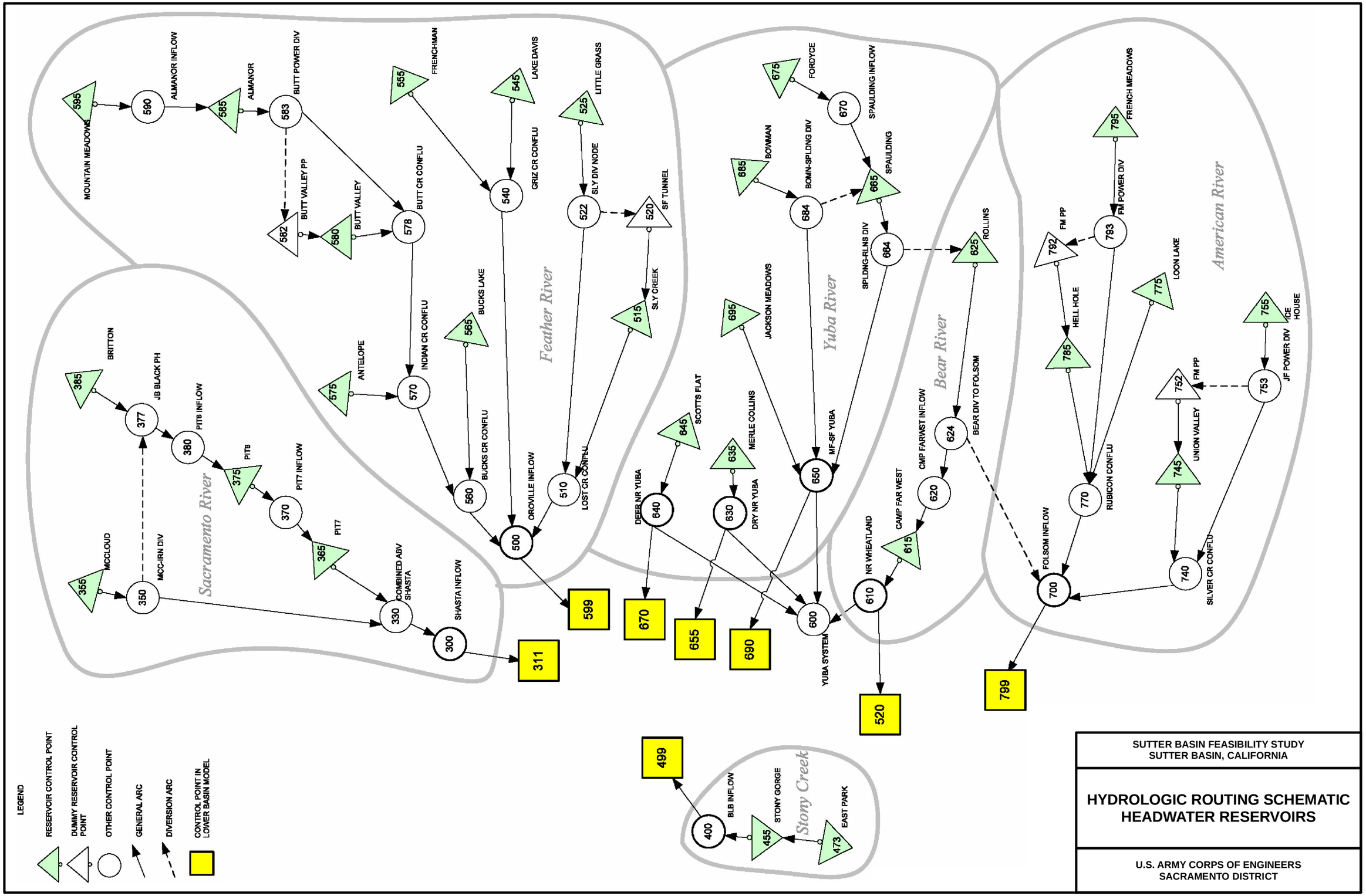


SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

CHEROKEE CANAL
SYNTHETIC 8-FLOOD SERIES
5-DAY WAVE HYDROGRAPHS

Source: Sutter County Feasibility Study, 2004

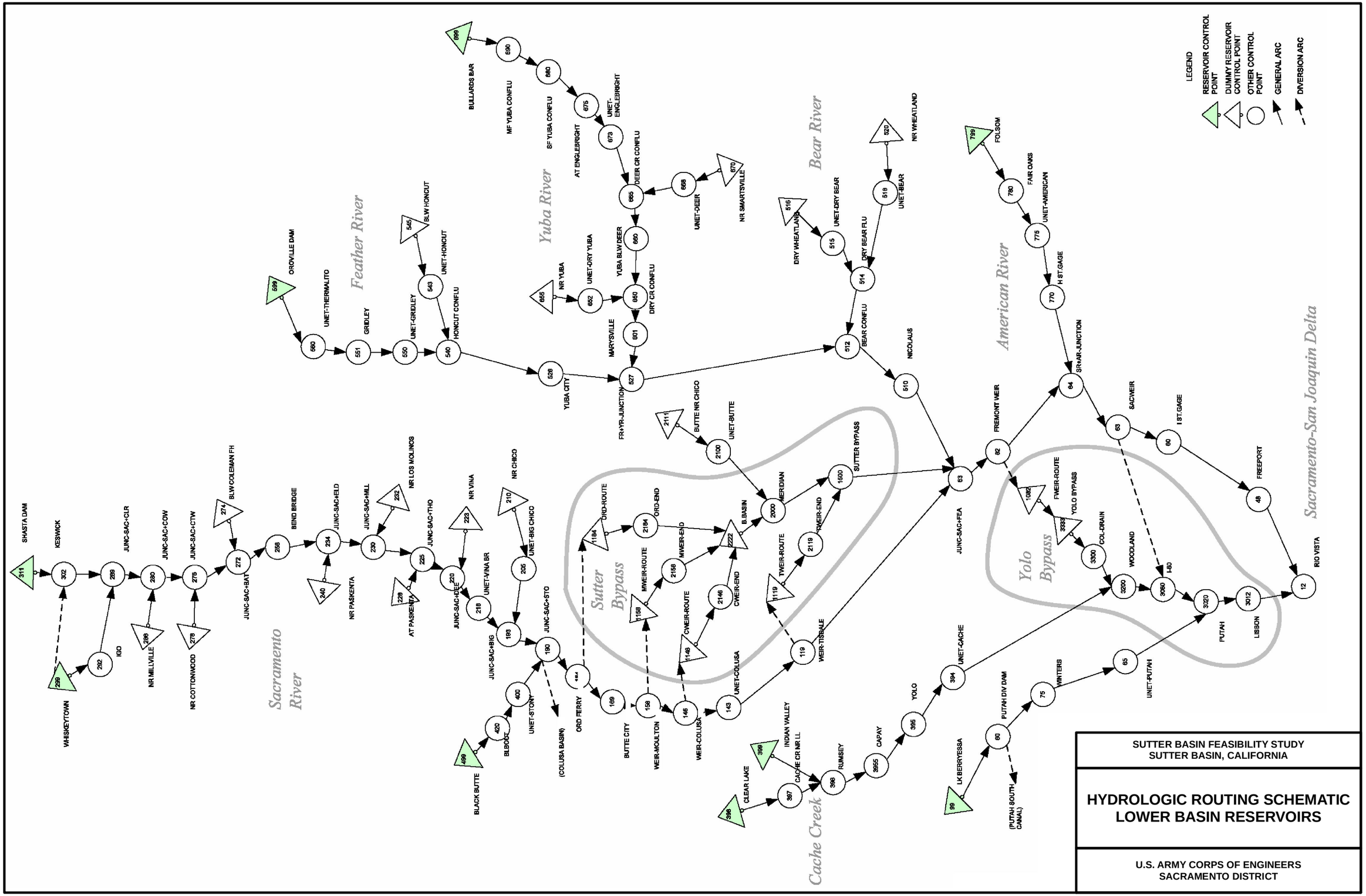
U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

HYDROLOGIC ROUTING SCHEMATIC HEADWATER RESERVOIRS

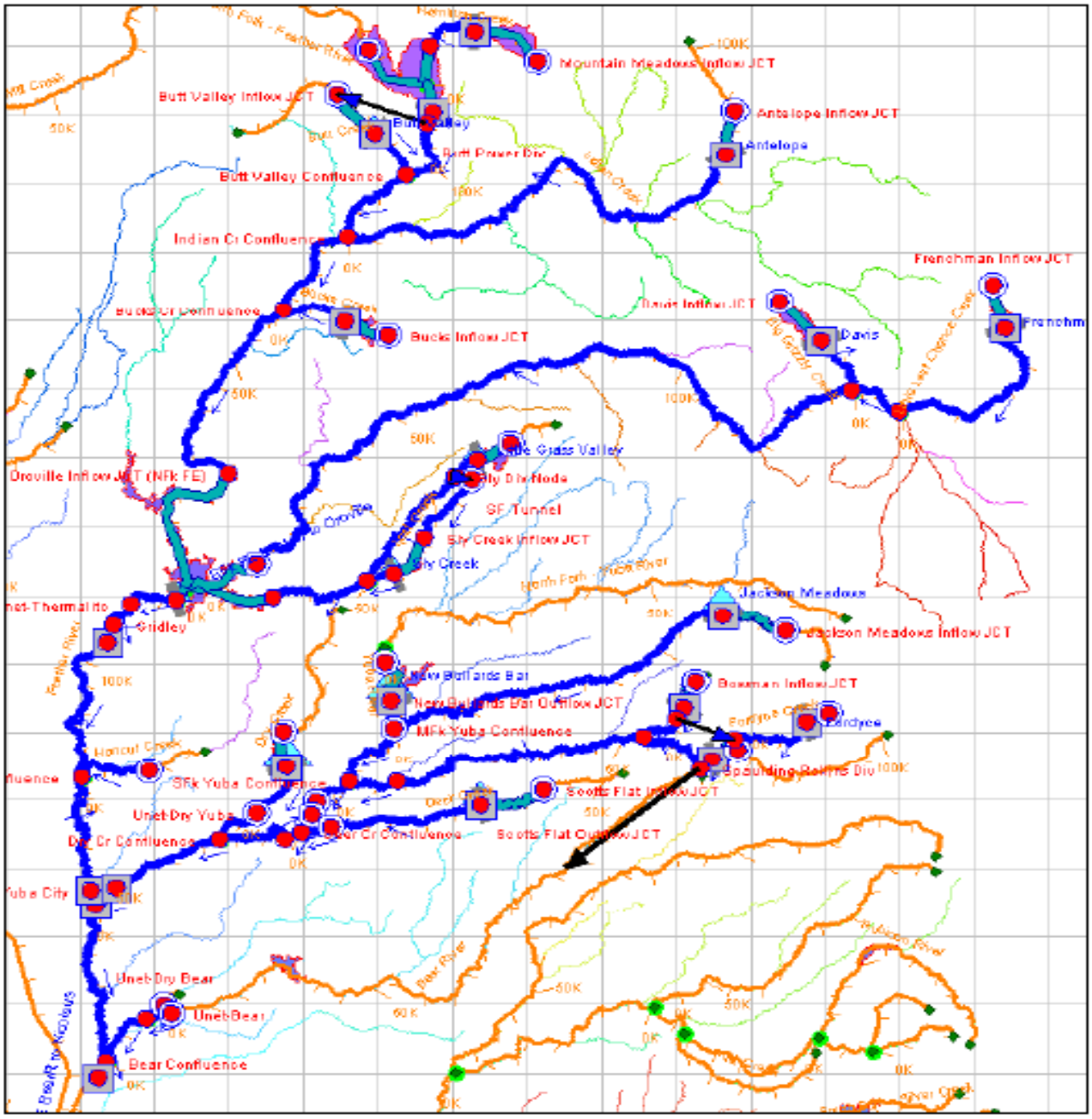
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

HYDROLOGIC ROUTING SCHEMATIC
LOWER BASIN RESERVOIRS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

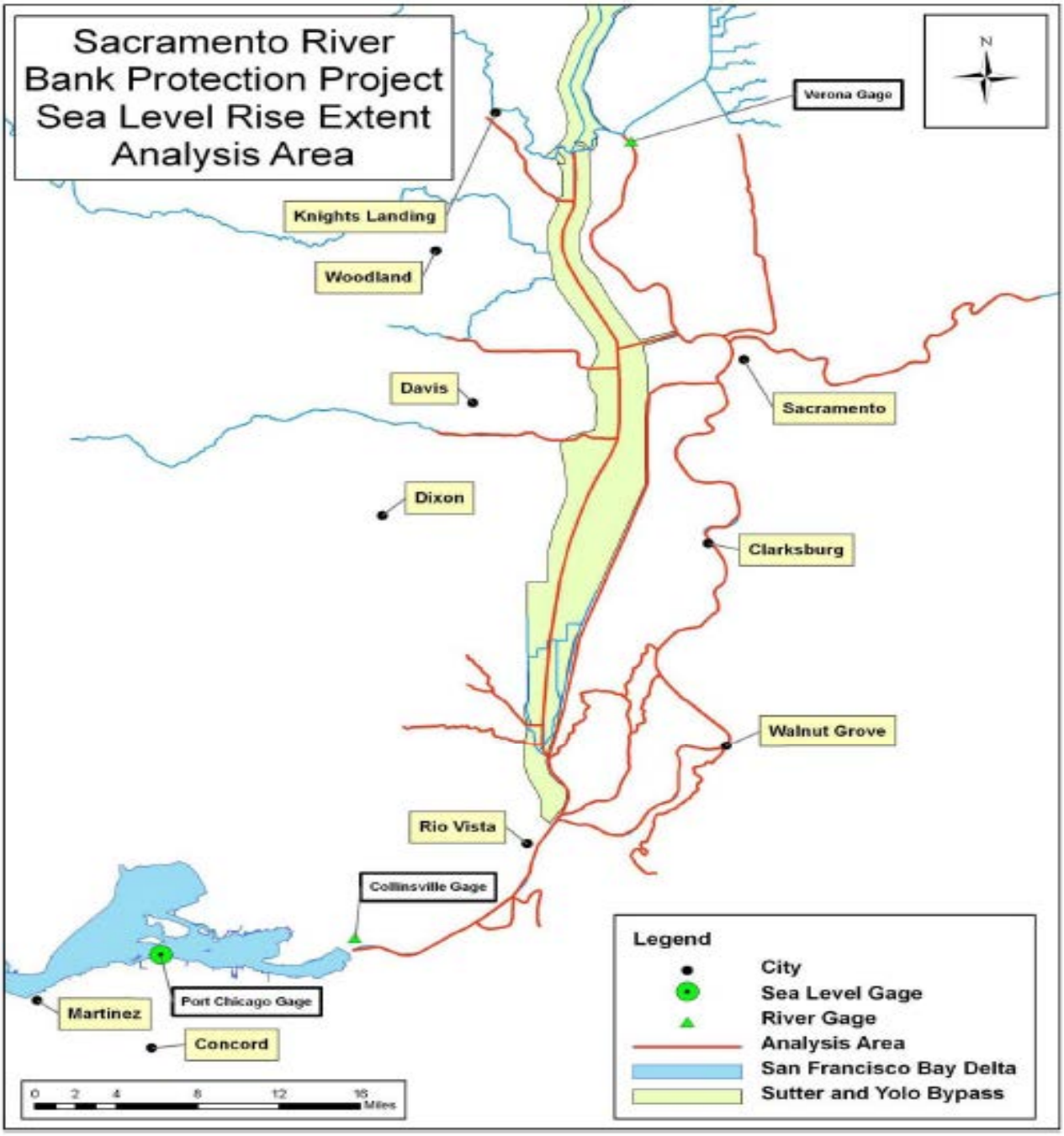


Source: Lower Feather River FPMS, 2004

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

ResSim Model Schematic

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

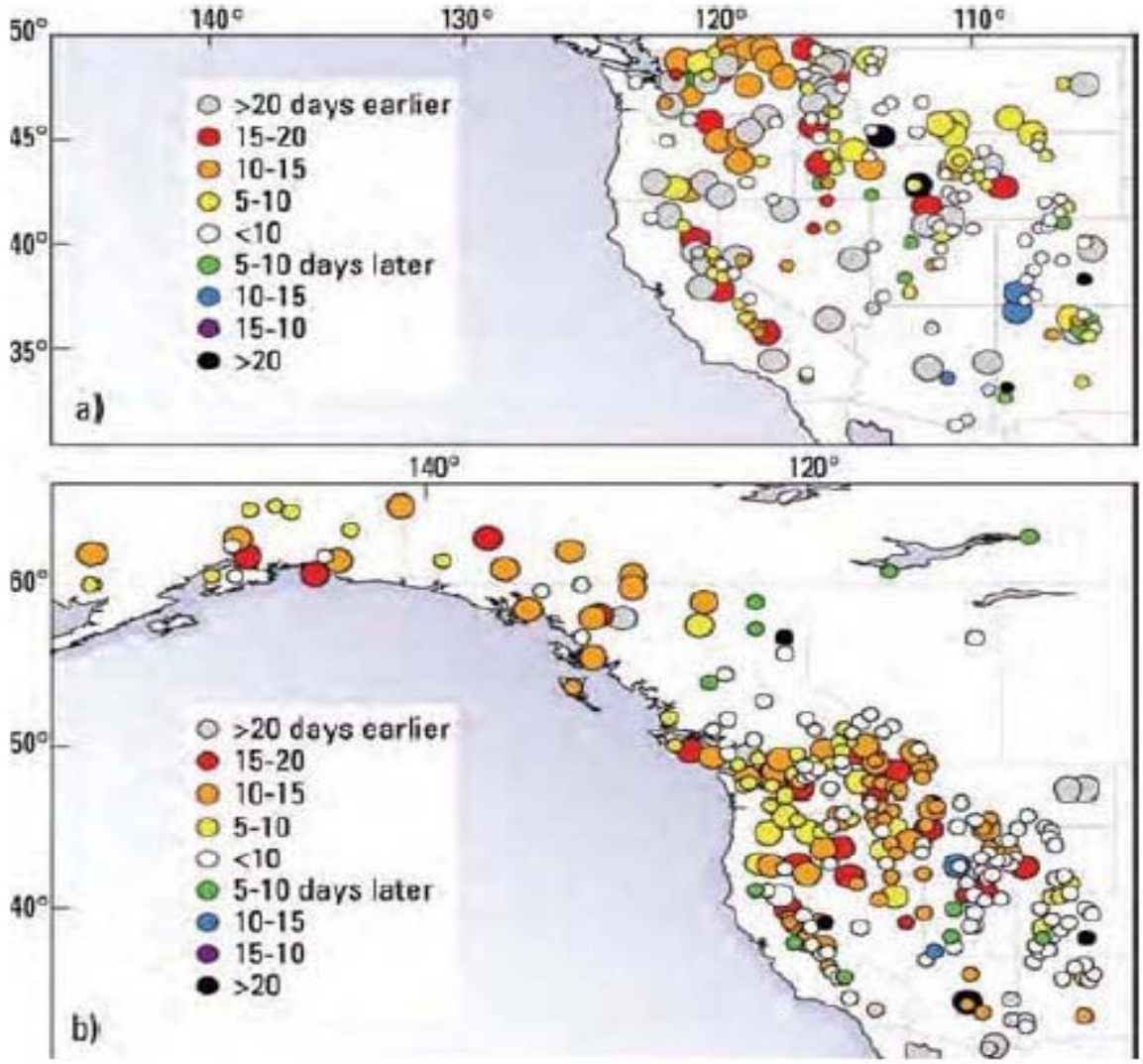


SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

Sea Level Rise Extent Analysis Area

Source: Sacramento Bank Protection Project, 2011

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



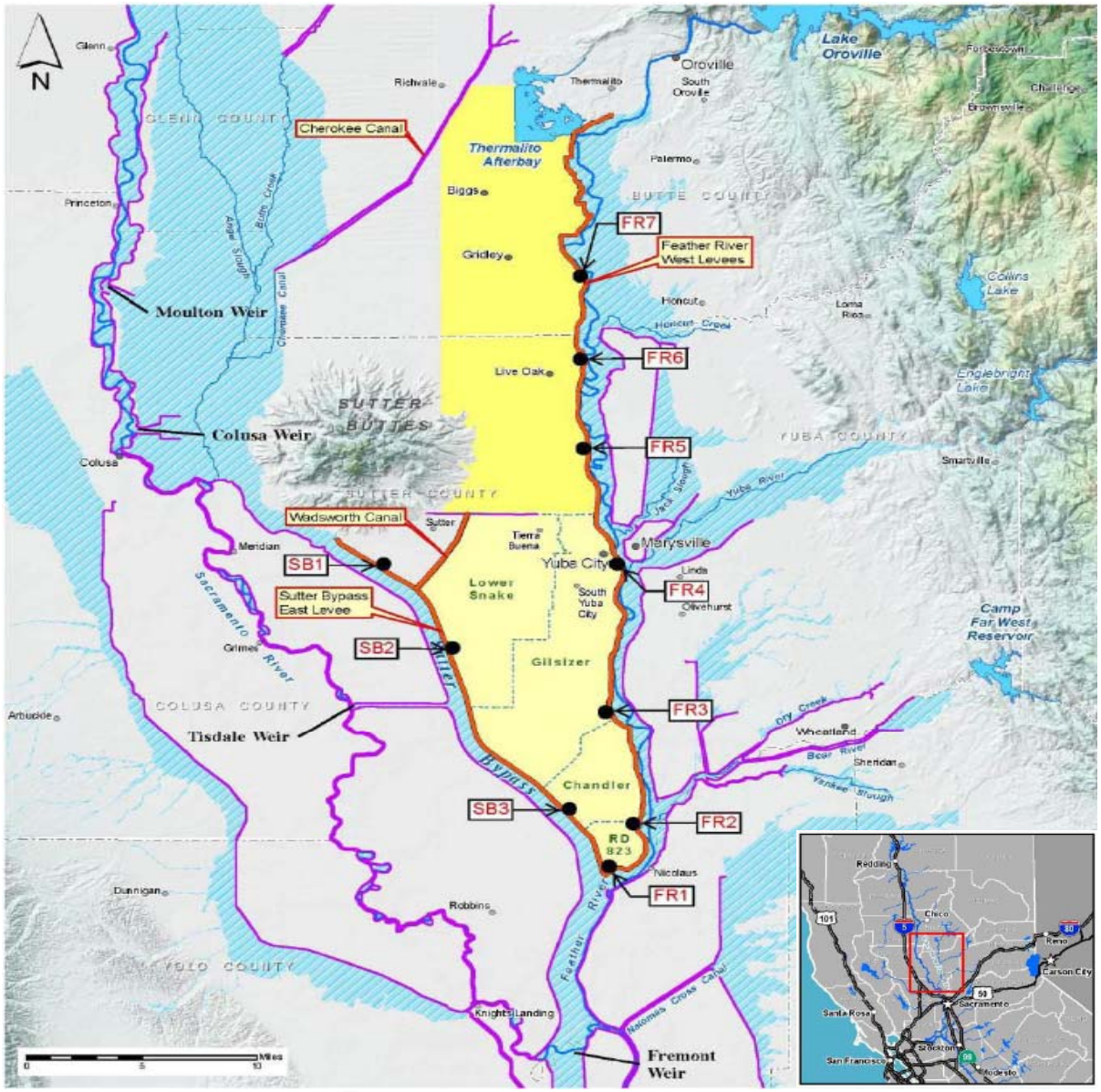
Trends in (a) yearly dates of spring snowmelt onset and (b) centers of volume of yearly streamflow hydrographs in rivers throughout western North America, based on U.S. Geological Survey streamgages in the United States and an equivalent Canadian streamflow network. Large circles indicate sites with trends that differ significantly from zero at a 90-percent confidence level; small circles are not confidently identified.

Source: USBR, Managing Water in the West, 2011.

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

Climate Change Trends

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Map Legend

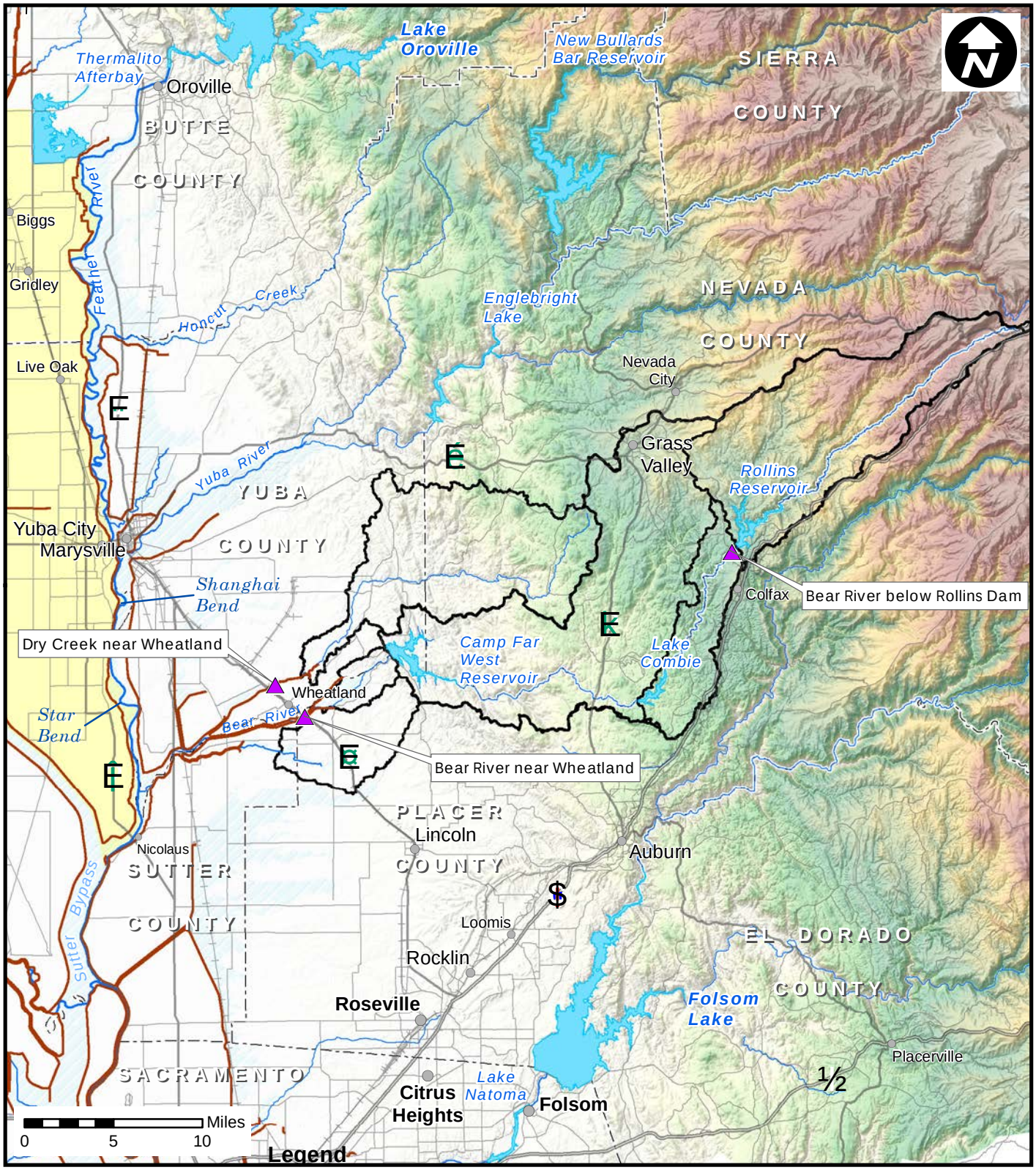
- Study Area
- Interior Drainage Area
- Selected Levees
- Federal Levee
- Runup Sites
- River or Stream
- Lake or Reservoir
- Designated Floodways
- County Boundary
- City or Town

Source: Ford, Wave Runup Analysis, 2011.

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

WAVE RUNUP STUDY AREA WITH INTERIOR DRAINAGE AREAS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Legend

USGS Stream Gages - CA

- USGS Stream Gages - CA
- Sutter Basin Study Area
- Watershed Boundary
- Designated Floodway
- Lake or Reservoir
- River or Stream
- Federal Levee
- Highway
- Major Road
- Railroad
- County Boundary
- City or Town

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

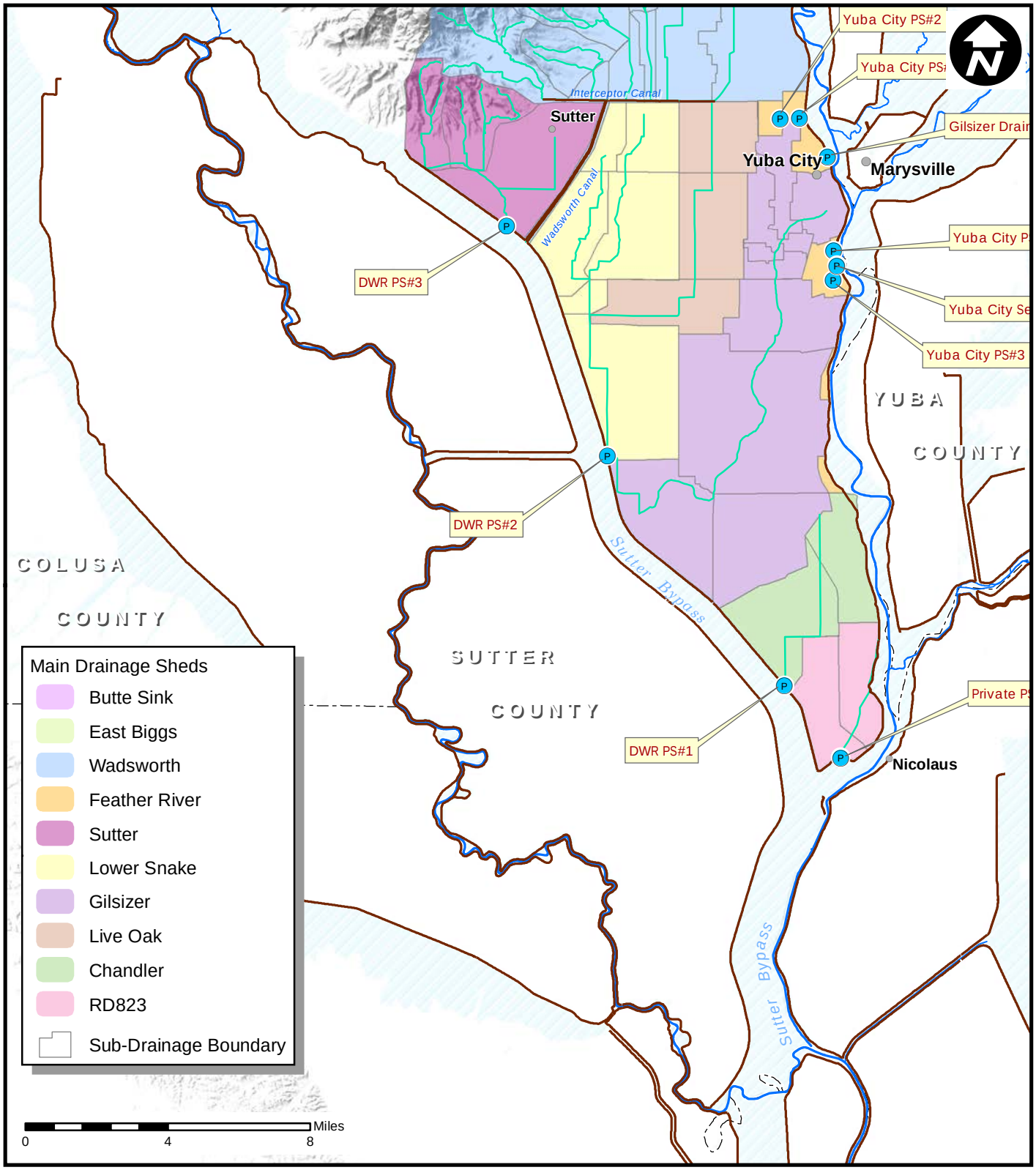
BEAR RIVER WATERSHED AND TOPOGRAPHY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 27



Legend

- Pump Station
- City or Town
- Drainage Flowline
- County Boundary
- River or Stream
- Federal Levee
- Lake or Reservoir
- Designated Floodway

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

HEC-HMS SUBBASINS and PUMP STATIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 28

Sutter Basin Feasibility Study

Sutter and Butte Counties, California

FLOOD RISK MANAGEMENT PROJECT

Hydraulic Design and Analysis
of
Final Alternatives

Hydraulic Analysis Section
Engineering Division
Sacramento District

12 April 2013 DRAFT

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Attachments

Attachment A. Memorandum for File: Sutter Basin Pilot Feasibility Study, Hydraulic Analysis of Refined Alternatives. 8 June 2012

Attachment B. Final Geotechnical Fragility Curves, February 2013.

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Acronyms and Abbreviations

ACE	Annual Chance of Exceedance
CNRFC	California Nevada River Forecast Center
CVFED	Central Valley Floodplain Evaluation and Delineation
CVFPP	Central Valley Flood Protection Plan
DWR	Department of Water Resources
FRM	Flood Risk Management
HEC	Hydrologic Engineering Center
HTOL	Hydraulic Top of Levee
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
NLDB	National Levee Database
NWS	National Weather Service
PBI	Peterson Brustad Incorporated
RD	Reclamation District
SD	Standard Deviation
SBFCA	Sutter Butte Flood Control Agency
TRLIA	Three Rivers Levee Improvement Authority
USGS	United States Geological Survey
USACE	United States Army Corps of Engineers
UPRR	Union Pacific Railroad
VE	Value Engineering

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1.0 Introduction

1.1 Purpose and Scope

The purpose of this report is to describe the hydraulic analysis conducted in support of the Sutter Basin Feasibility Study. This report documents the analysis of the final array of alternatives.

1.2 Background

The U.S. Army Corps of Engineers, together with the State of California and Sutter Butte Flood Control Agency (SBFCA) conducted this feasibility study to select a plan that reduces flood risk and provides ancillary Ecosystem Restoration and Recreation Benefits within the study area. The goal of the study is to identify a cost effective, technically feasible and locally acceptable project that best reduces flood risk and flood damages and complies with all Federal, State, and local laws and regulations.

1.3 Location

The Sutter Basin study area is located within the State of California approximately 25 miles north of Sacramento. A map of the watershed is included as Plate 1 and a map of the study area is included as Plates 2 and 3. The study area covers approximately 300 square miles and is approximately 43 miles north-south and 9 miles east-west. The study area includes the communities of Yuba City, Live Oak, Gridley, Biggs, and Sutter. Based on 2010 census data and floodplain mapping presented herein, approximately 95,000 people reside within the study area 0.2% (1/500) Annual Chance Exceedance (ACE) Floodplain. Yuba City is the largest community in the study area with a population of approximately 67,000 within the 0.2% (1/500) ACE Floodplain. A map of population density within the study area is provided in Plate 4 and tabulated in Table 1. The majority of land use in the study area is related to agricultural with Rice and Orchards comprising approximately 64.5% of land use. A map of land use types in the study area is presented in Plate 5 and tabulated in Table 2. The primary sources of flooding within the study area are the Butte Basin, Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal, and local interior drainage.

Table 1. 2010 Population, Sutter Basin Study Area

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	251
Yuba City Urban	0	67351	67368	67368	67368	67368	67368
Biggs Urban	0	19	1452	1452	1452	1452	1763
Gridley Urban	0	0	6379	6379	6379	6379	6379
Live Oak Urban	0	0	8362	8362	8362	8362	8362
Sutter County Rural	1089	4837	6260	6314	6323	6354	6378
Butte County Rural	0	9	4776	4788	4788	4793	4899
Total	1089	72216	94597	94663	94672	94707	95400

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Table 2. Land Use Types, Sutter Basin Feasibility Study Area

Land Use Type	Acres	Percent of Total
Abandoned	0	0.0
Burned Over Areas	0	0.0
Citrus and Subtropical	960	0.5
Deciduous Fruits and Nuts	61,230	31.2
Entry Denied	0	0.0
Field Crops	3,310	1.7
Grain and Hay Crops	4,520	2.3
Idle	4,800	2.4
Barren and Wasteland	50	0.0
Native Classes Unsegregated	0	0.0
Non-irrigated Idle	0	0.0
Riparian Vegetation	10,580	5.4
Not Surveyed	0	0.0
Native Vegetation	13,110	6.7
Water Surface	2,000	1.0
Pasture	5,810	3.0
Rice	65,360	33.3
Semi Agricultural and Incidental to Ag	2,620	1.3
Truck, Nursery and Berry Crops	3,080	1.6
Urban	6,410	3.3
Commercial	640	0.3
Industrial	1,490	0.8
Urban Landscape	600	0.3
Residential	5,120	2.6
Vacant	4,520	2.3
Vineyards	70	0.0
Outside	0	0.0
Total	196,260	100.0

Sources:
DWR 2004 Butte County Land Use Survey
DWR 2005 Sutter County Land Use Survey

1.4 Plan Selection Process

The final array of alternative plans described in this report were selected through a risk informed planning process involving multi-disciplinary analysis at increasing levels of detail. At each level of screening and analysis the level of detail was improved and the relative uncertainty was assessed. Measures and alternatives were carried forward if the level of detail was insufficient to screen it out.

Throughout this process the concept of absolute accuracy versus relative accuracy was considered in alternative comparisons. Although it would appear that every plan should be compared to the most accurate assessment of existing conditions, this is not necessary because the relative accuracy between plans is sufficient to select the most optimal plans to move forward.

Conceptual alternatives were developed from a broad array of measures at a qualitative level of detail. The conceptual alternatives were developed during a planning Charrette attended by the project sponsors and subject matter experts. Development of the conceptual alternatives is described in the Sutter Basin Feasibility Study report.

An array of draft alternatives were derived from the conceptual alternatives and evaluated at an increased level of detail. This level of detail included qualitative and quantitative engineering analyses. Analyses included floodplain hydraulic modeling, cost estimating, and economic

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benefit estimations. The level of detail was limited to that required to decide which plans to carry forward. Results were evaluated at a combined Value Engineering (VE) study and planning charette attended by the project sponsors and subject matter experts. At the conclusion of the VE and planning charette, refinements to the draft array of alternatives were identified for further, more detailed analysis. Selection of the draft array of alternatives is described in Progress Document 1.

Final alternatives were selected from the draft alternatives in the next level of detail. This level of detail included additional qualitative and quantitative engineering analyses. Analyses included refined channel hydraulic modeling, cost estimating, and economic benefit estimations. The level of detail was limited to that required to decide which plans to carry forward. Results were presented to the vertical team at Decision Point 2. At the conclusion of the Decision Point, a final array of alternatives was identified for further analysis. A summary of the hydraulic analysis performed for the draft array of alternatives is described in Attachment A. Additional details are described in internal memorandums on file within the Sacramento District Hydraulic Analysis Section.

1.5 Datum

As required by ER 1110-2-8160 all elevations provided herein are referenced to the NAVD88 vertical datum. All horizontal data provided herein are referenced to the North American Horizontal Datum of 1983 (NAD83) Horizontal datum. All horizontal coordinates are projected to the California State Plane Zone II coordinate system. River miles presented in this study are based on the Sacramento San Joaquin Comprehensive study. Project stationing presented in this study is based on the Feather River West Levee Project Stationing defined by SBFCA.

Historical elevation data were converted to NAVD88 from their original legacy reference datum. The method of conversion followed the requirements in ER 1110-2-8160 and the uncertainty in the conversion is accounted for in the study results.

The following generalized conversion is provided to compare NAVD88 elevations provided in this study to previous studies presented in the legacy NGVD29 datum. Expressed as an equation, Elevation (NGVD29) = Elevation (NAVD88) minus 2.40 feet. The conversion between NAVD88 and NGVD29 ranges from 2.3 to 2.4 feet in the study area.

2.0 Study Area

2.1 Watershed

The Sutter Basin study area is situated within the Sacramento River watershed. A map of the Sacramento River watershed is included as Plate 1. The principle watersheds upstream of the study area are the Sacramento River watershed and Feather River watershed. The Sacramento River watershed encompasses the McCloud River, Pit River, and Goose Lake, and Stony Creek. The watershed drains the Sierra Nevada Mountains and Cascade Ranges in the east and the Coast Range and Klamath Mountains in the west. The Feather River watershed encompasses the Yuba River and Bear Rivers. These watersheds drain the eastern slopes of the Sierra Nevada mountain range. The drainage area of the Sacramento River basin upstream of the study area is approximately 12,000 square miles. The drainage area of the Feather River upstream of the study area (including the Yuba and Bear Rivers) is approximately 5,900 square miles.

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2.2 Topography

A topographic map of the study area is presented in Plate 2. Elevations within the study area range from 110 ft NAVD88 in the north to 30 ft NAVD88 in the south. The study area has a general slope from northeast to south west. The general slope of the study area is interrupted by two major embankment features which impact hydraulic conveyance within the floodplain. The raised embankment of the Union Pacific Railroad traverses the study area in a north south alignment and the Sutter Bypass east levee traverses the study area in a north south alignment.

2.3 Flood Sources

The Sutter Basin Study area is susceptible to flooding from multiple sources including Butte Basin, Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal, and interior sources.

a. Butte Basin. The northwest portion of the study area is within the Butte Basin. The Butte Basin is a natural overflow and flood storage area north west of the Sutter Buttes and east of the Sacramento River. The basin provides approximately 1 million acre-feet of transitory storage at flood stage (DWR, 2010). Excess floodwaters from the Sacramento River enter the Butte Basin via overbank areas along the river and through the Moulton and Colusa weirs. Butte Creek and its tributaries, including Cherokee Canal, also flow into the Butte Basin. Outflow from the Butte Basin is naturally regulated by hydraulic conditions of Butte Slough and floodplain topography at the upstream entrance to the Sutter Bypass. In order to maintain the flood storage capabilities within Butte Basin, California has included regulation of the overflow area in Title 23 of the California Code of Regulations. In general these standards require approval from the board for any encroachments that could reduce or impede flood flows or would reclaim any of the floodplain within the Butte Basin (DWR, 2010).

b. Sutter Bypass. The southwest portions of the study area including the southern portion of Yuba City are susceptible to flooding from the Sutter Bypass. The Sutter Bypass is a leveed flood control channel approximately three quarters of a mile wide, bordered on each side by levees. The bypass is an integral feature of the Sacramento River Flood Control Project's Flood Bypass System. The Sutter Bypass conveys flood waters from the Butte Basin, Sacramento River, and Feather Rivers to the confluence of the Sacramento River and Yolo Bypass at the Fremont Weir.

Downstream of the Feather River the bypass is separated into two conveyance areas by a low levee. The area east of the middle levee conveys flows from the Feather River. This design maintains higher velocities and sediment transport capacity within the Feather River during low flow events while utilizing the large conveyance of the Sutter Bypass during larger events.

The Sutter Bypass also receives minor natural flow and agricultural return flow from Reclamation District 1660 to the west and from Wadsworth Canal and DWR pumping plants 1, 2, and 3 to the east. The Sutter Bypass is described by four hydrologic reaches based on tributary inflows; Butte Slough to Wadsworth Canal, Wadsworth Canal to Tisdale Bypass, Tisdale Bypass to Feather River, Feather River to Sacramento River.

c. Feather River. Nearly the entire study area is susceptible to flooding from the Feather River. The Feather River is a major tributary to the Sacramento River, merging with the Sutter

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Bypass upstream from the Sacramento River and Fremont Weir. The Yuba and Bear Rivers are major tributaries to the Feather River. Two major flood management reservoirs are located within the Feather River watershed. Oroville Dam and reservoir was completed on the Feather River in 1967. The reservoir has 3,358,000 acre-feet of storage with 750,000 acre-feet of dedicated flood management space. New Bullards Bar dam and reservoir was completed on the Yuba River 1970. The reservoir has 966,000 acre-feet of storage with 170,000 acre-feet of dedicated flood management space. The Feather River is described by four hydrologic reaches based on significant inflows; Thermalito to Honcut Creek, Honcut Creek to Yuba River, Yuba River to Bear River, and Bear River to Sutter Bypass.

d. Cherokee Canal. The northern portion of the study area is susceptible to flooding from Cherokee Canal which is a tributary to Butte Creek and the Butte Basin. The leveed canal was constructed between 1959 and 1960 by USACE under the authorization of the Flood Control Act of 1944. The canal drainage area is 94 square miles and varies in elevation from 70 feet to 2200 feet. The drainage area is bounded by the Feather River watershed to the east and southeast, Butte Creek and its tributaries to the north and west, and by Wadsworth Canal drainage to the south. The design capacity along the Cherokee Canal is 8,500 cubic feet per second (cfs) upstream of the junction with Cottonwood Creek, 11,500 cfs from the junction with Cottonwood Creek to the Biggs Princeton Highway (Afton Road) and 12,500 cfs from the Biggs Princeton Highway to Butte Creek. Based upon the flood frequency analysis at the time of design, the canal was estimated to provide flood protection from a 4% (1/25) ACE event and mitigated sediment transport problems within its watershed.

e. Wadsworth Canal and associated Interceptor canals are potential sources of flooding in the southwest portion of the study area. The Wadsworth Canal system is a feature of the Sacramento River Flood Control Project and consists of leveed channels that carry rainfall and agricultural runoff from 91 square miles of northeast part of Butte and Sutter Counties south to the Sutter Bypass.

(1) West Interceptor Canal. The West Interceptor Canal begins near the town of Sutter and extends 1.8 miles east to Wadsworth Canal. The canal is approximately 30 feet wide and includes a 4 to 5 foot tall Federal Project levee along its right bank. There is no federal levee along the left bank of the canal. The slope of the canal is approximately 25 feet per mile. The purpose of the canal is to intercept rainfall runoff that would otherwise pond against the eastern levee of the Sutter Bypass. The intercepted flow is diverted into the Wadsworth Canal where it is then conveyed to the Sutter Bypass. During extreme floods the peak flow of the canal would be significantly attenuated by the floodplain storage available along the left bank. The canal is also used for irrigation water. The operations and maintenance manual does not list a design flow for the West Interceptor canal.

(2) East Interceptor Canal. The East Interceptor Canal begins near Yuba City and extends 3.1 miles east to the Wadsworth Canal. The canal is approximately 30 foot wide and includes a 4 to 5 foot tall Federal Project levee along its left bank. The purpose of the canal is to intercept rainfall runoff that would otherwise flow southwest and pond against the eastern levee of the Sutter Bypass. There is no federal levee along the right bank of the canal. The slope of the canal is negligible and the top of levee has a level grade. The intercepted flow is diverted it into

the Wadsworth Canal where it is then conveyed to the Sutter Bypass. During extreme floods the peak flow of the canal would be significantly attenuated by the floodplain storage available along the right bank. The canal is also used for irrigation water during the summer irrigation season. The operations and maintenance manual does not list a design flow for the East Interceptor canal.

(3) Wadsworth Canal. Wadsworth Canal begins at the East and West Interceptor Canals near Butte House Road. The canal extends 4.5 miles south to the Sutter Bypass and includes Federal Project Levees along the left and right banks. The canal is a fairly uniform trapezoidal type channel. The purpose of the canal levee is to collect and convey rainfall runoff and irrigation water from the East and West Interceptor Canals to the Sutter Bypass. The existing Operations and Maintenance Manual for Wadsworth Canal describes a design capacity of 1,500 cfs.

f. Interior Drainage. Runoff from the interior of the study area may result in localized flooding. Interior drainage features include canals and streams tributary to Wadsworth Canal and pumps and culverts along the project levees.

2.4 Stream Gages.

A list of stream gages applicable to the study area is provided in Table 3. The stream gages are operated by the United States Geological Survey (USGS) and California Department of Water resources. Steam gages are shown on Plate 6.

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Table 3 Stream Gages, Sutter Basin Study Area

Gage Name	Area (Sq Mi)	Agency	Gage Number	Period of Record	Type
Bear R Nr Wheatland Ca	292	USGS	11424000	1928-2010	S,Q
Bear River at Pleasant Grove	300	DWR	A06535	1987-2010	S,Q
Butte Creek near Gridley	NA	DWR	A04150	1991-1999	S,Q
Butte Slough at Outfall Gates near Colusa	NA	WDL	A02967	1992-2010	S
Butte Slough near Meridian	NA	WDL	A02972	1981-2010	S,Q
Cherokee Canal nr Gridley	NA	DWR	A00910	1991-1998	S,Q
Cherokee Canal nr Richvale	NA	DWR	A02984	1976-2010	S,Q
Camp Far West Reservoir	NA	DWR	A65105	1998-2010	Q
Colusa Weir Spill to Butte Basin near Colusa	NA	WDL	A02981	1975-2010	S,Q
Deer C Nr Smartville CA	84.6	USGS	11418500	1935-2010	S,Q
Feather River at Nicholaus	5,921	DWR	A05103	1942-2010	S,Q(P)
Feather River at Oroville	3,624	USGS	11407000	1902-2010	S,Q
Feather River at Yuba City	3,974	DWR	A05135	1964-2010	S
Feather River near Gridley	3,676	DWR	A05165	1964-2010	S,Q
Moulton Weir Spill to Butte Basin nr Colusa	NA	DWR	A02986		
Sacramento R at Ord Ferry	12,030	DWR	A02570	1922-2010	S,Q
Sacramento R at Colusa Ca	12,090	USGS	11389500	1941-2010	S,Q
Sacramento R at Verona Ca	21,251	USGS	11425500	1929-2010	S,Q
Sacramento R Blw Wilkins Slough nr Grimes Ca	12,915	USGS	11390500	1931-2010	S,Q
Sacramento River at Butte Slough Outfall Gates	NA	DWR	A02400	1992-2004	S
Sacramento River at Fremont Weir (East)	NA	DWR	A02160	1935-2010	S
Sacramento River at Fremont Weir (West)	NA	DWR	A02170	1934-2010	S
Sacramento River at Knights Landing	14,535	DWR	A02200	1982-2010	S
Sacramento Slough near Karnak	NA	DWR	A02925	1981-2010	S
Sutter Bypass at R.D. 1500 P.P. near Karnak	NA	DWR	A02927	1975-2010	S
Sutter Bypass Channel at Pumping Plant #1	NA	DWR	SB1	2008-2010	S
Sutter Bypass Channel at Pumping Plant #2	NA	DWR	SB2	2008-2010	S
Sutter Bypass Channel at Pumping Plant #3	NA	DWR	SB3	2008-2010	S
Tisdale Weir near Grimes	NA	DWR	A02960	1975-2010	S,Q
Willow Slough near Nicolaus	NA	DWR	A02943	1991-2010	S
Yolo Bypass nr Woodland Ca	NA	USGS	11453000	1939-2011	S,Q
Yuba R blw Englebright Dam near Smartsville	1,108	USGS	11418000	1941-2011	S,Q
Yuba R Nr Marysville CA	1,339	USGS	11421000	1940-2011	S,Q
Wadsworth Canal near Sutter (lower)	96	DWR	A05927	1982-1997	S,Q
Wadsworth Canal near Sutter (upper)	96	DWR	A05929	1976-1997	S,Q
Note: S-Stage, Q-Discharge, NA- Not Available, (Partial Record)					

2.5 Historical Floods.

The Feather River near Oroville gage provides an indicator of large historical floods within the study area. The largest fifteen floods from 1951 to 2010 are presented in Table 4. The magnitudes of historical floods prior to 1967 are not directly comparable to later floods due to significant historical changes in the flood management system. In order to provide a comparison of similar hydrologic conditions, the table includes the estimated unregulated flow for each water year. The ranking of unregulated floods is substantially different than observed flood flows with the 1997 flood being the largest unregulated flood from 1951 to 2010. The following is a description of significant flood events within the study area.

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Table 4
Fifteen Largest Annual Maximum Floods
WY1951-WY2010, Feather River at Oroville

Measured				Regulated Peak Flow (CFS)	Unregulated Peak Flow (CFS)	Notes
Annual Ranking	Water Year	Date of Peak	Peak Flow (CFS)			
1	1956	12/23/1955	203,000	150,000	203,000	
2	1963	1/31/1963	191,000		191,000	
3	1997	1/2/1997	161,000	161,000	312,900	
4	1965	12/23/1964	158,000	150,000	260,000	Note 1
5	1960	2/8/1960	135,000		135,000	
6	1986	2/18/1986	134,000	134,000	217,000	
7	1953	1/9/1953	113,000		113,000	
8	1958	2/24/1958	102,000		102,000	
9	1951	11/21/1950	92,100		92,100	
10	1957	2/24/1957	83,100		83,100	
11	1995	3/14/1995	71,700	71,700	134,200	
12	1980	1/15/1980	69,500	69,500	137,600	
13	2006	12/31/2005	65,600	65,600		
14	1952	2/1/1952	59,500		59500	
15	1970	1/25/1970	56,300	56,300	117,700	
Note 1/ Dec 1964 Flood regulated by a partially completed Oroville Dam.						

a. December 1955. The December 1955 flood was the largest peak flow recorded at the Feather River at Oroville gage from 1951 to 2010. Major damage to the study area occurred in December 1955 when the west levee of the Feather River breached near Shanghai Bend killing 38 people. The peak flow measured at the Feather River at Oroville stream gage was 203,000 cfs. This flood occurred prior to construction of Oroville Dam (completed 1967) and New Bullards Bar Dam (completed 1970). Therefore, the flood does not reflect existing hydrologic conditions. A hypothetical flood routing of the 1955 flood is presented in the Oroville Dam and Reservoir water control manual. The flood routing indicates the reservoir would have regulated the peak outflow to 150,000 cfs.

b. December 1964. The December 1964 flood was the fourth largest peak flow recorded at the Feather River at Oroville gage from 1951 to 2010. The main center of precipitation was in the Feather, Yuba, and American River Basins. Rainfall was heaviest on December 22 and 23 1964. Runoff from streams of the Coast Ranges, almost without exception produced peak stages and peak flows that exceeded previous records. Runoff from the Sierra Nevada into the Feather, Yuba and American Rivers surpassed all previous records. This flood occurred during construction of Oroville Dam and was partially regulated to an outflow of 158,000 cfs. A hypothetical flood routing of the 1964 flood is presented in the Oroville Dam and Reservoir water control manual. The flood routing indicates the completed reservoir would have regulated the peak outflow to 150,000 cfs. Had it not been regulated, the peak flow would have been approximately 260,000 cfs which would have exceeded the 1955 flood peak by 57,000 cfs.

b. November 1982 - March1983. Water year 1983 was a result of the “El Niño” weather phenomenon. Northern and Central California experienced flooding incidents from November through March due to numerous storms. In early May, snow water content in the Sierra exceeded

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230 percent of normal, and the ensuing runoff resulted in approximately four times the average volume for Central Valley streams. System failures in the Sacramento River Basin were limited to a private levee on the Sacramento River and one failure on Cache Creek.

c. February 1986. Flooding in 1986 resulted from a series of four storms over a 9-day period during February. Rains from the first three storms saturated the ground and produced moderate to heavy runoff before the arrival of the fourth storm. Precipitation at Four Trees in the Feather River Basin set both a 24-hour rainfall record for the Sierra Nevada and the monthly record for any station in the State. During the flood, the left levee of the Yuba River failed just upstream of the Feather River confluence. The communities of Linda and Olivehurst were inundated, resulting in one death, 895 destroyed homes, and 150 destroyed businesses.

d. January 1995. "El Nino" conditions in the Pacific forced major storm systems directly into California during much of the winter and early spring of 1995. The largest storm systems hit California in early January and early March. The major brunt of the January storms hit the Sacramento River Basin and resulted in small stream flooding primarily due to storm drainage system failures.

e. January 1997. December 1996 was one of the wettest Decembers on record. Watersheds in the Sierra Nevada were already saturated by the time three subtropical storms added more than 30 inches of rain in late December 1996 and early January 1997. The third and most severe of these storms lasted from December 31, 1996, through January 2, 1997. Rain in the Sierra Nevada caused record flows that stressed the flood management system to capacity in the Sacramento River Basin and overwhelmed the system in the San Joaquin River Basin. During the flood, the left levee of the Feather River failed near Arboga, killing one person, destroying 180 homes and businesses, and prompting evacuation of about 15,000 people from Linda and Olivehurst. Nearly 50,000 people from Yuba City, Marysville, and surrounding areas were evacuated because of fears of additional levee breaks (USACE, 1998).

f. December 2005 - January 2006. Between 28 December 2005 and 9 January 2006, the State of California experienced a series of severe storms which impacted the levees within the Sacramento District's boundaries. Water rose a second time in April 2006, and remained high in some parts of the system until June. Many rivers and streams within the Sacramento and San Joaquin River systems ran above flood stage during these events, and there were significant erosion and seepage problems with the levees. The State of California Department of Water Resources and/or their maintaining agencies conducted the actual flood fight activities while the U.S. Army Corps of Engineers provided technical assistance to the State.

2.5 Climate Change.

The primary impacts of climate change on Flood Risk Management projects are related to changes in flood frequency estimates, changes in sea level, and their associated uncertainties. The primary climate change consideration within the study area is related to the potential changes in flood frequency estimates. An evaluation project performance related to changes in climate and flood frequency estimates was conducted using the HEC FDA program and is described in the Economics Appendix. Appendix C of EC 1165-2-212 provides a flow chart for

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evaluating sea level change for a potential project. Based on Step 1 of the flow chart, an evaluation of sea level rise is not required. The study area is approximately 30 feet above mean sea level. Base on sea level trends provided in EC 1165-2-212. Sea level rise would have no impact on the study area up to the year 2100.

3.0 Alternative SB-1 (Without Project Conditions)

3.1 Project Assumptions

a. Levee Design. All existing federal levees are assumed to be maintained to the 1957 design top of levee. The 1957 design top of levee is based on the 1957 design water surface profiles and the minimum freeboard specified in the 1951 Operations and Maintenance Manuals. The 1957 design water surface profile is described on the drawing set, Sacramento River Flood Control Project, California, Levee and Channel Profiles, Drawing File Number 50-10-3334, 15 March 1957. The 1957 design water surface is labeled on the drawing set as the Project Design Flood Plane.

The derivation of the 1957 water surface profiles is described in the memorandum "Levee and Channel Profiles, Sacramento River Flood Control Project" dated 1 July 1957. The 1957 design freeboard is described in the Operations and Maintenance manuals dated 1951. The Sacramento River Flood Control Project adopted multiple existing levees of varying height. The Operations and Maintenance manuals indicates the adopted levee segments met or exceeded the design freeboard. The 1957 design profile and freeboard are described in detail in memorandum on file in the Sacramento District Hydraulic Analysis Section.

b. TRILIA Feather River Setback Levee. The hydraulic analysis of without project conditions includes the setback levee along the left bank of the Feather River constructed by the Three Rivers Levee Improvement Authority (TRILIA).

c. Feather River Star Bend Setback Levee. The without project conditions assumes the levee setback levee on the right bank near Star Bend has not been constructed.

d. Interior Drainage Facilities. The hydraulic analysis assumes all drainage facilities are maintained to their design capacities.

e. Operation and Maintenance. The hydraulic analysis assumes vegetation conditions within the channel will be maintained with similar hydraulic conditions as the existing conditions.

3.2 Hydrology

a. Sutter Bypass, Feather River and Butte Basin. Hydrology for the Sutter Bypass, Feather River, and Butte Basin was based on the Sacramento-San Joaquin Comprehensive study (Comp Study) and Lower Feather River Floodplain mapping study. The Sacramento-San Joaquin Comprehensive study included the entire Sacramento and San Joaquin Valleys. The Lower Feather River Floodplain mapping study was based on the Comprehensive study but included revisions to flow frequencies and hydrographs on the Feather River. Balanced 30-day regulated

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flow hydrographs developed for 50% (1/2) ACE, 10% (1/10) ACE, 4% (1/25) ACE, 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE, and 0.2% (1/500) in the hydraulic analysis.

The synthetic hydrology investigated unregulated flood frequencies at mainstem and tributary locations throughout the Sacramento Basin. The flood frequency analysis involved evaluations of long term historical records at the stream gages. The unregulated flow frequency statistics and period of record for the Sacramento River at Bend Bridge, Feather River at Oroville, and Feather River at Shanghai Bend were used to estimate hydrologic uncertainty in the Sutter Basin Feasibility Study. The adopted statistics and period of record for the unregulated conditions are provided in Tables 5, 6, and 7.

Table 5
Rain Flood Frequency, Sacramento River at Ord Ferry
Unregulated Conditions

Flood Duration	Adopted Log Mean	Adopted Log Standard Deviation	Adopted Log Skew	Record (Years)	
				Years Evaluated	Years Used
1-Day	5.009	0.281	0.0	1922-1997 (1977 censored)	75
3-Day	4.939	0.281	0.0	1922-1997 (1977 censored)	75
5-Day	4.866	0.279	-0.1	1922-1997 (1977 censored)	75
10-Day	4.809	0.278	-0.1	1922-1997 (1977 censored)	75
15-Day	4.680	0.267	-0.3	1922-1997 (1977 censored)	75
30-Day	4.562	0.258	-0.3	1922-1997 (1977 censored)	75
1977 censored as a low outlier					

Table 6
Rain Flood Frequency, Feather River at Oroville
Unregulated Conditions

Flood Duration	Adopted Log Mean	Adopted Log Standard Deviation	Adopted Log Skew	Record (Years)	
				Years Evaluated	Years Used
Peak	4.743	0.390	-0.2	11 years	11
1-Day	4.639	0.390	-0.2	1901-1997	97
3-Day	4.533	0.392	-0.2	1901-1997	97
7-Day	4.387	0.377	-0.3	1901-1997	97
15-Day	4.250	0.351	-0.4	1901-1997	97
30-Day	4.129	0.326	-0.4	1901-1997	97

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Table 7
Rain Flood Frequency, Feather River at Shanghai Bend
Unregulated Conditions

Flood Duration	Adopted Log Mean	Adopted Log Standard Deviation	Adopted Log Skew	Record (Years)	
				Years Evaluated	Years Used
Peak	4.951	0.402	-0.3	1904-1997	94
1-Day	4.857	0.402	-0.3	1904-1997	94
3-Day	4.733	0.404	-0.3	1904-1997	94
7-Day	4.582	0.387	-0.3	1904-1997	94
15-Day	4.443	0.363	-0.4	1904-1997	94
30-Day	4.321	0.340	-0.4	1904-1997	94

Seven storm centerings were formulated in the Comp Study to represent the many different possibilities of aerial storm distributions and antecedent watershed conditions. For each centering, synthetic 30-day natural flow hydrographs were computed at locations throughout the Central Valley. Typically, each tributary basin contained one hydrograph location. Many of these sites were inflow points to major flood management projects (i.e., Feather River at Oroville Dam). These natural flow hydrographs represent flood time series produced by a wholly unimpaired drainage area. The unimpaired hydrographs do not reflect the influence of headwater reservoirs. The hydrographs were balanced so the average flow for all durations matched the given frequency. For example, the peak, 1-day, 3-day, 5-day, 15-day, and 30-day volumes match the given frequency event.

A 3-step process was required to conduct simulations of reservoir regulations for each storm centering. To begin the sequence, the headwaters reservoirs upstream of the flood control reservoirs were simulated. Then, using the resulting storage time series for select headwater facilities, top of conservation storage for those flood damage reduction projects with established credit space agreements were computed. Next, using the results of the headwater simulations and the computed top of conservation series, the lower basin reservoir models were simulated, thereby completing the reservoir simulation procedure.

A regulated set of hydrographs was obtained from “hand off” points in the lower basin reservoir simulation model. These hydrographs were used as the input to the HEC-RAS unsteady flow models in the feasibility study. A review of the seven storm centerings found that peak stages along the Sutter Bypass and Feather Rivers are generated by either the Sacramento River storm centering or Shanghai Bend storm centering. Therefore, these are the only two centerings modeled in the feasibility study. In order to determine the peak stage for a given frequency event both storm centerings are modeled. The set of unregulated flow hydrographs provided at hydraulic model boundary locations shown on Plate 6 and listed in Table 8.

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Table 8 Regulated Boundary Condition Hydrographs

Model Boundary	Name
1	BEAR RIV BLW CAMP FAR WEST
2	BEST SLOUGH AT FORTY MILE ROAD
3	BUTTE SLOUGH AT WEST BUTTE ROAD
4	CACHE C A YOLO CA (#11452500)
5	YUBA - DRY CREEK AT HWY 20
6	BEAR RIVER - DRY CREEK AT JASPER LN
7	FEATHER RIVER AT OROVILLE (#11407000)
8	HONCUT CREEK AT HWY 70
9	JACK SIMMERLY AT WOODRUFF LN
10	KLRC AT KNIGHTS LANDING
11	NATOMAS CROSS CANAL AT GARDEN HWY
12	SACRAMENTO R A COLUSA CA (#11389500)
13	SACRAMENTO R A VERONA CA (#11425500)
14	UP INTERCEPT SA REEDS
15	WADSWORTH CANAL AT HWY 20
16	YANKEE SLOUGH AT SWETZER ROAD
17	YOLO BYPASS NR WOODLAND CA (#11453000)
18	YUBA RIVER AT RS 13.84

b. Wadsworth Canal. Flow frequency analysis for Wadsworth Canal is described in the Feasibility Study Hydrology Appendix. Wadsworth canal is an unregulated stream. The Wadsworth Canal unregulated frequency curve was developed from graphical frequency analysis of gage records at Wadsworth Canal near Sutter (DWR stream gage A05929) following Bulletin 17B guidelines. The analysis was based on mean daily flows from 1939 to 1996. The years 1976 and 1977 were screened as low outliers and were not used in the analysis. The peak flow frequency was estimated from the mean daily flows. A 37 year equivalent period of record is recommended for the peak flow frequency to account for the additional hydrologic uncertainty. A table of peak unregulated flows for Wadsworth Canal is provided in Table 9. These flows represent a storm centered over the Wadsworth canal drainage area.

Table 9
Flow Frequency, DWR Gage Wadsworth Canal near Sutter

Peak Discharge by ACE (cfs)						
50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
820	2,250	3,200	4,000	4,830	5,750	7,070

The water surface profile of Wadsworth Canal is influenced by inflow from the East and West Interceptor Canals and the coincident downstream stage in the Sutter Bypass. Inflow from Wadsworth canal is approximately 1% of the flow in the Sutter Bypass. Therefore, inflow from Wadsworth Canal has negligible impact on stages in the Sutter Bypass during the flood season. Stage and flow frequency estimates for the Sutter Bypass were obtained from the Sutter Bypass and Feather River model. Peak flow and stage frequency estimates are provided in Tables 10 and 11 respectively.

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Table 10
Flow Frequency, Sutter Bypass below Wadsworth Canal

Scenario	Peak Flow (FT-NAVD88)						
	50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
A. No Overtopping or Failure	57,600	102,800	127,200	156,100	185,400	229,500	328,900
B. Overtopping without Failure	Same	Same	Same	Same	Same	228,300	255,000
HEC-RAS model, Sutter Bypass, Wads-Tisdale, Section 84.14							

Table 11
Stage Frequency, Sutter Bypass at Wadsworth Canal Confluence

Scenario	Peak Stage (FT-NAVD88)						
	50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
A. No Overtopping or Failure	46.87	50.64	52.75	54.42	56.19	58.53	63.21
B. Overtopping without Failure	Same	Same	Same	Same	Same	58.45	59.82
HEC-RAS model, Sutter Bypass, Wads-Tisdale, Section 84.14							

c. Cherokee Canal. Hydrologic analysis conducted for Cherokee Canal is described in the report "Sutter, Basin California, General Investigation Feasibility Study, Cherokee Canal Hydrology Appendix, Cottonwood Creek to Afton Road Butte County, California", August 2010. Flood frequency curves and a suite of 30 day balanced hydrographs were developed for the Cherokee Canal near Richvale Gage (DWR stream gage A02984). The frequency analysis was conducted using Bulletin 17b methods based on 46 years of record from 1961 to 2006. Flood frequency statistics for the Cherokee Canal near Richvale Gage are provided in Table 12. A table of discharges by frequency and duration is provided in Table 13.

Table 12
Flood Frequency Statistics, DWR Gage Cherokee Canal near Richvale

Flood Duration	Log Mean	Log Standard Deviation	Log Skew (Adopted)	Record (Years)	
				Years Evaluated	Years Used
Peak	3.7484	0.2241	-0.70	46	46
1-Day	3.4576	0.2241	-0.70	46	46
3-Day	3.2656	0.2241	-0.70	46	46
5-Day	3.1618	0.2241	-0.70	46	46
10-Day	3.0052	0.2241	-0.70	46	46
15-Day	2.9130	0.2241	-0.70	46	46
30-Day	2.7525	0.2241	-0.70	46	46

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Table 13
Flood Frequency, DWR Gage Cherokee Canal near Richvale

Flood Duration	Duration Average Discharge by ACE (CFS)						
	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Peak	5,900	10,300	12,100	13,200	14,300	15,200	16,300
1-Day	3,040	5,280	6,190	6,870	7,310	7,780	8,340
3-Day	1,960	3,390	3,980	4,360	4,700	5,000	5,360
5-Day	1,540	2,670	3,130	3,430	3,700	3,940	4,220
10-Day	1,070	1,860	2,180	2,390	2,580	2,750	2,950
15-Day	870	1,510	1,770	1,940	2,090	2,220	2,380
30-Day	600	1,040	1,220	1,340	1,440	1,540	1,650

Balanced 30-day hydrographs were developed for 50% (1/2) ACE, 10% (1/10) ACE, 4% (1/25) ACE, 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE, and 0.2% (1/500) ACE events. The hydrographs were developed using the same methodology as described in the Sacramento-San Joaquin Rivers Comprehensive Study. The 5-day flood pattern for the synthetic hydrographs was based on the 30 December 2005 to 4 January 2006 flood. The 30-day hydrograph was then constructed from 6 waves, each 5 days in duration. The highest wave volume is distributed into the fourth, or main, wave. The second and third highest volumes precede and follow the main wave, respectively. The fourth highest volume is distributed into the 2nd wave, and the 5th highest is distributed into the final of the 6 waves. The 6th and smallest wave volume is distributed into the 1st wave of the series. The shape of each wave is identical and the magnitude is determined by the total volume that the wave must carry.

d. Interior Drainage. An interior drainage analysis was performed by Peterson-Brustad Incorporated (PBI) for the Sutter Butte Flood Control Agency (SBFCA). The interior drainage analysis evaluated rainfall runoff and flood depths for 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE flood events. Storm events with 24-hour and 96 hour durations were evaluated.

The analysis utilized an HEC-HMS model to compute sub basin runoff and a FLO-2D two dimensional hydraulic model to route the runoff through the study area. A total of 16 drainage basins covering approximately 340 square miles were identified within the interior drainage boundary. The drainage basins were further divided into a total of 77 sub basins. The model included ten storm water pump stations that pump drainage water into the Feather River or Sutter Bypass. The FLO-2D model uses a 1,000-foot by1,000-foot grid size and includes the main drainage channels throughout the study area as channel elements. The resulting interior drainage maps were reviewed and adopted for use in this study. The maps are further described in the analysis of alternatives below.

3.3 Hydraulic Models

Without project conditions were evaluated using five separate hydraulic models that were adapted from existing hydraulic models utilized for studies within the Sacramento Valley. Water surface profiles for Sutter Bypass and Feather River were computed using an HEC-RAS

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unsteady one-dimensional flow model of the Sacramento River system. Water surface profiles for Wadsworth Canal were computed using an HEC-RAS steady one-dimensional flow model. Water surface profiles for Cherokee Canal were computed using an HEC-RAS unsteady one-dimensional flow model. Water surface elevations for Butte Basin were based on the UNET unsteady model results obtained from the Comp Study. Inundation depths from levee breach simulations were evaluated using a FLO-2D 2-dimensional unsteady flow model of the study area.

Three types of hydraulic models were used for this analysis. HEC-RAS calculates steady or unsteady gradually varied flow in natural and manmade channels by performing step-backwater calculations of the 1-D flow energy equation through a series of input geometric cross-sections with empirically defined hydraulic roughness coefficients. The computer model, UNET is a predecessor to HEC-RAS and has similar functionality and assumptions. FLO-2D is a 2-dimensional, dynamic flood routing model that simulates movement of water across the ground surface while reporting volume conservation. It numerically routes flood hydrographs over a system of grid elements, and predicts the area of inundation and floodwave attenuation.

a. Sutter Bypass and Feather River. Water surface profiles for Sutter Bypass and Feather River were computed using an HEC-RAS unsteady one-dimensional flow model of the Sacramento River system. A map of the HEC-RAS hydraulic model domain showing cross sections and hydrograph boundary locations is provided as Plate 6.

(1) Cross Sections. The model contains a total of 1,382 cross sections. The cross sections are spaced at roughly ¼-mile intervals along the river reaches. Cross section geometry data were obtained from the 1999 Sacramento-San Joaquin Comprehensive Study (NAVD88 datum update).

(2) Storage Areas. The model contains a total of 53 storage areas throughout the domain.

(3) Bridges and Inline Structures. The model contains a total of 33 bridges, 3 inline structures and 2 major weir diversions (Fremont and Tisdale). The Highway 99 Bridge was modified over the period of the feasibility study. The model represents the widened bridge.

(4) Lateral Stuctures (Levees). The HEC-RAS model utilizes the lateral weir option to simulate overtopping of the levee crest. The structures were manually coded into each HEC-RAS cross section based upon Top of Levee (TOL) elevation data from the USACE National Levee Database (NLDB) survey data. The lateral structure outflow is linked to the storage areas described above.

(5) Blocked Obstructions. Blocked obstructions are used in the HEC-RAS model to eliminate conveyance for portions of the cross sections outside of the levees. The obstructions extend from the levee centerline to the end of the cross section on the landward side. The heights of the blocked obstructions were made sufficiently high to contain a 0.2% ACE flood event.

(6) Ineffective Flow Areas. Ineffective flow areas were incorporated into the model to simulate areas where water is stored, but is not active conveyance area.

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(7) Manning's Roughness Values. Manning's n-values were selected based on model calibration to high water marks collected during the January 1997 and December 2005 - January 2006 flood events. Boundary condition inflows for the model calibration were based on DWR and USGS stream gage records. Manning's roughness values range from 0.031 to 0.07 in the main channel and 0.05 to 0.10 in the overbanks. The model calibration is described below.

(8) Upstream Boundary Conditions. Upstream boundary conditions are a set of regulated flow hydrographs. The boundary locations are shown on Plate 6 and listed in Table 3.

(9) Downstream Boundary Conditions. The PBI Sutter Basin model includes two downstream boundary conditions; 1) the Sacramento River at Verona and 2) the Yolo Bypass near Woodland. Both boundary conditions consist of rating curves developed from stream gage data.

A stage-discharge rating curve was developed for the downstream boundary at the Sacramento River at Verona gage. The current USGS rating at the gage was found to be at the low end of historical data. The USGS stage-discharge rating was modified to reflect the average conditions expected throughout the life of the project. The resulting curve is provided as Plate 7.

A stage-discharge curve was developed for the Yolo Bypass near Woodland Gage. The published USGS Yolo Bypass near Woodland gage rating curve could not be used for the boundary condition because it incorporates an adjustment for Sacramento Weir inflow into the Yolo Bypass. The gage, however, is located upstream of the confluence with the Sacramento Bypass. As a result, the USGS rating curve does not represent the stage-flow relationship at the gage. The curve used for the feasibility study was developed by plotting historical discharge measurements and comparing to modeled profiles of the Yolo Bypass. The resulting curve is provided as Plate 8.

(10) Model Calibration. The model was calibrated to two historic flood events that occurred in January 1997 and December 2005 - January 2006. Calibration efforts were specifically focused on the Feather River, Sutter Bypass, and Wadsworth Canal. Detailed calibration for all of the other rivers and storage areas within the HEC-RAS model was considered outside of the scope of this study.

The differences in the physical configuration of the Feather River between 1997 and 2006 (such as the Shanghai Bend Setback Levee completed in 1999) were taken into account in the calibration process. In addition, due to the fact that both the 2006 and 1997 flood events occurred before the construction of the TRLIA setback levees, the calibration was performed with a HEC-RAS geometry file that does not include the setback levees.

The January 1997 flood event was considered the best flood event to use for calibration due to its size and the quantity of measured data. However, three major levee breaches occurred during the 1997 flood event which introduced significant uncertainty in flow estimates throughout the system. The storm that occurred from December 2005 to January 2006 was smaller in size

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compared to the 1997 event, but it was large enough to produce overbank flows and reliable measured data throughout the river network with no levee failures.

Manning's n-values were adjusted to duplicate stages for the 2006 flood event. The 1997 flood event was then simulated and adjustments were made to achieve a compromise in modeled versus observed stages for the two calibration events. For the 1997 event the difference between modeled and observed stages ranged from -0.30 feet to +1.92 feet at the 12 stream gages. The greatest deviation between observed stage and the modeled stage occurred at the Sutter Bypass pumping Plant 1 gage.

For the 2006 event the difference between modeled versus observed stages ranged from -0.46 feet to +1.03 feet at the 12 stream gages. The greatest deviation between modeled and observed stages occurred at the Feather River at Yuba City gage. The model overestimated the stage by 1.03 feet. The calibration is described in the PBI report, Design Water Surface Profiles for the Feather River West Levee Project, 26 July 2012.

(11) Stage Uncertainty. The total SD of stage uncertainty was computed at 11 index points on the Feather River and Sutter Bypass. The total SD was found to range from 1.2 feet to 1.7 feet. A SD of 1.5 feet is recommended for all reaches of the Sutter Bypass and Feather River.

Stage uncertainty was estimated following methods described in EM-1110-2-1619. The total stage uncertainty was estimated from natural, model, and sedimentation uncertainty. The following provides a summary of the stage uncertainty analysis. A detailed description of the stage uncertainty analysis is provided in the Sutter Basin Feasibility Study Hydraulics Report prepared by Peterson Brustad Inc. (SBFCA, 2012). The standard deviation (SD) of total stage uncertainty was calculated using the following equations modified from EM1110-2-1619.

$$\mathrm{SD}_{\mathrm{total}} = \sqrt{\mathrm{SD}^2_{\mathrm{natural}} + \mathrm{SD}^2_{\mathrm{model}} + \mathrm{SD}^2_{\mathrm{sedimentation}}}$$

$$\mathrm{SD}_{\mathrm{model}} = \sqrt{\mathrm{SD}^2_{\mathrm{topo}} + \mathrm{SD}^2_{\mathrm{n-value}}}$$

The natural uncertainty, *SDnatural*, is the uncertainty of the stage-discharge relationship caused by the natural variation in the physical characteristics of the stream and errors that occur in the stage and discharge measurements.The SD of natural uncertainty is 0.70 feet for the Feather River and 0.55 ft for the Sutter Bypass. The SD for natural uncertainty was based on a review of stage discharge measurements at the DWR stream gage Butte Slough near Meridian (A02972) and USGS gage Sacramento River near Verona (11425500).

The uncertainty in hydraulic model results is highly correlated to the uncertainty in the topographic data used to represent the geometric characteristics of the river reaches. The SD for topographic uncertainty is estimated to be 0.48 ft. This uncertainty value was based on the

description of the topographic survey data provided in the Aryes Final Topographic Survey Report (AYRES, 2003)

The SD associated with Manning's roughness was estimated at 11 locations throughout the model. The standard deviation was found to range from 0.78 feet to 1.25 feet. The values were estimated by computing water surface profiles with roughness values increased and decreased by 20 percent.

The SD associated with sedimentation accounts for the sensitivity of the computed water surface profiles to future sediment deposition or scour. A SD of 0.75 feet was estimated for all reaches based on a review of sedimentation reports.

b. Wadsworth Canal. Water surface profiles for Wadsworth Canal were computed using an HEC-RAS steady one-dimensional flow model. A map of the HEC-RAS hydraulic model domain showing cross sections and hydrograph boundary locations is provided as Plate 9. The hydraulic model extends 4.5 miles from the East and West Interceptor Channel to the Sutter Bypass.

(1) Cross Sections. The model contains 36 cross sections from the East and West Interceptor Channels to the Sutter Bypass. Cross section geometry data were obtained from the 1999 Sacramento-San Joaquin Comprehensive Study (NAVD88 datum update). The underwater portion of each cross section was adjusted to reflect recent NAVD88 ground surveyed bathymetric cross section data obtained by the State of California Department of Water Resources in 2010 (DWR, 2011).

(2) Storage Areas. The model is a steady state model used to model profiles. Therefore, the model does not include storage areas.

(3) Bridges and Inline Structures. Bridges and inline structures were coded into the model from field sketches obtained during the 1999 Sacramento-San Joaquin Comprehensive Study and the State of California Department of Water Resources Central Valley Floodplain Evaluations and Delineation (CVFED) mapping. The five bridges within the model reach are Butte House Road, South-Butte Road, Sutter Bike Trail (old railroad bridge), Colusa Highway (State Highway 20), and Franklin Road.

Topographic and NLDB data in the vicinity of the Sutter Bike Trail bridge indicated a dip in the left and right bank levee profile. A review of photographs indicated the top of levee should tie to the concrete wing walls and railing. The DWR Sutter Yard Field Superintendent indicated this location would be sandbagged during a flood event (DWR, 2013). Therefore, the top of levee was coded into the model at the top of the wing wall elevation.

Weir number 4 located just upstream from South-Butte Road was coded into the model as an inline structure assuming the flash boards were removed. The DWR Sutter Yard Field Superintendent indicated the flash boards would not be in place during the flood season (DWR, 2013).

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(4) Levees. The levee crest elevation was specified for each cross section. The top of levee elevation was obtained from the NAVD88 National Levee Database (NLDB) ground survey conducted in 2007-2008.

(5) Blocked Obstructions. Blocked obstructions are used in the HEC-RAS model to eliminate conveyance from portions of the cross sections outside of the levees. The obstructions extend from the levee centerline to the end of the cross section on the landward side. The heights of the blocked obstructions were made sufficiently high to contain a 0.2% (1/500) ACE flood event.

(6) Ineffective Flow Areas. Ineffective flow areas were incorporated into the model to simulate areas where water is stored, but is not active conveyance area.

(7) Manning's Roughness Values. Manning's roughness values were estimated to be 0.035 for the Wadsworth Canal reach. This value was based on a comparison of channel conditions to photographs in Chow, 1959.

(8) Upstream Boundary Conditions. Model boundary conditions for stage and flow are described in the Model Simulations and Results section.

(9) Downstream Boundary Conditions. Model boundary conditions for stage and flow are described in the Model Simulations and Results section of this report.

(10) Model Calibration. The model was not calibrated due to lack of measured data. Selection of Manning's roughness values are described above.

(11) Stage Uncertainty. The total SD was found to vary between 1.5 feet and 1.6 feet throughout the reach. Stage uncertainty was estimated following methods described in EM-1110-2-1619. The total stage uncertainty was estimated from natural, model, sedimentation uncertainty, and coincident flow uncertainty. The SD of stage uncertainty releated to natural, model, and sedimentation uncertainty was assumed to be the same as the Sutter Bypass (1.5 feet) because water surface profiles in Wadsworth Canal are highly correlated to the stage in the Sutter Bypass.

Additional stage uncertainty was included to account for uncertainty in coincident flow conditions. The maximum stage uncertainty related to coincident flow conditions is assumed to be the difference between the maximum and minimum coincident flow extremes. Equation 5-7 of EM 1110-2-1619 was used to compute the standard deviation of stage uncertainty as 1/4 of the difference between the upper and lower bounds. The stage uncertainty associated with coincident flow varies throughout the reach and is the largest (0.6 feet) near Sutter Butte Road (Comp Study River Mile 3.32). The standard deviation (SD) of total stage uncertainty was calculated using the following equation provided in EM1110-2-1619.

$$\mathrm{SD}_{\mathrm{total}} = \sqrt{\mathrm{SD}^2_{\mathrm{natural}} + \mathrm{SD}^2_{\mathrm{model}} + \mathrm{SD}^2_{\mathrm{sedimentation}} + \mathrm{SD}^2_{\mathrm{coincident\ flow}}}$$

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c. Cherokee Canal. Water surface profiles for Cherokee Canal were computed using an HEC-RAS unsteady one-dimensional flow model. A map of the HEC-RAS hydraulic model domain showing cross sections and hydrograph boundary locations is provided as Plate 10. Model geometry was obtained from an existing California Department of Water Resources model developed in 2006. The model reach extends 9 miles from Nelson Road downstream to Highway 162.

(1) Cross Sections. The Cherokee Canal HEC-RAS hydraulic model contains a total of 153 cross sections. The cross sections are spaced at roughly 400-ft intervals. Cross sections are also coded at the upstream and downstream face of each bridge crossing.

The topography included in the DWR 2006 model (excluding the cross sections imported from the URS 2003 model) was obtained from field surveys completed in June and August of 2006 by DWR. Supplemental field surveys were completed by PBI in June and October of 2009 in order to add 4 cross sections downstream of the Highway 162 Bridge.

(2) Storage Areas. The model contains no storage areas.

(3) Bridges and Inline Structures. The model includes 4 bridges, Nelson-Shippee Road, Richvale Road, Union Pacific Railroad, and Highway 162. All of the bridges geometry data within the model were obtained from the 2006 DWR model and reviewed for reasonableness. The bridge deck elevation for all bridges was surveyed to verify the vertical datum was NAVD88.

(4) Lateral Stuctures (Levees). The HEC-RAS model utilizes the lateral weir option to simulate overtopping of the levee crest. The structures were manually coded into each HEC-RAS cross section based upon Top of Levee (TOL) elevation data from the USACE NLDB survey data described above. Lateral structures were not coded in for the reach upstream of Nelson-Shippee Road in order to ensure that all inflows enter the study area. Lateral structure lengths were coded in to be no greater than 1 mile.

(5) Blocked Obstructions. Blocked obstructions are used in the HEC-RAS model to eliminate conveyance area for portions of the cross sections outside of the levees. The obstructions extend from the levee centerline to the end of the cross section on the landward side. The heights of the blocked obstructions were made sufficiently high to contain a 0.2% (1/500) ACE flood event.

(6) Ineffective Flow Areas. The model contains no ineffective flow areas. The ineffective flow areas upstream of the Nelson-Shippee Road Bridge (outside of the study area) were eliminated from the base DWR model in order to stabilize the unsteady flow calculations.

(7) Manning's Roughness Values. The Manning's n-values for the main channel range from 0.033 to 0.059. The Manning's n-values for the channel overbanks range from 0.037 to 0.088. Manning's n-values were selected based on model calibration to high water marks

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collected during the December 2005 - January 2006 flood events. Boundary condition inflows for the model calibration were based on DWR stream gage records.

(8) Upstream Boundary Conditions. The hydrograph provided for Cherokee Canal was based on stream records below the Cottonwood creek tributary. However, the model extends upstream of Cottonwood creek. The hydrograph was divided and 75% was applied at the upstream end of the model at Nelson Road and 25% was applied at the Cottonwood Creek confluence. This apportionment was based upon the percent differences in the design capacities of the Cherokee Canal upstream and downstream of the Cottonwood Creek confluence. No detailed hydrologic analysis was completed since these sections were outside of the focus study area. A 1-hour time delay was applied to the inflow hydrograph at Cottonwood Creek in order to synchronize the combined peak flows.

(9) Downstream Boundary Conditions. A normal depth (friction slope) boundary condition of 0.00068 was utilized for the model. The friction slope was estimated from the surveyed high water mark elevations in the downstream one-mile of the model.

(10) Model Calibration. Manning's n-values were selected based on model calibration to high water marks collected during the December 2005 - January 2006 flood events. Boundary condition inflows for the model calibration were based on DWR stream gage records. Manning's n-values were adjusted (within reason) to duplicate stages for the event. The calibrated water surface profile was found on average to be within 0.3-ft of known HWM's. There are two instances within the study focus area where the difference between the known HWM's and the modeled water surface was greater than 0.5-feet. However, considering uncertainty in high water mark data collection, these were considered outliers. A detailed description of the stage model calibration is provided in the Sutter Basin Feasibility Study Hydraulics Report prepared by Peterson Brustad Inc. (SBFCA, 2012).

(11) Stage Uncertainty. The total SD of stage uncertainty was computed at two index points on the Cherokee Canal and a SD of 1.5 feet is recommended. Stage uncertainty was estimated following methods described in EM-1110-2-1619. The total stage uncertainty was estimated from natural, model, sedimentation, and bridge debris loading uncertainty. The following provides a summary of the stage uncertainty analysis. A detailed description of the stage uncertainty analysis is provided in the Sutter Basin Feasibility Study Hydraulics Report prepared by Peterson Brustad Inc. (SBFCA, 2012). The standard deviation (SD) of total stage uncertainty was calculated using the following equation provided in EM1110-2-1619.

$$\mathrm{SD}_{\mathrm{total}} = \sqrt{\mathrm{SD}^2_{\mathrm{natural}} + \mathrm{SD}^2_{\mathrm{model}} + \mathrm{SD}^2_{\mathrm{sedimentation}} + \mathrm{SD}^2_{\mathrm{bridge\ debris}}}$$

$$\mathrm{SD}_{\mathrm{model}} = \sqrt{\mathrm{SD}^2_{\mathrm{topo}} + \mathrm{SD}^2_{\mathrm{n-value}}}$$

The natural uncertainty, *Snatural*, is the uncertainty of the stage-discharge relationship caused by the natural variation in the physical characteristics of the stream and errors that occur in the stage and discharge measurements. The SD of natural uncertainty is 0.48 feet. The SD for natural

uncertainty was based on a review of stage discharge measurements at the DWR stream gage Cherokee Canal nr Richvale (A02984).

The uncertainty in hydraulic model results is highly correlated to the uncertainty in the topographic data used to represent the geometric characteristics of the river reaches. The SD for topographic uncertainty was assumed to be negligible because the cross sections were ground surveyed.

The SD associated with Manning's roughness was estimated at two locations throughout the model. The standard deviation was found to range from 0.73 feet to 0.78 feet. The values were estimated by computing water surface profiles with roughness values increased and decreased by 20 percent.

The SD associated with sedimentation accounts for the sensitivity of the computed water surface profiles to future sediment deposition or scour. A SD of 0.75 feet was estimated for all reaches based on a review of sedimentation reports.

The SD associated bridge debris loading was estimated at two locations throughout the model. The values were estimated by computing water surface profiles with bridge pier widths increased 2 feet. The standard deviation was found to range from 0.02 feet to 0.03 feet.

d. Butte Basin. Water surface elevations within the Butte Basin were obtained from the Sacramento San Joaquin Comprehensive Study UNET model DSS files. All stage data provided in the Comprehensive Study were based on the NGVD29 datum. These data were converted to the NAVD88 vertical datum using a topographic datum conversion surface developed specifically for converting Comp Study topographic data to NAVD88. Model geometry, details and assumptions are described in the Sacramento San Joaquin Comprehensive Study report.

(1) Boundary Conditions. Hydrologic inputs to the comp study UNET hydraulic model consisted of a set of 30-day regulated flow hydrographs for all inflow boundary locations. Sets of boundary condition hydrographs were provided for each of seven ACE events. Storm centering scenarios were provided for each ACE event to determine the maximum water surface elevations within the river channels. The development of regulated flow hydrographs is described in detail in the hydrology appendix.

(2) Model Calibration. The UNET model of the Sacramento River Basin was calibrated to the 1997 flood during the comp study. Inflow hydrographs to the model were created using 1997 flood gage information from major tributaries and flood control structures. Model result hydrographs were compared to gage records and peak stage data where available. The UNET model parameters for Manning's n, weir coefficients, and levee breaches were then adjusted as needed in an iterative procedure to modify the model results to more closely match the calibration data.

(3) Stage Uncertainty. Stage uncertainty was estimated following methods described in EM-1110-2-1619. The total stage uncertainty was estimated from natural, model, sedimentation uncertainty, and coincident flow uncertainty. The SD of stage uncertainty releated to natural,

model, and sedimentation uncertainty was assumed to be the same as the Sutter Bypass and Feather River model described above (1.5 feet) because the comp study UNET model data sources and assumptions are nearly identical to the HEC-RAS model.

e. FLO-2D Model. A FLO-2D model was utilized to evaluate water surface elevations resulting from levee breaches within the study area. A detailed description of the model is provided in the report- Sutter Basin Feasiblity Study, Hydraulics Report prepared by Peterson Brustad, Inc. 14 December 2012. A map of the model domain is provided in Plate 11.

(1) Computational Domain**.** The valid computational domain is defined as the Sutter Basin Feasibility study area. The model's domain extends beyond the valid computational domain in order to establish model boundary conditions. All results outside the valid domain were truncated from the results.

(2) Grid Elements**.** A 1,000-ft grid size was selected in order to keep the number of grid elements down to a workable number and to avoid long model run times. The Comp Study and USGS data were used to develop the FLO-2D grid cell elevations, with the Comp Study topography comprising approximately 55% of the FLO-2D grid. The USGS topography is utilized for the areas of the model which Comp Study topography did not cover. Since both the Comp Study and USGS data is based upon NGVD29 datum, the FLO-2D grid cell elevations were converted to NAVD88.

(3) Channel Elements**.** Two channels were added to the 2009 Sutter Basin FLO-2D model; the Wadsworth Interceptor Canal Unit 1 (West Canal) and Interceptor Canal Unit 2 (East Canal). The channels were included in order to simulate the collection and drainage of runoff out of the basin via the Wadsworth Canal. The Wadsworth Canal is approximately 4.3 miles in length and conveys runoff from southeast of the Sutter Buttes into the Sutter Bypass. The two interceptor channels act as collectors in the model and route flow towards an outflow node that is located at the beginning of the Wadsworth Canal. The outflow node contains a discharge rating curve that is based upon flood depths. This simulates drainage water flowing through the Wadsworth Canal and out of the basin. The Wadsworth Canal was not modeled as a FLO-2D channel due to model limitations regarding the backwater effects of the Sutter Bypass.

(4) Floodplain Roughness and Area Reduction Factors. Overland n-values and area reduction factors (ARF) were developed for a variety of different land uses. For consistency, the Manning's n and ARF values are based upon reference values utilized in recent USACE FLO-2D studies (which are based upon values listed in the FLO-2D User's Manual, as adapted from the 1990 HEC-1 User's Manual).

(5) Levees and Embankments. Levee elements were added to the FLO-2D model to represent the river channel levees and railroad embankments as found on the floodplain. The model includes the levees & embankments along the Sutter Bypass, Wadsworth Canal, Interceptor Canals, Cherokee Canal Feather River, and UPRR Embankment. The levee crest elevations were determined from the surveyed National Levee Database. The Union Pacific Railroad (UPRR) embankment elevations were based on field survey data obtained by the sponsor in May and June of 2009. The UPRR embankment elevations was input into the model

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based upon even grades between the survey points. The railroad embankment generally ranges in height from 1 to 7 feet above the existing terrain.

(6) Hydraulic Structures. Hydraulic structures were re-coded into the FLO-2D model using estimated stage-discharge rating curves developed from HEC-RAS, which utilizes a hydraulic gradient based upon the length between the two sides of the embankment. Five estimated rating curves (one for each different bridge length) were developed using HEC-RAS and then coded into FLO-2D.

(7) Pump Stations. Three pumping stations located within the Sutter basin were incorporated into the FLO-2D model. The pumping stations are maintained by the California Department of Water Resources (DWR) Sutter Maintenance Yard. All three pump stations transfer storm water runoff from inside the Sutter Basin into the Sutter Bypass. The plants are modeled as constant flow outflow nodes within the model. The pumping stations are assumed to be inoperable during the 0.2% (1/500) ACE scenario due to extensive flooding and power outages.

(8) Boundary Condition Inflows. The inflow hydrographs for the FLO-2D model consist of levee overtopping and breach hydrographs obtained from HEC-RAS model simulations. A simulation run time of 720 hours was used in order to allow enough time for the flood waters to collect at the southern portion of the basin.

(9) Boundary Condition Outflows. The purpose of the FLO-2D model is to simulate the movement of breach floodwaters within the study area on the interior side of the Feather River and Sutter Bypass levee system. Therefore outflow elements were specified on the river side of the Sutter Bypass and Feather Rivers and the lowest part of the Butte Basin.

(10) Stage Uncertainty. The total combined standard deviation of stage uncertainty was estimated to be 1.2 feet using the equation above. The uncertainty of computed flood depths for the Sutter Basin FLO-2D model can primarily be attributed to the hydraulic modeling inaccuracies and the levee breach assumptions. The uncertainty was measured for a hypothetical breach along the Feather River at RM 57.17 using the 1% (1/100) ACE flood event (Shanghai storm centering). The uncertainties associated with roughness values and breach widths were evaluated. A detailed description of the stage uncertainty analysis is provided in the Sutter Basin Feasibility Study Hydraulics Report prepared by Peterson Brustad Inc. (SBFCA, 2012). The standard deviation (SD) of total stage uncertainty was calculated using the following equation provided in EM1110-2-1619.

$$\mathrm{SD}_{\mathrm{total}} = \sqrt{\mathrm{SD}_{\mathrm{model}}^2 + \mathrm{SD}_{\mathrm{breach}}^2}$$

$$\mathrm{SD}_{\mathrm{model}} = \sqrt{\mathrm{SD}_{\mathrm{topo}}^2 + \mathrm{SD}_{\mathrm{n-value}}^2}$$

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The uncertainty in hydraulic model results is highly correlated to the uncertainty in the topographic data used to represent the geometric characteristics of the river reaches. The SD for topographic uncertainty is estimated to be 0.48 ft. This uncertainty value was based on the description of the topographic survey data provided in the Ayres Final Topographic Survey Report (AYRES, 2003)

The SD associated with roughness was estimated at two locations throughout the model. The values were estimated by computing water surface profiles with roughness values increased and decreased by 20 percent. The standard deviation was found to be 0.3 feet based on the average change in water surface elevation within the upper and lower inundation limits.

The SD associated with breach width was computed by simulating breach widths by +/-33%. The standard deviation was found to be 1.0 feet based on the average change in water surface elevation between the upper and lower inundation limits.

3.4 Hydraulic Model Results.

The hydraulic models described above were utilized to compute water surface profiles for two levee overtopping scenarios. Models were also utilized to simulate inundation depths within the study area from levee breach scenarios at 14 locations.

a. Levee Infinite Height Scenario (Scenario A). For this scenario, water surface profiles were simulated assuming all levees were infinitely high and would contain all flow within the infinite channel without overtopping. This scenario was used to evaluate the sensitivity of water surface elevations to levee overtopping assumptions. Infinite levee water surface profiles were developed for Sutter Bypass (Plate 12), Feather River (Plate 13), Wadsworth Canal (Plate 14), and Cherokee Canal (plates 15 and 16). Peak stage and flow frequency estimates at index points throughout the study area are presented in Tables 14 through 18. Peak stage frequency and flow frequency curves for the index points are provided in Plates 17 to 30.

b. Levee Overtopping Scenario (Scenario B). For this scenario, water surface profiles were based on the assumption that all Flood Risk Management levees can be overtopped but they do not fail. Peak stage and flow frequency tables for index points throughout the study area are presented in Tables 14 through 18. Peak stage frequency and flow frequency curves for the index points are provided in Plates 17 to 30.

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Table 14
Feather River Hydraulic Characteristics, Alternative SB-1
Oroville Dam to Yuba River

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	50%	10%	4%	2%	1%	0.5%	0.2%
Feather River at RM 57.95 (Geotechnical Index MA 7 – 0.51) 1957 Design Top of Levee = 132.32 FT-NAVD88 2008 NLDB Top of Levee = 136.00 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC/SHY	SAC	SHY	SAC/SHY	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS) 1/	0	60,000	100,000	150,000	150,000	150,000	174,000	320,400
Stage (FT-NAVD88)	96.13	118.95	123.97	127.58	127.58	127.58	128.84	131.27
Velocity (FPS)	0	5.43	7.28	8.10	8.22	8.22	8.50	9.00
Overtopping Levee Model (Scenario B)								
Flow (CFS) 1/	0	60,000	100,000	150,000	150,000	150,000	174,000	320,400
Stage (FT-NAVD88)	96.13	118.95	123.97	127.58	127.58	127.58	128.84	131.18
Velocity (FPS)	-	5.94	7.28	8.22	8.22	8.22	8.50	9.09
Feather River at RM 44.50 (Geotechnical Index MA 16 – 2.9) 1957 Design Top of Levee = 93.59 FT-NAVD88 2008 NLDB Top of Levee = 93.73 FT-NAVD88								
Controlling Storm Centering	-	SAC	SHY	SAC	SHY	SAC	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	50,300	107,100	157,100	159,600	164,600	182,400	294,600
Stage (FT-NAVD88)	48.65	79.49	83.78	86.61	86.85	86.97	88.16	94.59
Velocity (FPS)	-	1.91	2.23	2.51	2.50	2.55	2.58	2.77
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	50,300	107,100	157,100	159,600	164,600	182,400	309,800
Stage (FT-NAVD88)	48.65	79.49	83.78	86.61	86.85	86.97	88.16	93.90
Velocity (FPS)	-	1.91	2.23	2.51	2.50	2.55	2.58	3.02
Feather River at RM 41.20 (Geotechnical Index MA 16 – 0.9) 1957 Design Top of Levee = 90.48 FT-NAVD88 2008 NLDB Top of Levee = 91.02 FT-NAVD88								
Controlling Storm Centering	-	SAC	SHY	SAC	SHY	SAC	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	49,400	106,800	157,100	159,600	162,700	182,300	293,600
Stage (FT-NAVD88)	43.04	74.93	80.12	83.49	83.89	83.90	85.48	92.96
Velocity (FPS)	-	2.15	1.91	1.99	1.96	1.99	1.97	2.03
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	49,400	106,800	157,100	159,600	162,700	182,300	294,200
Stage (FT-NAVD88)	43.04	74.93	80.12	83.49	83.89	83.90	85.47	91.87
Velocity (FPS)	-	2.15	1.91	1.99	1.96	1.99	1.97	2.15
Feather River at RM 30.25 (Geotechnical Index LD9 – 0.52) 1957 Design Top of Levee = 84.17 FT-NAVD88 2008 NLDB Top of Levee = 86.52 FT-NAVD88								
Controlling Storm Centering	-	SHY	SHY	SAC	SHY	SHY	SHY	2/
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	48,100	106,500	156,700	157,600	156,300	165,400	292,800
Stage (FT-NAVD88)	31.86	63.00	72.01	75.58	76.52	76.50	79.31	87.04
Velocity (FPS)	-	1.88	1.88	2.30	2.17	2.16	2.01	2.67
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	48,100	106,500	156,700	157,600	156,300	165,400	267,700
Stage (FT-NAVD88)	31.86	63.00	72.01	75.58	76.52	76.50	79.31	85.79
Velocity (FPS)	-	1.88	1.88	2.30	2.17	2.16	2.01	2.56

Notes:
1/ Flow at index point MA 7–0.51 is split into two parallel model reaches. Estimated flow is from cross section upstream of split.
2/ Controlling Storm Centering for 0.2% ACE is SHY for Scenario A and SAC for Scenario B.

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Table 15
Feather River Hydraulic Characteristics, Alternative SB-1
Yuba River to Sutter Bypass

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	50%	10%	4%	2%	1%	0.5%	0.2%
Feather River at RM 23.25 (Geotechnical Index LD1 – 9.31) 1957 Design Top of Levee = 76.87 FT-NAVD88 2008 NLDB Top of Levee = 78.50 FT-NAVD88								
Controlling Storm Centering	-	SHY	SHY	SHY	SHY	SAC	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	71,100	192,800	257,000	281,800	283,700	361,900	535,900
Stage (FT-NAVD88)	19.36	53.30	63.06	66.50	67.74	67.96	71.36	77.80
Velocity (FPS)	-	3.72	3.08	3.22	3.27	3.25	3.46	3.90
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	71,100	192,800	257,000	281,800	283,800	361,900	522,700
Stage (FT-NAVD88)	19.36	53.30	63.06	66.50	67.73	67.94	71.35	76.56
Velocity (FPS)	-	3.72	3.08	3.22	3.27	3.25	3.46	3.99
Feather River at RM 16.75 (Geotechnical Index LD1 – 3.99) 1957 Design Top of Levee = 67.90 FT-NAVD88 2008 NLDB Top of Levee = 68.40 FT-NAVD88								
Controlling Storm Centering	-	SHY	SHY	SHY	SHY	SHY	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	70,500	191,500	255,800	280,500	283,000	360,200	533,900
Stage (FT-NAVD88)	12.53	47.11	56.47	60.02	61.31	61.73	64.97	71.05
Velocity (FPS)	-	3.96	3.06	3.19	3.24	3.22	3.44	3.96
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	70,500	191,600	255,700	280,400	282,900	360,200	491,800
Stage (FT-NAVD88)	12.53	47.11	56.46	60.00	61.28	61.68	64.92	69.20
Velocity (FPS)	-	3.96	3.06	3.20	3.25	3.21	3.45	3.91
Feather River at RM 12.50 (Geotechnical Index MA 3 – 4.92) 1957 Design Top of Levee = 59.88 FT-NAVD88 NLDB Top of Levee = 64.59 FT-NAVD88								
Controlling Storm Centering	-	SHY	SHY	SHY	SHY	SAC	SHY	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	53,900	151,800	209,700	233,300	240,800	305,000	449,800
Stage (FT-NAVD88)	16.77	43.87	50.88	53.95	55.19	55.98	58.44	63.14
Velocity (FPS)	-	1.44	2.29	2.64	2.75	2.73	3.09	3.78
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	53,900	151,500	209,000	232,300	239,600	304,000	403,600
Stage (FT-NAVD88)	16.77	43.83	50.83	53.90	55.14	55.90	58.34	61.63
Velocity (FPS)	-	1.44	2.29	2.63	2.74	2.73	3.09	3.59

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Table 16
Sutter Bypass Hydraulic Charachteristics, Alternative SB-1

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	**50%**	**10%**	**4%**	**2%**	**1%**	**0.5%**	**0.2%**
Sutter Bypass at RM 84.31 (Geotechnical Index Sutter – 4) 1957 Design Top of Levee = 59.57 FT-NAVD88 2008 NLDB Top of Levee = 60.60 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	57,400	102,000	126,200	155,100	184,200	228,200	326,900
Stage (FT-NAVD88)	33.97	46.87	50.64	52.75	54.42	56.19	58.53	63.21
Velocity (FPS)	-	1.78	2.16	2.27	2.49	2.66	2.9	3.35
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	57,400	102,000	126,200	155,100	184,200	228,200	265,200
Stage (FT-NAVD88)	33.97	46.86	50.64	52.75	54.43	56.18	58.45	59.82
Velocity (FPS)	-	1.78	2.16	2.27	2.49	2.66	2.91	3.16
Sutter Bypass at RM 82.45 (Geotechnical IndexSutter – 6.2) 1957 Design Top of Levee = 58.73 FT-NAVD88 2008 NLDB Top of Levee = 58.30 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	57,700	102,800	126,800	156,000	185,000	229,000	327,200
Stage (FT-NAVD88)	29.28	44.95	49.08	51.41	53.03	54.82	57.15	61.83
Velocity (FPS)	-	1.69	2.04	2.13	2.36	2.53	2.78	3.23
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	57,700	102,800	126,800	156,000	185,100	227,900	247,800
Stage (FT-NAVD88)	29.28	44.92	49.08	51.42	53.04	54.81	57.06	58.51
Velocity (FPS)	-	1.69	2.04	2.13	2.36	2.53	2.78	2.82
Sutter Bypass at RM 72.17 (Geotechnical Index Sutter – 17.3) 1957 Design Top of Levee = 54.20 FT-NAVD88 2008 NLDB Top of Levee = 54.10 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	71,000	117,300	141,100	162,900	197,000	236,500	328,900
Stage (FT-NAVD88)	25.50	41.00	45.16	47.97	49.15	50.70	52.75	57.13
Velocity (FPS)	-	1.40	1.75	1.80	1.96	2.21	2.43	2.86
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	69,100	117,400	141,300	163,800	197,600	236,500	257,800
Stage (FT-NAVD88)	25.50	40.94	45.17	47.98	49.15	50.68	52.62	54.41
Velocity (FPS)	-	1.37	1.75	1.80	1.98	2.22	2.44	2.48

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Table 17
Wadsworth Canal Hydraulic Characteristics, Alternative SB-1

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	**50%**	**10%**	**4%**	**2%**	**1%**	**0.5%**	**0.2%**
Wadsworth Canal at RM 4.54 1957 Design Top of Levee = 61.65 FT-NAVD88 2008 NLDB Top of Levee = 62.10 FT-NAVD88								
Controlling Storm Centering	-	WAD	WAD	WAD	WAD	WAD	WAD	WAD
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	820	2250	3200	4000	4830	5750	7070
Stage (FT-NAVD88)	40.50	50.18	55.75	58.20	59.75	61.21	62.61	64.75
Velocity (FPS)	-	4.24	4.30	4.42	4.50	4.58	4.61	4.44
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stage (FT-NAVD88)		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Velocity (FPS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wadsworth Canal at RM 0.81 (Geotechnical Index Wadsworth – 0.84 1957 Design Top of Levee = 59.35 FT-NAVD88 2008 NLDB Top of Levee = 58.80 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	820	2,250	3,200	4,000	4,830	5,750	7,070
Stage (FT-NAVD88)	36.35	46.88	50.67	52.79	54.46	56.23	58.57	63.24
Velocity (FPS)	-	0.54	1	1.18	1.3	1.39	1.41	1.32
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stage (FT-NAVD88)		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Velocity (FPS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wadsworth Canal at RM 0.25 (Geotechnical Index Wadsworth– 0.5) (XS 0.19) 1957 Design Top of Levee = 59.35 FT-NAVD88 2008 NLDB Top of Levee = 60.30 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	820	2,250	3,200	4,000	4,830	5,750	7,070
Stage (FT-NAVD88)	37.06	46.87	50.65	52.76	54.43	56.20	58.54	63.21
Velocity (FPS)	-	0.47	0.86	1.03	1.13	1.2	1.23	1.16
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stage (FT-NAVD88)		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Velocity (FPS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: N/A - Scenario not modeled.
Velocities based on coincident peak Sutter Bypass stage and peak Wadsworth canal inflow. Velocities would be greater for a low Sutter bypass stage and peak Wadsworth canal inflow.

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Table 18
Cherokee Canal Hydraulic Characteristics, Alternative SB-1

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	50%	10%	4%	2%	1%	0.5%	0.2%
Cherokee Canal Cherokee at RM 12.529 Geotech index Cherokee Canal– 9.5 1959 Design Top of Levee = 112.10 FT-NAVD88 2008 NLDB Top of Levee = 112.00 FT-NAVD88								
Controlling Storm Centering	-	CHK	CHK	CHK	CHK	CHK	CHK	CHK
Stage Uncertainty (Ft- 1 S.D.)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	5,500	9,700	11,300	12,400	13,300	14,200	15,300
Stage (FT-NAVD88)	98.89	108.34	110.84	111.80	112.40	112.95	113.45	114.00
Velocity (FPS)	-	2.26	2.83	2.99	3.07	3.13	3.18	3.26
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	5,600	9,500	10,000	10,200	10,200	10,300	10,400
Stage (FT-NAVD88)	98.89	108.36	110.74	111.07	111.14	111.19	111.22	111.25
Velocity (FPS)	-	2.27	2.81	2.86	2.88	2.88	2.89	2.89

c. Levee Breach Scenarios. Inundation maps were developed for fifteen levee breach locations within the study area. These breach locations were spatially distributed throughout the study area to reflect the floodplain characteristics. All breach scenarios assume levees were overtopped without failure at all locations other than the breach location. Breaches were simulated for 50% (1/2) ACE, 10% (1/10) ACE, 4% (1/25) ACE, 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE, and 0.2% (1/500) ACE events. The resulting inundation maps are hypothetical simulations of levee failures and do not represent the probability of occurrence. A summary of the breach simulation locations is provided in Table 19.

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Table 19
Simulated Levee Breaches

Breach ID	River Mile	Horizontal Coordinates (FT- NAD83 CCS Zone II)		Breach Width (Feet)	Breach Elevation at Toe (FT-NAVD88)
		Northing	Easting		
Feather River					
FR 9.0 R	57.17	2283867	6661785	1500	115.00
FR 8.0 R	50.20	2258021	6662669	1500	95.74
FR 7.0 R	41.55	2225167	6665302	1500	41.59
FR 6.0 R	34.07	2201918	6666623	1500	69.54
FR 5.0 R	28.25	2178130	6672485	1500	55.82
FR 4.5 R	26.00	2167420	6673291	1500	52.20
FR 4.0 R	17.00	2128205	6675848	1500	45.38
FR 3.0 R	10.50	2095813	6680073	1500	36.45
Sutter Bypass					
SB 5.0 L	88.04	2168107	6626586	1000	39.90
SB 4.0 L	82.45	2158851	6631970	1000	37.36
SB 3.0 L	77.05	2131434	6640141	1000	28.96
Wadsworth Canal					
W2.0R	2.42	2178179	6634678	1000	39.90
W2.0L	2.42	2178079	6634839	1000	43.80
Cherokee Canal					
CC2.0L	13.34	2305152	6638905	50	103.00
CC1.0L	11.4	2296019	6634326	50	103.00

Eight breaches were simulated on the Feather River from the Thermalito Afterbay to the Sutter Bypass. Each breach was simulated using the HEC-RAS model and the breach outflow hydrograph was translated to the FLO-2D model to simulate the inundation area of the breach. A 1,500 foot wide breach width was used for the simulations. The breach width was based on sensitivity analysis presented in the F3 Sutter Basin Feasibility Study report. The breach was initiated at the beginning of the flood simulation and assumed to take 1-hour to develop to the full width. Breach inundation maps are shown on Plates 31 to 38.

Three breaches were simulated on the Sutter Bypass between Wadsworth Canal and Feather River. Each breach was simulated using the HEC-RAS model and the breach outflow hydrograph was translated to the FLO-2D model to simulate the inundation area of the breach. A 1,000 foot wide breach width was used for the simulations. The breach width was based on sensitivity analysis presented in the F3 Sutter Basin Feasibility Study report. The breach was initiated at the beginning of the flood simulation and assumed to take 1-hour to develop to the full width. Breach inundation maps are shown on Plates 39 to 41.

One breach was simulated on the left bank of Wadsworth Canal. The breach was simulated using the HEC-RAS model and the breach outflow hydrograph was translated to the FLO-2D model to simulate the inundation area of the breach. The characteristics of this breach were assumed to be very similar as a breach on the Sutter Bypass because the volume of flow through the breach would originate from the Sutter Bypass. Therefore a 1,000 foot wide breach width was used for the simulations. The breach was initiated at the beginning of the flood simulation and assumed to take 1-hour to develop to the full width. Breach inundation maps are shown on Plate 42.

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One breach was simulated on the right bank of Wadsworth Canal. A breach on the right bank levee of the Wadsworth Canal would flood a triangular area between Wadsworth Canal, the Sutter Bypass, and the natural ground elevation south of the Town of Sutter. It was assumed the volume of the Sutter Bypass flood hydrograph would be sufficient to fill this volume to the stage of the channel at the breach location. The breach inundation was simulated by projecting the channel stage on the FLO-2D grid elevations and computing the resulting depths. The breach inundation maps are shown on Plate 43.

Two breaches were simulated on Cherokee Canal upstream and downstream of the Union Pacific Railroad. Each breach was simulated using the HEC-RAS model and the breach outflow hydrograph was translated to the FLO-2D model to simulate the inundation area of the breach. A 50 foot wide breach width was used for the simulations. The breach width was based on historical breach occurrences along the Cherokee Canal. The breach was initiated 1-hour before the peak flood stage and assumed to take 1-hour to develop to the full width. Breach inundation maps are shown on Plates 44 and 45.

d. Natural (Non-Breach) Inundation. Flood depth inundation maps were developed for two natural (non-breach) flood sources within the study area. These sources of flooding are from interior drainage and flood storage within the Butte Basin.

Flood depths from interior drainage were obtained from analysis performed by Peterson-Brustad Incorporated (PBI) a consultant to the Sutter Butte Flood Control Agency (SBFCA). The interior drainage analysis evaluated rainfall runoff and flood depths for 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE flood events. These maps indicated flooding was limited to non-urban areas and flooding from levee breach sources were far greater sources of damage. Therefore, maps were limited to these three events. Inundation maps from interior flooding are shown on Plate 46.

Flood depths within the Butte Basin were obtained from the Sacramento San Joaquin Comprehensive Study model results. The model is described above. Inundation within the Butte Basin was simulated by projecting the model stage on the FLO-2D grid elevations and computing the resulting depths. Inundation was simulated for 50% (1/2) ACE, 10% (1/10) ACE, 4% (1/25) ACE, 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE, and 0.2% (1/500) ACE events. The breach inundation maps are shown on Plate 47.

3.5 Hydraulic Design.

Alternative SB1 is the without project condition and does not include any features requiring hydraulic design.

3.6 Wind Wave Analysis.

An analysis of wind wave runup and wind setup was conducted for the east levee of the Sutter Bypass and west levee of the Feather River. The analysis did not include Cherokee Canal or Wadsworth Canal because wind waves were not considered to be a significant factor in these reaches because their fetch lengths are less than 400 feet. The complete analysis is described in

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the report “Sutter Basin wave runup analysis”, 15 July 2011. The analysis was performed for three representative sites on the Sutter Bypass and seven representative sites along the Feather River. Results for wind wave run up and setup up for a hypothetical water level at the levee crest are summarized in Tables 20 and 21.

Wind wave runup and setup were evaluated for three wind speed scenarios over a range of four flood stages. These results could then be interpolated depending on the needs of the study. An analysis of wind speed and flood stage found very low correlation. This indicated that wind wave run-up could be assessed independently of flood frequency. In addition, it was found that wind wave runup and setup were largely independent of water surface elevation in the top 2/3 of the levee height. At these depths the fetch lengths are similar and the waves are not depth limited.

The minimum probable wind scenario was based on the minimum of the annual maximum wind speeds. The most likely wind scenario was based on the average of the annual maximum wind speeds. The maximum probable wind scenario was based on the annual maximum wind speeds. The wind analyses were based on 80 years of record at the Sacramento Executive Airport wind gage.

For each of the wind scenarios, wind wave runup was calculated for four water levels corresponding to the levee toe, 1/3 height, 2/3 height, and top of levee. As described above, it was found that wind wave runup and setup were largely independent of water surface in the top 2/3 of the levee height. Therefore, only the wind wave runup and setup result for the top of levee stage are provided in the Table.

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Table 20
Estimated Wind Wave Runup and Setup at Top of Levee
Feather River West Levee, Alternative SB-1

Reach River Mile	Reach Name	Comp Study River Mile	Wind Wave Analysis Index Point	Wind Scenario	Wind Stress	Wave Runup Ru2% (Feet)	Wind Setup (Feet)
58.75							
	Feather River North Upper	48.85	WW-FR7	Probable High Most Likely Probable Low	82.5 mph 40.7 mph 23.1 mph	7.06 4.52 2.43	0.46 0.15 0.04
48.85							
	Feather River North Middle	43.28	WW-FR6	Probable High Most Likely Probable Low	66.5 mph 40.7 mph 23.1 mph	5.01 2.90 2.43	0.15 0.03 0.01
38.71							
	Feather River North Lower	35.78	WW-FR5	Probable High Most Likely Probable Low	72.3 mph 40.7 mph 23.1 mph	4.67 2.90 1.81	0.10 0.03 0.01
30.25							
	Feather River South Shanghai	27.50	WW-FR4	Probable High Most Likely Probable Low	66.5 mph 37.2 mph 27.3 mph	3.74 1.60 1.24	0.07 0.01 0.00
20							
	Feather River South Abbot	19.25	WW-FR3	Probable High Most Likely Probable Low	72.3 mph 40.7 mph 23.1 mph	5.26 3.26 2.03	0.12 0.04 0.01
15.5							
	Feather River South Bear	11.75	WW-FR2	Probable High Most Likely Probable Low	66.5 mph 40.7 mph 23.1 mph	5.41 3.06 1.91	0.15 0.04 0.01
7.5							

Table 21
Estimated Wind Wave Runup and Setup at Top of Levee
Sutter Bypass East Levee, Alternative SB-1

Reach River Mile	Reach Name	Comp Study River Mile	Wind Wave Analysis Index Point	Wind Scenario	Wind Stress	Wave Runup Ru2% (Feet)	Wind Setup (Feet)
87.86							
	Sutter Bypass above Wadsworth	86.18	WW-SB1	Probable High Most Likely Probable Low	82.5 mph 39.9 mph 24.4 mph	3.67 2.00 1.33	0.12 0.03 0.01
83.62							
	Sutter Bypass Upper	80.96	WW-SB2	Probable High Most Likely Probable Low	105.8 mph 36.0 mph 18.5 mph	4.39 1.84 1.33	0.15 0.02 0.01
75.3							
	Sutter Bypass Lower	70.12	WW-SB3	Probable High Most Likely Probable Low	82.5 mph 39.9 mph 24.4 mph	3.67 2.00 1.33	0.11 0.03 0.01
66.3							

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3.7 Sedimentation and Channel Stability. An evaluation of sedimentation and channel stability was based on existing studies. The following gives a brief description of the Sutter Bypass, Feather River, and Cherokee Canal.

a. Sutter Bypass. The Sutter Bypass follows the low point of the historic Sutter Basin. Prior to construction of the Sacramento River Flood Protection project the Sutter Basin was a natural overflow area adjacent to natural levees of the Sacramento and Feather Rivers.

The Sutter Bypass is a depositional feature. The rate of sediment deposition along the Sutter Bypass from Long Bridge to Tisdale Weir has been estimated to be 135,000 tons/yr. The deposition rate from Tisdale Weir to Highway 113 (upstream of the Feather River confluence) has been estimated to be 683,000 tons per year. These rates were estimated as part of the 1970 Sacramento River and Tributaries Bank Protection and Erosion Control Investigation. The results were based on an evaluation of sediment transport capacities and are presented in a 4 September, 1986 USACE information pamphlet for Field Reconnaissance Visit of U.S.- Japan Cooperative Science Project on River Meandering (NSF). Deposition rates from the Feather River to the Sacramento River are estimated at 400,000 tons per year based on a comparison of 1939 and 1979 topographic profiles across the bypass. The USACE report concluded that "a significant" portion of the sediment deposited in the lower bypass was derived from the Feather River System.

The Sutter Bypass is inspected as part of the Sacramento River Bank Protection Project. The last complete inspection of the Sutter Bypass east levee occurred in 2011. One active site was identified at RM 77.2 and was 160 feet long. The site was reported to be a slump caused by wind wave erosion.

b. Upper Feather River (River Mile 61-28). The upper Feather River reach extends from Oroville to the mouth of the Yuba River. Within this reach the levee embankment system on the upper Feather River is set back, and the river occupies a wide meander belt similar to the Sacramento River upstream of Colusa. The Lower Feather River is estimated to be degrading. This reach is inspected for erosion sites as part of the Sacramento River Bank Protection Project. The last complete inspection of the Feather River occurred in 2011. One active site was identified at RM 47.6 and was 850 feet long. The site was reported to be scour along the waterside levee toe.

The upper Feather River is significantly different from the lower Feather River in that it did not receive the tremendous sediment influx from hydraulic mining from the Yuba River. Although hydraulic mining took place on the upper Feather River, the amount of material introduced to the river was significantly less. As with all other locations disturbed by the hydraulic mining debris, the upper Feather River aggraded during the late 19th century due to the influx of sediment. Subsequently, the river has degraded into the debris. In addition to hydraulic mining sediments, the river itself was dredged and the tailings were deposited in mounds which essentially block the hydraulic conveyance of the overbank. Construction of the Oroville Dam has altered the hydrology significantly and has reduced the sediment load.

From Oroville Dam to River mile 56, Gold mining dredge spoils border the river. As high flows bypass the majority of dredge spoils via the Thermalito Afterbay, coarse sediment within the

spoils is rarely transported. In this reach the sinuosity is low, split flow around mid channel bars is common, and sediment is dominated by coarse gravel to cobble-sized materials. From River Mile 56 to River Mile 44.2 (Honcut Creek) the Feather River is a sand to fine gravel-dominated, high sinuosity stream.

From River Mile 44.2 to River Mile 27 (Yuba River) the Feather River is a sinuous, meandering river whose bed material is dominated by sand to fine gravel-size sediment. The river is highly dynamic and contains large point bars and chute channels. Bank erosion is extensive; however, wide levee setback precludes direct levee threat. Where the channel flows close to the levee, Modesto outcrops compose the channel banks, resisting erosion. Sand channels are commonly preserved in the bank stratigraphy, suggesting that during hydraulic mining, large quantities of sand were stored within this reach. Vegetation displaying distinct adventitious root zones also records a period of rapid aggradation. Point bars generally consist of sand-sized sediment. Active point bar growth, chute cutoffs and bendway migration are evidenced active bank erosion and active chutes across the bars.

Sediments that make up the active channel and floodplain deposits of the upper Feather River can be divided into Holocene (recent) and Pleistocene ages. The Pleistocene deposits affecting the river include the Riverbank and Modesto Formations. Pleistocene sedimentary rocks of the Riverbank and Modesto Formations bound the active meanderbelt of the upper Feather River. .The Modesto Formation is the most common bounding unit, bordering the Feather River meanderbelt along the line of the project levees. Consequently, as the river approaches the levee, in many cases lateral migration is effectively arrested as it encounters resistant sediments of the Modesto Formation, similar to the Sacramento River upstream of Colusa. The Modesto Formation consists of fluvial sediments that include channel fill, point bar, and lateral and vertical accretion deposits. It is generally cohesive and resistant to erosion.

Modes of bank failure that occur on the Feather River study reach are highly dependent on bank lithology and stratigraphy. There is a great deal of erosion happening from RM 45-28. Here the channel is sinuous and actively meandering.

Migration rates are highly variable along the Feather River study reach, reflecting the heterogeneity of materials present, and the range of stages of bend development. Although bankline migration rates are commonly high, levee setback is sufficient so that very little direct levee threat can be demonstrated on the Feather River. From RM 45-28 the channel bed has degraded over time.

b. Lower Feather River (River Mile 28 to 0). The Lower Feather River extends from the Yuba River to the Sacramento River opposite the Fremont Weir. The Lower Feather River estimated to be degrading. This reach is inspected for erosion sites as part of the Sacramento River Bank Protection Project. The last complete inspection of the Feather River occurred in 2011. No active erosion sites were identified.

The lower Feather River reach is presently a wide, low sinuosity, sand-dominated system that is presently sediment-laden. The bed of the Feather River in this reach contains large sand waves, which were observed to be slowly migrating downstream under relatively low flow conditions of

mid-summer. These sand waves are generally several hundred feet long and several hundred feet wide, occupying the majority of the channel width. Generally the sinuosity decreases in the downstream direction.

The river planform of this reach prior to 1850 was much like the present-day Sacramento River. Hydraulic mining has had a severe effect on the lower Feather River. The initial surge of hydraulic mining debris in the Feather River consisted of silts and clays known as "slickens". Later on, floods brought down coarser sediment that overlaid the slickens. The average fill thickness in the Feather River from the mouth of the Yuba River to Nicolaus was 20 feet. The original sinuous channel was completely in filled. The high sediment loads caused the rate of bendway cutoffs to increase and the channel sinuosity decreased (slope increased) as a result. Alternate bars formed in response to the generally increased sediment load. The channel was a wide, shallow, sand-dominated system that had low, ill-defined banks, which were commonly overtopped. Levees were later put in place to prevent flooding.

After hydraulic mining was discontinued, the subsequent reduction in sediment load caused the river to incise into the hydraulic mining debris. Degradation of the hydraulic mining has since mostly come to an end. The channel maintained its low sinuosity as it incised, preserving bars as perched geomorphic features. The stratigraphy into which the channel incised consists of clean mining derived sands underlain by fine-grained, thinly bedded silts and clays of the slickens. The slickens add stability to the Feather River system, as the fine-grained sediments commonly form a cohesive toe. Recent data indicate, however, that the Feather River has locally eroded through the slickens such that the lowermost parts of the banks below the water may be composed of pre-hydraulic mining deposits. If the channel has eroded into the sands, then it is important to consider potential ramifications of the changing erodibility of the channel perimeter. Though the Feather River is sand-dominated there is also evidence of coarser materials being deposited from the Yuba River.

The slickens are laterally continuous and very homogeneous, and therefore display little variability in terms of erosion resistance for a given stratigraphic horizon. The slickens are underlain by pre-hydraulic mining Feather River meanderbelt deposits. These older deposits are likely to be much more heterogeneous than those exposed along the river today, in that they were deposited in a coarse grained meanderbelt, much like the Sacramento River above Colusa. Such material diversity will likely result in variable erosion rates, causing planform adjustment to the differences in resistance of materials encountered following degradation. Any rapid lateral adjustment of the river could in turn create a threat to bordering flood control levees.

The erosion-resistant nature of the Modesto Formation has resulted in the formation of a steep knick zone that contains over 5 feet of drop in bed elevation in a few hundred feet of channel. The report indicates the location as river mile 24.8. This headcut has migrated upstream as a horseshoe-shaped feature. Migration of the headcut upstream has serious implications with respect to upstream continuation of the degradation.

Bank failure mechanisms on the Feather River are highly correlated to bank stratigraphy. Sand-sized sediment is derived from Feather River bank erosion as well as from tributaries. Upper bank sediments on this reach of the Feather River commonly consist of clean sands underlain by a fine-grained cohesive toe. Both of these units represent hydraulic mining debris deposited during the

aggradational period of the hydraulic mining era. The upper bank unit is prone to erosion and contributes sand size sediment to the system. Bed sediments consist primarily of sand. Where the bank stratigraphy is not the coarsening upward hydraulic mining sequence, it is generally Pleistocene-age Modesto Formation. The Modesto Formation consists of tan and light gray gravely sand, silt, and clay. Both types of bank materials are relatively erosion resistant at the bank toe and are responsible for the low bank erosion rates in the study reach. In general the Modesto Formation forms a high bank that is highly resistant to erosion and is therefore capable of significant bendway distortion and planform control.

As mentioned previously, the sinuosity generally increases in the upstream direction in this reach of the Feather River. An increase in sinuosity in the upstream direction reflects the increasing amount of Modesto outcrop exposed in the channel banks, which has helped to maintain channel planform. The channel has incised into the cohesive slickens, which has also helped to maintain the channel planform. Flow control in the watershed has also contributed to the maintenance of channel planform. Though the river is largely stable, if the river degrades through the slickens and high shear stresses are imparted on less cohesive underlying bank strata, channel migration rates and sinuosity may increase due to the significant bank erosion and development of channel asymmetry. As the supply of sand to the study reach appears relatively constant and incision rates have slowed significantly since the early part of this century, incision into underlying strata may not be imminent.

d. Wadsworth Canal. The Wadsworth Canal is a leveed channel which conveys interior drainage into the Sutter Bypass. A search of past studies and reports found no information about sedimentation rates in the canal. This reach is inspected for erosion sites as part of the Sacramento River Bank Protection Project. The last complete inspection of the Wadsworth Canal occurred in 2011. Two erosion sites were identified. Site WAD_2-1_L is located on the left bank and extends from River Mile 2.25 to River Mile 1.8. The site was identified as a bank failure with leaning trees and exposed roots. Site WAD_2-4L is also located on the left bank and extends from River Mile 3.15 to River Mile 2.2. The site was identified as a bank failure.

e. Cherokee Canal. Cherokee Canal is a leveed channel that conveys runoff from the Clear Creek, Dry Creek, Gold Run Creek, and Cottonwood Creek watersheds to Butte Slough. DWR has completed several sediment removal projects along the canal to maintain the design capacity. A sediment yield and transport study was completed by URS Corporation for the Sacramento District in January 2003. The study indicated the channel is depositional. Cherokee Canal is not inspected for bank erosion by the Sacramento Bank Protection Project.

3.8 Flood Risk.

Flood risk is defined as the probability of a flood event occurring and the consequences of occurrence. Flood risk was assessed using the USACE FDA model version 1.2.5a (USACE, 2010). The FDA model combines flow-frequency, stage-discharge, geotechnical fragility, and stage-damage relationships to estimate damages. Uncertainty in each relationship is incorporated by assigning uncertainty estimates and applying a Monte Carlo type approach to combine the results.

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Flow-frequency, stage discharge, and geotechnical frequency relationships reflect the exterior (probability) side of the risk calculations. Inundation depth and stage-damage relationships reflect the interior (consequence) side of the risk calculations. For the probability side of the risk calculations, the hydraulic model assumptions are based on flows contained to the channel (allowed to overtop without failure). For the consequence side of the risk calculations, the hydraulic model assumptions are based on levee breach failure or simply the depth for natural overbank (non-levee) conditions.

The risk assessment approach included an evaluation of potential flood sources with respect to geotechnical fragility, channel hydrology, channel hydraulics, and potential inundation patterns of a levee breach or natural overbank (non-levee). Thirteen geotechnical reaches were identified. Within each of the geotechnical reaches a representative geotechnical fragility curve was developed and a stage-discharge relationship was developed using a system based hydraulic model. Selection of the geotechnical reaches is described in detail in the geotechnical analysis report. Fifteen breach sources and one non-leveed flood sources were identified. All breach source locations identified within a geotechnical reach were assigned to the same geotechnical fragility curve location.

a. Levee Assurance. The reliability of Flood Risk Management (FRM) features within the study area is expressed as an assurance level (conditional non-exceedance probability) for a given median ACE hydrologic event. The assurance varies over levee reaches due to variations in geotechnical fragility, hydrology, and hydraulic characteristics and their uncertainties.

Levee assurance was computed for the 13 geotechnical reaches within the study area using the HEC-FDA computer program. The reaches are shown on Plate 48 and described in Tables 22 through 26. Assurance was calculated at the geotechnical fragility curve location within each reach and assumed to represent the assurance throughout the entire reach. Assurance was calculated with the HEC-FDA program using an unregulated flow-frequency curve, unregulated to regulated transform, stage-discharge relationships, geotechnical fragility curves, and Hydraulic Top of Levee Elevation (HTOL). Uncertainty in each relationship was incorporated using the FDA Monte Carlo simulation. Wind wave runup and setup were not included in the assurance calculations. FDA input assumptions are described in Tables 22 through 26.

Flow-frequency curves were based on the analytical statistics computed for unregulated conditions. Uncertainty in the flow-frequency curve is based on the period of record described in the hydrology section above. For the Sutter Bypass and Feather Rivers, the nearest upstream analytical curve statistics were utilized in combination with an unregulated-regulated transform. The unregulated flow in the transform is computed directly from the flow frequency statistics. The regulated flow used in the transform was obtained from the hydraulic model at the index location (Tables 14 -18). The transforms are used to translate the uncertainty in flow frequency estimates to the regulated condition.

The geotechnical fragility curves were based on geotechnical analysis and are presented in the geotechnical appendix and provided as Attachment B to this report. The curves are assumed to have a 100% probability of failure at the levee crest. The crest elevation was modified in the

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FDA model to reflect the Hydraulic Top of Levee (HTOL). The hydraulic top of levee is defined as the elevation at the index point corresponding to the first point of overtopping within the reach. The HTOL is lower than the actual top of levee at index points with high localized crest elevations.

Stage discharge curves used in the analysis are described in Tables 14 through 18. For index points that represent the first levee segment downstream of high ground, stages and flows are based on Scenario A (infinite levee height). This was done to prevent overestimating the assurance within these reaches. The overestimate would occur if upstream overtopping reduces the flow and stage at the index point but the overtopping failure is not accounted for in the performance evaluation.

Table 22
FDA Input for Feather River West Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
58.75							
	Feather River North Upper	57.95	129.62	MA7-Ham Bend	A	at Oroville with Regulated Transform	- Represents Breaches F9.0R, F8.0R - HTOL based on overtopping at RM 58.25 - NLDB TOL 136.00 FT-88
48.85							
	Feather River North Middle	41.20	91.02 (NLDB)	MA16-0.9	B	at Oroville with Regulated Transform	- Represents Breaches F7.0R
38.71							
	Feather River North Lower	30.25	85.01	LD9-0.52	B	at Oroville with Regulated Transform	-Represents Breaches F6.0R, F5.0R - HTOL based on overtopping at RM 32.35 - NLDB TOL 86.52 FT-88
30.25							
	Feather River South Shanghai	23.25	75.79	LD1-9.31	B	at Shanghai with Regulated Transform	- Assumes sandbag closure at Railroad. - Represents Breaches F4.5R, F4.4R - HTOL based on overtopping at RM 27.19 - NLDB TOL 78.50 FT-88
20							
	Feather River South Abbot	16.75	67.53	LD1-3.99	B	at Shanghai with Regulated Transform	- Represents Breaches F4.1R, F4.0R - HTOL based on overtopping at RM 19.28 - NLDB TOL 68.50 FT-88
15.5							
	Feather River South Bear	12.50	60.75	MA3-4.92	B	at Shanghai with Regulated Transform	- Represents Breaches F3.0R - HTOL based on overtopping at RM 9.18 - NLDB TOL 64.60 FT-88
7.5							
NLDB - Top of Levee in 2008 National Levee Database							

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Table 23
FDA Input for Sutter Bypass East Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
87.86							
	Sutter Bypass above Wadsworth	83.70	59.21	Sutter-4	B	at Ord Ferry with Regulated Transform	- Model XSEC 84.31 - Represents Breach S5.0L - HTOL based on overtopping at RM 85.19 - NLDB TOL 60.60 FT-88
83.62							
	Sutter Bypass Upper	81.92	57.72	Sutter - 6.2	B	at Ord Ferry with Regulated Transform	- Model XSEC 82.45 - Represents Breach S4.0L - HTOL based on overtopping at RM 83.53 - NLDB TOL 58.20 FT-88
75.3							
	Sutter Bypass Lower	71.65	52.93	Sutter - 17.3	B	at Ord Ferry with Regulated Transform	Model XSEC 72.17 -Represents Breach S3.0L - HTOL based on overtopping at RM 66.3 - NLDB TOL 54.10 FT-88
66.3							
NLDB - Top of Levee in National Levee Database							

Table 24
FDA Input for Wadsworth Canal South Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
4.54							
	Wadsworth Canal at Interceptor Canals	4.54	62.10 (NLDB)	None	A	Wadsworth Canal nr Sutter	- No breach represented
4.50							
	Wadsworth Canal Left Levee	0.81	58.80 (NLDB)	Wadsworth LB- 0.83	A	None	- Based on Stage Frequency Curve - Represents Breach WC 2.0L
0							
NLDB - Top of Levee in National Levee Database							

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Table 25
FDA Input for Wadsworth Canal North Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
4.54							
	Wadsworth Canal at Interceptor Canals	4.54	62.10 (NLDB)	None	A	Wadsworth Canal nr Sutter	- No breach represented
4.50							
	Wadsworth Canal Right Levee	0.25	60.30 (NLDB)	Wadsworth RB- 0.83	A	None	- Based on Stage Frequency Curve - Represents Breach WC 2.0R
0							
NLDB - Top of Levee in National Levee Database							

Table 26
FDA Input for Cherokee Canal South Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
15.7							
	Cotton Wood Creek to Hwy 162	12.53	110.6 (NLDB)	Cherokee 9.50	A	Cherokee Canal nr Richvale	- Represents Breaches CC1.0L and CC 2.0 L - HTOL based on overtopping at RM 13.42 - NLDB TOL 112.00 FT NAVD88
10.8							
NLDB - Top of Levee in National Levee Database							

b. Composite Flood Depths. Maps showing composite floodplains were developed to demonstrate FRM assurance relative to a standard assurance criterion. The maps show inundation from any flood source that would not meet a risk and uncertainty based assurance criterion. The assurance criterion was based on the NFIP levee system analysis criteria described in EC 1110-2-6067 and was adopted for use in describing the performance of all ACE events. This criterion is described as “Option 2” in the DWR Urban Levee Design Criteria. The assurance criterion utilized for this study does not account for wind wave overtopping.

- For assurance less than 90% the levee does not pass criteria
- For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria.
- For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria.

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The composite floodplains are provided in Plates 49 through 56. All maps include the natural (non-leveed) flood inundation depths. Table27 provides performance values at simulated breach locations.

Table 27
Project Performance at Simulated Levee Breach Locations, Alternative SB-1

Simulated Breach		Annual Exceedance Probability		Long Term Risk			Flood Risk Management Assurance by Event Flood Frequency (Breach included in floodplain map if shaded)						
Label	River Mile	Median	Exp.	10 Years	30 Years	50 Years	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Feather River													
F9.0R	57.17	0.0696	0.0769	0.5506	0.9092	0.9817	0.9909	0.8187	0.6499	0.6087	0.5777	0.4781	0.331
F8.0R	50.20	0.0686	0.0768	0.5504	0.9091	0.9816	0.9909	0.8187	0.6499	0.6087	0.5777	0.4781	0.331
F7.0R	41.55	0.0203	0.0238	0.2138	0.5140	0.6996	0.9999	0.9299	0.7965	0.7586	0.7209	0.5657	0.298
F6.0R	34.07	0.0353	0.0391	0.3286	0.6973	0.8635	0.9999	0.848	0.744	0.6685	0.5995	0.4486	0.2193
F5.0R	28.25	0.0353	0.0391	0.3286	0.6973	0.8635	0.9999	0.848	0.744	0.6685	0.5995	0.4486	0.2193
F4.5R	26.00	0.0909	0.1071	0.6778	0.9666	0.9965	0.9838	0.8025	0.6253	0.581	0.5626	0.4788	0.2988
F4.4R	25.99	0.0909	0.1071	0.6778	0.9666	0.9965	0.9838	0.8025	0.6253	0.581	0.5626	0.4788	0.2988
F4.1R	17.00	0.0622	0.0676	0.5036	0.8777	0.9699	0.9999	0.7722	0.6232	0.5759	0.5396	0.3996	0.175
F4.0R	16.99	0.0622	0.0676	0.5036	0.8777	0.9699	0.9999	0.7722	0.6232	0.5759	0.5396	0.3996	0.175
F3.0R	10.50	0.0167	0.0192	0.1766	0.4418	0.6216	0.9999	0.9443	0.9171	0.889	0.8447	0.6847	0.4057
Sutter Bypass													
S5.0L	88.04	0.2184	0.2331	0.9297	0.9997	0.9999	0.8232	0.5684	0.4267	0.3803	0.2991	0.1896	0.0827
S4.0L	82.45	0.4468	0.5156	0.9993	0.9999	0.9999	0.5362	0.3336	0.3257	0.2956	0.2223	0.1391	0.0631
S3.0L	77.05	0.1945	0.2104	0.9058	0.9992	0.9999	0.8101	0.6612	0.635	0.6009	0.5021	0.3426	0.1654
Wadsworth Canal													
W3.0R	4.54	0.0065	0.0086	0.0826	0.2279	0.3501	0.9999	0.9995	0.9951	0.9338	0.705	0.3791	0.0786
W2.0R	2.42	0.3590	0.3577	0.9880	0.9999	0.9999	0.6394	0.3611	0.239	0.2263	0.1884	0.0874	0.0074
W2.0L	2.42	0.1137	0.1157	0.7075	0.9750	0.9979	0.9583	0.7575	0.5626	0.4783	0.3363	0.1392	0.0056
Cherokee Canal													
CC2.0L	13.34	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015
CC1.0L	11.4	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015

Notes: Assurance based on existing top of levee or 1957 design top of levee, whichever is higher within the reach. Assurance accounts for stage uncertainty, hydrologic uncertainty, and geotechnical uncertainty.

d. Flood Velocities. The average velocity within the floodway is provided in Tables 14 through 18. If a levee breach were to occur, inundation velocities and depths within the study area would vary by proximity to a breach, breach location, and magnitude of flood event. The velocity field for a levee breach can be characterized as highest near the breach due to the rapidly varying flow conditions. The remaining area would have lower velocities associated with the slope of the topography and floodplain roughness. For evaluation of life loss consequence the study area can be divided into a breach zone, zone with rapidly rising water, and a remaining zone (Yonkman, 2008). The simulated levee breach at F9.0R during a 1% (1/100) ACE event is representative of the study area.

(1) Breach zone. The breach zone is characterized by destruction of buildings and the highest life safety consequence. Yonkman describes this area as having velocities greater than 6 feet per second and the product of depth and velocity greater than 22 ft^2 per second. For the Sutter Basin Feasibility study, velocities within 1000 feet of the breach were assumed to be great

enough to destroy buildings. This distance is based on evaluation of the 1955 levee breach which showed structures knocked off their foundations.

(2) Zone with rapidly rising water. This zone is characterized by rapidly changing velocity and depth. Model results indicate velocities of less than 3 feet per second within a few thousand feet from a levee breach.

(3) Remaining zone. This zone is characterized by slower onset of flooding. The majority of the study area is defined as the remaining zone. Models of the F9.0R breach indicate velocities of less than 2fps for the remaining portion of the inundation area. Higher velocities are indicated where flows overtop linear features such as the UPRR railroad embankment. Additional locations with higher velocities may occur. However, they would be localized and uncertain.

e. Evacuation Routes. The composite floodplain maps include the location of potential evacuation routes within the Sutter Basin study area. The Sutter County Evacuation and Mass Shelter/Care Plan identify Highways 20, 99 and 113 as the primary evacuation routes in the region. These routes are subject to change since these routes are event-specific and official routes are established by the County Sheriff's office during an emergency. The Butte County Office of Emergency Management does not have published evacuation routes at this time, but anticipates Highways 99, 162 and the Colusa Highway could be used as conditions allow (SBFCA, 2012).

The maps provide an indication of evacuation reliability associated with potential flood depths within the basin. However, the following limitations should be considered when comparing the floodplain maps to the evacuation routes.

(1) Evacuation routes depicted on the maps may be closed due to localized flooding related to interior drainage. During the 1997 flood event, seven different evacuation zones were established over seven days due to constantly changing conditions (SBFCA, 2012). The main evacuation routes used for this flood event were Highway-99 north and Highway-113 south. Highway-20 west and Highway-99 south were used intermittently since all portions of these roads were not accessible at all times during the flood. During the 1955 flood one of the spans of 5th street bridge crossing from Yuba City to Marysville collapsed into the river due to pier scour.

(2) The destination of the evacuation routes are also at risk of flooding.

(3) The FLO-2D model results shown on the maps are based on a grid element size of 1000 feet. Depths shown are an average over the grid element. The model includes the large scale features that impact the general depth and direction of flooding. These large features include levees, railroad embankment and bridges and culverts through the railroad embankment. Small scale topographic features such as drainage ditches, roadway embankments, and roadway culverts are not represented in the model. In addition, small scale topographic variations along roadways (vertical crests and vertical sags) are not represented. As a result, the small scale depressions that can make a roadway impassable are not represented. Whereas the model results may show 0.1 feet of average depth along a roadway alignment, the actual depths could be 3 feet

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deep in the smaller topographic depressions. A model depth of 0.1 feet should be used as a likely indicator that a roadway is impassable.

(4) The maps are the composite of multiple breach simulations. The maps depict long term probabilities. However, each flood event would result from different breach locations. The evacuation route during a breach would be highly uncertain. Individual breach inundation maps are provided in Plates 31 though 48.

(5) The maps include representative breach locations and resulting depth fields. Additional levee breach simulations may result in greater depths in some locations.

f. Flood Warning Time. Flood warning time varies throughout the area and is dependent on the source of flooding. The principle sources of flood warnings are advisories by the National Weather Service (NWS) and river stage forecasts by the California Nevada River Forecast Center (CNRFC).

Flood warnings/small river and stream flood warnings are issued by the NWS when flooding of main stem rivers is occurring or imminent (CNRFC, 2013). Main stem river flooding refers to flooding of gauged and forecasted rivers (CNRFC, 2013). The product can also be used to issue Small River and Stream Flood Warnings for smaller rivers/streams which do not have forecast points.

Flash Flood Warnings are issued when flooding is reported; when precipitation capable of causing flooding is observed by radar and/or satellite; when observed rainfall exceeds flash flood guidance or criteria known to cause flooding; or when a dam or levee failure has occurred or is imminent (CNRFC, 2013). A flash flood is defined as a flood caused by heavy or excessive rainfall in a short period of time, and occurring generally within 6 hours of the causative event (CNRFC, 2013).

In addition to the advisories described above, the NWS in coordination with the California Department of Water Resources issues forecasts and guidance for river flows through the CNRFC. In general, river forecasts are based on modeled runoff from observed precipitation, snowmelt estimates, and reservoir operations. The forecast length varies depending on the location. River guidance is based on modeled runoff from forecasted precipitation, snowmelt estimates, and reservoir operations. The forecasts and guidance are issued for a forecast site in a graphical format that compares the future river stage to a monitor stage, flood stage, and danger stage. The combined forecast and guidance are made 5 days into the future.

Flooding from interior drainage sources within the study area is likely to be the result of localized concentrated rainfall. It is assumed these floods would be preceded by a general flood watch issued by the NWS 12 to 24 hours in advance and a flash flood warning 6 hours in advance of the localized flooding.

Flooding from a levee overtopping event along the Feather River would result from a large regional storm event in the Feather, Yuba, and Bear River watersheds. CNRFC river flood forecast points on the Feather River are located at Gridley, Yuba City, Boyds Landing, and

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Nicholas. It is assumed that an overtopping flood would be preceded by a flood warning and river guidance issued by the NWS and CNRFC five days in advance. A more accurate warning of potential levee overtopping, based on river forecasts, would likely be made 24 to 36 hours in advance. This estimate was based on a review of the flood guidance plots for December 2005-January2006 flood which indicate an approximate 24 to 36 hour lag between observed rain plus snowmelt in the basin and the peak measured stage at the Feather River near Gridley stream gage forecast point.

Flooding from a levee overtopping event along the Sutter Bypass would result from a large regional storm event in Sacramento River watershed. There are no CNRFC forecast points on the Sutter Bypass. However, the forecast point on the Sacramento River at Fremont Weir represents flood conditions within the Sutter Bypass. It is assumed these floods would be preceded by a flood warning and river guidance issued by the NWS and CNRFC five days in advance. A more accurate warning of potential levee overtopping, based on river forecasts, would likely be made 24 to 36 hours in advance. This estimate was based on a review of the flood guidance plots for the December 2005-January2006 flood which indicate an approximate 24 to 36 hour lag between observed rain plus snowmelt in the basin and the peak measured stage at the Sacramento River at Fremont Weir gage forecast point.

It is estimated that flooding from a geotechnical levee breach would have little to no advance warning (less than 1 hour) and the floodwave would rapidly inundate the adjacent areas. The levee breach that occurred at Shanghai Bend during the December 1955 flood is an indicator of flood warning times associated with geotechnical related failures. The levee failure was preceded by the Governor of the State of California issuing a “Stage of Emergency” on 22 December due to the abnormal and heavy rainfall (Sutter County, 1957). However, the general evacuation order was given approximately 1-hour after the break (Sutter County, 1957).

g. Loss of Life Potential. To evaluate the potential for loss of life, the population density within the study area was compared to the composite floodplain maps. The distribution of population within the study area was based on 2010 census blocks. A map of the estimated population density throughout the study area is provided in Plate 4. The population within areas greater than 0 feet, 2 feet, and 15 feet are provided in Tables 28, 29, and 30 respectively.

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Table 28.
Population within Alternative SB1 Floodplain
Depths Greater Than 0 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	251
Yuba City Urban	0	67351	67368	67368	67368	67368	67368
Biggs Urban	0	19	1452	1452	1452	1452	1763
Gridley Urban	0	0	6379	6379	6379	6379	6379
Live Oak Urban	0	0	8362	8362	8362	8362	8362
Sutter County Rural	1089	4837	6260	6314	6323	6354	6378
Butte County Rural	0	9	4776	4788	4788	4793	4899
Total	1089	72216	94597	94663	94672	94707	95400

Table 29.
Population within Alternative SB1 Floodplain
Depths Greater Than 2 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	57736	63471	64529	64529	66380	67368
Biggs Urban	0	0	1352	1352	1352	1353	1554
Gridley Urban	0	0	1176	1176	1176	1186	5483
Live Oak Urban	0	0	4156	5882	5882	6498	8362
Sutter County Rural	767	4088	4840	5098	5095	5505	6199
Butte County Rural	0	0	2424	2527	2527	2887	3882
Total	767	61824	77418	80564	80561	83809	92847

Table 30.
Population within Alternative SB1 Floodplain
Depths Greater Than 15 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	137	137	137	303	934
Biggs Urban	0	0	0	0	0	0	0
Gridley Urban	0	0	0	0	0	0	0
Live Oak Urban	0	0	0	0	0	0	0
Sutter County Rural	0	499	774	944	958	1059	1183
Butte County Rural	0	0	0	0	0	0	0
Total	0	499	911	1080	1095	1362	2117

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3.9 Potential Adverse Effects.

a. Induced Flooding. There is no induced flooding associated with the without project condition.

b. Transfer of Flood Risk. There is no transfer of flood risk associated with the without project condition. However, Alternative SB-1 forms the basis for evaluating the transfer of risk for other alternatives. The transfer of flood risk is evaluated by comparing with-project and without-project performance values at index points throughout the system. For purposes of evaluating system impacts, the risk analysis is limited to hydrologic and hydraulic parameters and their uncertainties. This approach is consistent with Section 3.b (2) of the memorandum "Clarification Guidance on the Policy and Procedural Guidance for the Approval of Modifications and Alterations of Corps of Engineers Projects" (USACE, 2008). The performance values associated with hydrologic and hydraulic parameters, and their uncertainties, are provided in Table 31.

Table 31
Project Performance at Simulated Levee Breach Locations
Hydrologic and Hydraulic Parameters Only

Simulated Breach		Annual Exceedance Probability		Long Term Probability of Failure			Flood Risk Management Assurance by Event Flood Frequency						
Label	River Mile	Median	Exp.	10 Years	30 Years	50 Years	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Feather River													
F9.0R	57.17	0.0020	0.0023	0.0233	0.0683	0.1112	0.9999	0.9999	0.9949	0.9915	0.9726	0.8551	0.6390
F8.0R	50.20	0.0001	0.0023	0.0225	0.0659	0.1075	0.9999	0.9999	0.9949	0.9915	0.9726	0.8551	0.6390
F7.0R	41.55	0.0022	0.0022	0.0220	0.0646	0.1054	0.9999	0.9999	0.9999	0.9999	0.9895	0.8576	0.5427
F6.0R	34.07	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5547
F5.0R	28.25	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5548
F4.5R	26.00	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.4R	25.99	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.1R	17.00	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F4.0R	16.99	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F3.0R	10.50	0.0024	0.0027	0.0267	0.0781	0.1267	0.9999	0.9999	0.9999	0.9992	0.9744	0.8030	0.4813
Sutter Bypass													
S5.0L	88.04	0.0027	0.0037	0.0362	0.1048	0.1686	0.9999	0.9999	0.9995	0.9874	0.9087	0.7126	0.4666
S4.0L	82.45	0.0029	0.0040	0.0390	0.1126	0.1805	0.9999	0.9999	0.9994	0.9857	0.8992	0.6903	0.4306
S3.0L	77.05	0.0036	0.0036	0.0520	0.1481	0.2344	0.9999	0.9999	0.9977	0.9713	0.8483	0.6001	0.3058
Wadsworth Canal													
W3.0R	4.54	0.0065	0.0086	0.0826	0.2279	0.3501	0.9999	0.9995	0.9951	0.9338	0.705	0.3791	0.0786
W2.0R	2.42	0.0048	0.0055	0.0394	0.1137	0.1823	0.9999	0.9995	0.9995	0.9995	0.9946	0.7118	0.0904
W2.0L	2.42	0.0036	0.0048	0.0540	0.1534	0.2424	0.9999	0.9995	0.9995	0.9984	0.9521	0.4586	0.0181
Cherokee Canal													
CC2.0L	13.34	0.1205	0.1576	0.8200	0.9942	0.9998	0.9999	0.3986	0.1293	0.0474	0.0177	0.0077	0.0018
CC1.0L	11.4	0.1205	0.1576	0.8200	0.9942	0.9998	0.9999	0.3986	0.1293	0.0474	0.0177	0.0077	0.0018

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4.0 Alternative SB-7 (Sunset Weir to Laurel Ave)

4.1 General Design Features

a. Levees. This project would involve fixing the Feather River levees to meet current USACE design standards from Sunset Weir to Laurel Ave. The levee height would be based on the 1957 design profile or the existing profile, whichever is higher. In no cases would the levee be raised above these profiles.

b. Interior Drainage Facilities. The project would involve the replacement of gravity drainage culverts within the reach. All replacement culverts would remain the same capacity as the without project conditions.

c. Operation and Maintenance. The project will be maintained to meet current design standards. The project will rely on one sand bag closure structure at the UPRR railroad bridge crossing (RM 29.8).

4.2 Hydrology.

The hydrology associated with Alternative SB-7 is identical to Alternative SB-1 (without project conditions).

4.3 Hydraulic Models

Hydraulic models associated with Alternative SB-7 are identical to Alternative SB-1 (without project conditions). The alternative does not include any features that change the hydraulic conditions or geometry.

4.4 Hydraulic Model Results.

Hydraulic model results associated with Alternative SB-7 are identical to Alternative SB-1 (without project conditions).

4.5 Hydraulic Design.

a. Levee Height. This project would involve fixing the Feather River levees to meet current USACE design standards from Thermalito Afterbay to Laurel Avenue. The levee height would be based on the 1957 design profile or the existing profile, whichever is higher. In no cases would the levee be raised above these profiles.

b. Closure Structures. A sandbag type closure structure is specified where the UPRR crosses the levee embankment at River Mile 29.8. This closure structure must be operated in order for the project to obtain the assurance level described below. Failure to sandbag this closure structure could result in a failure of the levee that would rapidly inundate the urban area of Yuba City.

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c. Levee Superiority. The definition of levee superiority per EC 1110-2-6066 (*Design of I-Walls*, 31 October 2010) is the increment of additional height added to a flood risk management system to increase the likelihood that when the design event is exceeded, controlled flooding will occur at the design overtopping section. Since alternative SB-7 is based on an existing levee profile, the design top of levee was reviewed relative to the modeled mean water surface profiles to determine the likely initial overtopping location. A single initial overtopping location was determined within the SB-7 project reach. It is estimated that the initial overtopping would likely occur between River Miles 19 and 20 (FRWLP Station 547+00 to 604+60). This location is a non-urbanized area and initial overtopping is estimated to occur between the mean 0.5% (1/200) ACE and 0.2% (1/500) ACE events. Within this 1-mile reach, the landward side of the levee will be covered with anchored High Performance Turf Reinforced Mat (HPTRM). This design will increase the erosion resistance of the levee and allow for more controlled failure of the levee due to overtopping.

d. Erosion Protection. Erosion protection was not specified within the design reach.

e. Interior Drainage Facilities. If replacement is required to meet USACE design standards, the existing drainage features will be replaced with the same hydraulic capacity.

4.6 Wind Wave Analysis

Wind wave runup and setup associated with Alternative SB-7 is identical to Alternative SB-1 (without project conditions).

4.7 Sedimentation and Channel Stability

Sedimentation and Channel Stability associated with Alternative SB-7 is identical to Alternative SB-1 (without project conditions).

4.8 Flood Risk.

Flood risk would be reduced by Alternative SB-7 by reduction of the geotechnical fragility within the project reach.

a. Levee Assurance. Levee assurance values within reaches modified by the project were recomputed using geotechnical fragility curves that reflect no failure until overtopping. All other inputs to calculate assurance were identical to Alternative SB-1, the without project condition. The assurance values are provided in Table 32.

b. Composite Floodplains. Maps showing composite floodplains were developed to demonstrate FRM reliability for Alternative SB-7. The composite floodplains are provided in Plates 57 to 64. All maps include the natural (non-leveed) flood inundation depths. Table 32 provides the assurance values used to determine if a simulated breach was included in the composite floodplain map.

d. Flood Velocities. Flood velocities for a levee beach would be identical as alternative SB-1.

Table 32
Assurance at Simulated Levee Breach Locations, Alternative SB-7

Simulated Breach		Annual Exceedance Probability		Long Term Risk			Flood Risk Management Assurance by Event Flood Frequency (Breach included in floodplain map if shaded)						
Label	River Mile	Median	Exp.	10 Years	30 Years	50 Years	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Feather River													
F9.0R	57.17	0.0696	0.0769	0.5506	0.9092	0.9817	0.9909	0.8187	0.6499	0.6087	0.5777	0.4781	0.331
F8.0R	50.20	0.0686	0.0768	0.5504	0.9091	0.9816	0.9909	0.8187	0.6499	0.6087	0.5777	0.4781	0.331
F7.0R	41.55	0.0203	0.0238	0.2138	0.5140	0.6996	0.9999	0.9299	0.7965	0.7586	0.7209	0.5657	0.298
F6.0R	34.07	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5547
F5.0R	28.25	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5548
F4.5R	26.00	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.4R	25.99	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.1R	17.00	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F4.0R	16.99	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F3.0R	10.50	0.0167	0.0192	0.1766	0.4418	0.6216	0.9999	0.9443	0.9171	0.889	0.8447	0.6847	0.4057
Sutter Bypass													
S5.0L	88.04	0.2184	0.2331	0.9297	0.9997	0.9999	0.8232	0.5684	0.4267	0.3803	0.2991	0.1896	0.0827
S4.0L	82.45	0.4468	0.5156	0.9993	0.9999	0.9999	0.5362	0.3336	0.3257	0.2956	0.2223	0.1391	0.0631
S3.0L	77.05	0.1945	0.2104	0.9058	0.9992	0.9999	0.8101	0.6612	0.635	0.6009	0.5021	0.3426	0.1654
Wadsworth Canal													
W3.0R	4.54	0.0065	0.0086	0.0826	0.2279	0.3501	0.9999	0.9995	0.9951	0.9338	0.705	0.3791	0.0786
W2.0R	2.42	0.3590	0.3577	0.9880	0.9999	0.9999	0.6394	0.3611	0.239	0.2263	0.1884	0.0874	0.0074
W2.0L	2.42	0.1137	0.1157	0.7075	0.9750	0.9979	0.9583	0.7575	0.5626	0.4783	0.3363	0.1392	0.0056
Cherokee Canal													
CC2.0L	13.34	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015
CC1.0L	11.4	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015

Notes: Assurance based on existing top of levee or 1957 design top of levee, whichever is higher within the reach. Assurance accounts for stage uncertainty, hydrologic uncertainty, and geotechnical uncertainty.
Index points within the Alternative SB-7 project reach shown in Bold Italics

d. Evacuation Routes. Evacuation routes for alternative SB-7 are shown on the composite floodplain maps. Relative to Alternative SB-1, the project increases the reliability of the evacuation route to Marysville.

e. Flood Warning Time. A description of flood warning time is provided in Alternative SB-1. Alternative SB-7 will result in a significant increase in warning time to the population within Yuba City because the probability of flooding from a geotechnical type failure (1-hour warning time) would be reduced and the warning time for overtopping type failures are significantly longer (24 to 36 hours).

f. Loss of Life Potential. To evaluate the potential for loss of life, the population density within the study area was compared to the composite floodplain maps of alternative SB-7. The distribution of population within the study area was based on 2010 census blocks. A map of the estimated population density throughout the study area is provided in Plate 4. The population within areas greater than 0 feet, 2 feet, and 15 feet are provided in Tables 33, 34, and 35 respectively.

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Table 33.
Population within Alternative SB-7 Floodplain
Depths Greater Than 0 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	251
Yuba City Urban	0	43	6194	12519	14429	67368	67368
Biggs Urban	0	19	1452	1452	1452	1452	1763
Gridley Urban	0	0	6379	6379	6379	6379	6379
Live Oak Urban	0	0	8362	8362	8362	8362	8362
Sutter County Rural	1089	1718	4788	5742	5867	6354	6378
Butte County Rural	0	9	4776	4788	4788	4793	4899
Total	1089	1789	31951	39242	41276	94707	95400

Table 34.
Population within Alternative SB-7 Floodplain
Depths Greater Than 2 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	16	699	976	66380	67368
Biggs Urban	0	0	1352	1352	1352	1353	1554
Gridley Urban	0	0	1176	1176	1176	1186	5483
Live Oak Urban	0	0	4156	5882	5882	6498	8362
Sutter County Rural	767	1478	2073	2930	3267	5505	6199
Butte County Rural	0	0	2424	2527	2527	2887	3882
Total	767	1478	11196	14567	15180	83809	92847

Table 35.
Population within Alternative SB-7 Floodplain
Depths Greater Than 15 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	0	0	0	303	934
Biggs Urban	0	0	0	0	0	0	0
Gridley Urban	0	0	0	0	0	0	0
Live Oak Urban	0	0	0	0	0	0	0
Sutter County Rural	0	0	4	231	303	1059	1183
Butte County Rural	0	0	0	0	0	0	0
Total	0	0	4	231	303	1362	2117

4.9 Potential Adverse Effects.

a. Induced Flooding. The hydraulic features associated with Alternative SB-7 are identical to Alternative SB-1. Therefore, there is no induced flooding associated with Alternative SB-7.

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b. Transfer of Flood Risk. The hydraulic features associated with Alternative SB-7 are identical to Alternative SB-1. Therefore, there is no induced flooding associated with Alternative SB-7.

5.0 Alternative SB-8 (Thermalito to Laurel Avenue)

5.1 General Design Features

a. Levees. This project would involve fixing the Feather River levees to meet current USACE design standards from Thermalito Afterbay to Laurel Avenue. The levee height would be based on the 1957 design profile or the existing profile, whichever is higher. In no cases would the levee be raised above these profiles. Within three reaches, the levee will be shifted 20 feet towards the river. This was required to provide an access road on the landward side of the levee toe. Additional details are discussed in the hydraulic design section below.

b. Interior Drainage Facilities. The project would involve the replacement of gravity drainage culverts within the reach. Five of the gravity drainage culverts will be removed because they are no longer used for drainage and one culvert will be downsized. Additional details are discussed in the hydraulic design section below.

c. Operation and Maintenance. The project will be maintained to meet current design standards. The project will rely on one sand bag closure structure at the UPRR railroad bridge crossing.

5.2 Hydrology.

The hydrology associated with Alternative SB-8 is identical to Alternative SB-1 (without project conditions).

5.3 Hydraulic Models

Hydraulic models were revised to incorporate the 20 foot riverward shift in the levee along three reaches. The shift in the levee alignment was necessary to provide an access road adjacent to an existing canal located along the landward toe. The upstream reach is 2.3 miles long and extends from RM 45.5 (FRWL station 1675+00) to RM 47.55 (FRWL station 1753+00). The middle reach is 0.25 miles long and extends from RM 44.6 (FRWL Station 1610+00) to RM 44.8 (FRWL Station 1623+00). The lower reach is 0.28 miles long and extends from RM 38.8 (FRWL Station 1434+00) to RM 39.1 (FRWL Station 1449+00). All other model features are the same as the SB-1 alternative.

5.4 Hydraulic Model Results.

The hydraulic model created for Alternative SB-8 computed the same water surface profiles as Alternative SB-1. Within the three reaches where the levee will be shifted 20 feet riverward, the channel cross section width is over 5000 feet and this was found to have no measureable impact

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on the water surface throughout the model domain. Therefore, the hydraulic model results provided for Alternative SB-1 are applicable to SB-8.

5.5 Hydraulic Design.

a. Levee Height. This project would involve fixing the Feather River levees to meet current USACE design standards from Thermalito Afterbay to Laurel Avenue. The levee height would be based on the 1957 design profile or the existing profile, whichever is higher. In no cases would the levee be raised above these profiles.

b. Closure Structures. A sandbag type closure structure is specified where the UPRR crosses the levee embankment. This closure structure must be operated in order for the project to obtain the assurance level described below. Failure to sandbag this closure structure could result in a failure of the levee that would rapidly inundate the urban area of Yuba City.

c. Levee Superiority. The definition of levee superiority per EC 1110-2-6066 (*Design of I-Walls*, 31 October 2010) is the increment of additional height added to a flood risk management system to increase the likelihood that when the design event is exceeded, controlled flooding will occur at the design overtopping section. Since alternative SB-8 is based on an existing levee profile, the design top of levee was reviewed relative to the modeled mean water surface profiles to determine likely initial overtopping locations. Alternative SB-8 extends upstream and downstream of the Yuba River tributary. Initial overtopping locations were identified upstream and downstream of confluence to account for the uncertainty in the aerial centering of storm events.

It is estimated that the initial overtopping location upstream of the Yuba River confluence would occur between River Miles 43.5 and 45.5 (FRWLP Station 1582+00 to 1601+00). This location is a non-urbanized area and initial overtopping is estimated to occur between the mean 0.5% (1/200) ACE and 0.2% (1/200) ACE events.

It is estimated that the initial overtopping location downstream of the Yuba River would occur between River Miles 19 and 20 (FRWLP Station 547+00 to 604+60). This location is a non-urbanized area and initial overtopping is estimated to occur between the mean 0.5% (1/200) ACE and 0.2% (1/200) ACE events. This is identical to the reach identified for the SB7 alternative.

Within both 1-mile reaches, the landward side of the levee will be covered with anchored High Performance Turf Reinforced Mat (HPTRM). This design will increase the erosion resistance of the levee and allow for more controlled failure of the levee due to overtopping.

d. Erosion Protection. Erosion protection was not specified within the design reach.

e. Interior Drainage Facilities. All drainage features would be replaced with the same capacity except at six locations described in Table 36. Five of the facilities appear to provide no interior drainage function and one location appears to be oversized. Each of the six sites was visited by SBFCA's engineering consultant, PBI, and adjacent land owners were reviewed. The results of the analysis are described in a technical memorandum to the Sutter Butt Flood Control

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Agency titled, Culvert Removal Analysis for the Feather River West Levee Improvement Project, 17 August, 2012.

Table 36
Proposed Culvert Modifications, Alternative SB-8

River Mile	FRWLP Station	Culvert Size	Notes
44.90	1639+00	2-24”	Remove Culvert, Culvert inlet was filled with soil with no obvious signs of a drainage path leading to the culvert
48.00	1785+24	1-24”	Remove Culvert, Culvert did not appear to be used with no signs of a drainage path leading to the culvert
51.20	1961+03	2-60”	Reduce Culvert Size, Culvert appeared to be oversized. Recommend reducing size to 1-36”
57.05	2239+66	1-24”	Remove Culvert, No culvert inlet was found.
57.10	2245+52	1-24”	Remove Culvert, Culvert inlet was filled with soil with no obvious signs of a drainage path leading to the culvert
57.15	2256+94	1-24”	Remove Culvert, Culvert inlet was nearly buried. Culvert is located near another culvert. Nearby culvert should provide adequate capacity.

5.6 Wind Wave Analysis.

Wind wave runup and setup associated with Alternative SB-8 is identical to Alternative SB-1 (without project conditions).

5.7 Sedimentation and Channel Stability

Sedimentation and Channel Stability associated with Alternative SB-8 is identical to Alternative SB-1 (without project conditions).

5.8 Flood Risk.

Flood risk would be reduced by Alternative SB-8 by reduction of the geotechnical fragility within the reach.

a. Levee Assurance. Levee assurance values within reaches modified by the project were recomputed using geotechnical fragility curves that reflect no failure until overtopping. All other inputs to calculate assurance were identical to Alternative SB-1, the without project condition.

b. Composite Floodplains. Maps showing composite floodplains were developed to demonstrate FRM reliability for Alternative SB-8. The composite floodplains are provided in Plates 65 through 71. All maps include the natural (non-leveed) flood inundation depths. Table 37 provides the assurance values used to determine if a simulated breach was included in the floodplain map.

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Table 37
Project Performance at Simulated Levee Breach Locations, Alternative SB-8

Simulated Breach		Annual Exceedance Probability		Long Term Risk			Flood Risk Management Assurance by Event Flood Frequency (Breach included in floodplain map if shaded)						
Label	River Mile	Median	Exp.	10 Years	30 Years	50 Years	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Feather River													
F9.0R	57.17	0.0020	0.0023	0.0233	0.0683	0.1112	0.9999	0.9999	0.9949	0.9915	0.9726	0.8551	0.6390
F8.0R	50.20	0.0001	0.0023	0.0225	0.0659	0.1075	0.9999	0.9999	0.9949	0.9915	0.9726	0.8551	0.6390
F7.0R	41.55	0.0022	0.0022	0.0220	0.0646	0.1054	0.9999	0.9999	0.9999	0.9999	0.9895	0.8576	0.5427
F6.0R	34.07	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5547
F5.0R	28.25	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5548
F4.5R	26.00	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.4R	25.99	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.1R	17.00	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F4.0R	16.99	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F3.0R	10.50	0.0167	0.0192	0.1766	0.4418	0.6216	0.9999	0.9443	0.9171	0.889	0.8447	0.6847	0.4057
Sutter Bypass													
S5.0L	88.04	0.2184	0.2331	0.9297	0.9997	0.9999	0.8232	0.5684	0.4267	0.3803	0.2991	0.1896	0.0827
S4.0L	82.45	0.4468	0.5156	0.9993	0.9999	0.9999	0.5362	0.3336	0.3257	0.2956	0.2223	0.1391	0.0631
S3.0L	77.05	0.1945	0.2104	0.9058	0.9992	0.9999	0.8101	0.6612	0.635	0.6009	0.5021	0.3426	0.1654
Wadsworth Canal													
W3.0R	4.54	0.0065	0.0086	0.0826	0.2279	0.3501	0.9999	0.9995	0.9951	0.9338	0.705	0.3791	0.0786
W2.0R	2.42	0.3590	0.3577	0.9880	0.9999	0.9999	0.6394	0.3611	0.239	0.2263	0.1884	0.0874	0.0074
W2.0L	2.42	0.1137	0.1157	0.7075	0.9750	0.9979	0.9583	0.7575	0.5626	0.4783	0.3363	0.1392	0.0056
Cherokee Canal													
CC2.0L	13.34	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015
CC1.0L	11.4	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015

Notes: Assurance based on existing top of levee or 1957 design top of levee, whichever is higher within the reach. Assurance accounts for stage uncertainty, hydrologic uncertainty, and geotechnical uncertainty.
Index points within the Alternative SB-8 project reach shown in Bold Italics

c. Flood Velocities. Flood velocities for a levee beach would be identical as alternative SB-1.

d. Evacuation Routes. Evacuation routes for alternative SB-8 are shown on the composite floodplain maps. Relative to Alternative SB-1, the project increases the reliability of the evacuation routes for Marysville, Biggs, Gridley, and Live Oak.

e. Flood Warning Time. A description of flood warning time is provided in Alternative SB-1. Alternative SB-8 will result in a significant increase in warning time to the population within Yuba City, Biggs, Gridley and Live Oak because the probability of flooding from a geotechnical type failure (1-hour warning time) would be reduced and the warning time for overtopping type failures are significantly longer (24 to 36 hours).

f. Loss of Life Potential. To evaluate the potential for loss of life, the population density within the study area was compared to the composite floodplain maps of alternative SB-8. The distribution of population within the study area was based on 2010 census blocks. A map of the estimated population density throughout the study area is provided in Plate 4. The population within areas greater than 0 feet, 2 feet, and 15 feet are provided in Tables 39, 40, and 41 respectively.

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Table 38.
Population within Alternative SB8 Floodplain
Depths Greater Than 0 Feet

Economic Evaluation Area	Peak Stage (FT-NAVD88)						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	251
Yuba City Urban	0	43	255	4923	6480	67368	67368
Biggs Urban	0	19	19	19	19	1452	1763
Gridley Urban	0	0	0	0	0	6379	6379
Live Oak Urban	0	0	0	0	0	8362	8362
Sutter County Rural	1089	1718	2110	3036	3269	6354	6378
Butte County Rural	0	9	9	9	18	4793	4899
Total	1089	1789	2393	7987	9786	94707	95400

Table 39.
Population within Alternative SB1 Floodplain
Depths Greater Than 2 Feet

Economic Evaluation Area	Peak Stage (FT-NAVD88)						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	16	417	665	66380	67368
Biggs Urban	0	0	0	0	0	1353	1554
Gridley Urban	0	0	0	0	0	1186	5483
Live Oak Urban	0	0	0	0	0	6498	8362
Sutter County Rural	767	1478	1700	2368	2704	5505	6199
Butte County Rural	0	0	0	0	0	2887	3882
Total	767	1478	1716	2785	3369	83809	92847

Table 40.
Population within Alternative SB1 Floodplain
Depths Greater Than 15 Feet

Economic Evaluation Area	Peak Stage (FT-NAVD88)						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	0	0	0	303	934
Biggs Urban	0	0	0	0	0	0	0
Gridley Urban	0	0	0	0	0	0	0
Live Oak Urban	0	0	0	0	0	0	0
Sutter County Rural	0	0	4	231	303	1059	1183
Butte County Rural	0	0	0	0	0	0	0
Total	0	0	4	231	303	1362	2117

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5.9 Potential Adverse Effects.

a. Induced Flooding. The hydraulic features associated with Alternative SB-8 are nearly identical to Alternative SB-1. The hydraulic model created for Alternative SB-8 computed the same water surface profiles as Alternative SB-1. Therefore, there is no induced flooding.

b. Transfer of Flood Risk. Analysis of the alternative found no transfer of flood risk. The hydraulic model created for Alternative SB-8 computed the same water surface profiles as Alternative SB-1. Within the three reaches where the levee will be shifted 20 feet riverward, the channel cross section width is over 5000 feet and this was found to have no measureable impact on the water surface throughout the model domain.

6.0 SUMMARY

This report describes hydraulic, sedimentation, and operations and maintenance analyses performed for the final alternatives of the Sutter Basin Feasibility Study. Analyses were performed for without-project and two project alternative conditions. The report provides an update of the previous analysis of the without-project conditions.

The study is focused on Sutter Basin Feasibility Study area. Composite floodplain delineations are provided for 50% (1/2) ACE, 10% (1/10) ACE, 4% (1/25) ACE, 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE, and 0.2% (1/500) ACE events for the existing and alternative conditions.

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Legend

- Study Area Extent
- Sacramento Basin
- Watershed Boundaries
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levees
- City

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

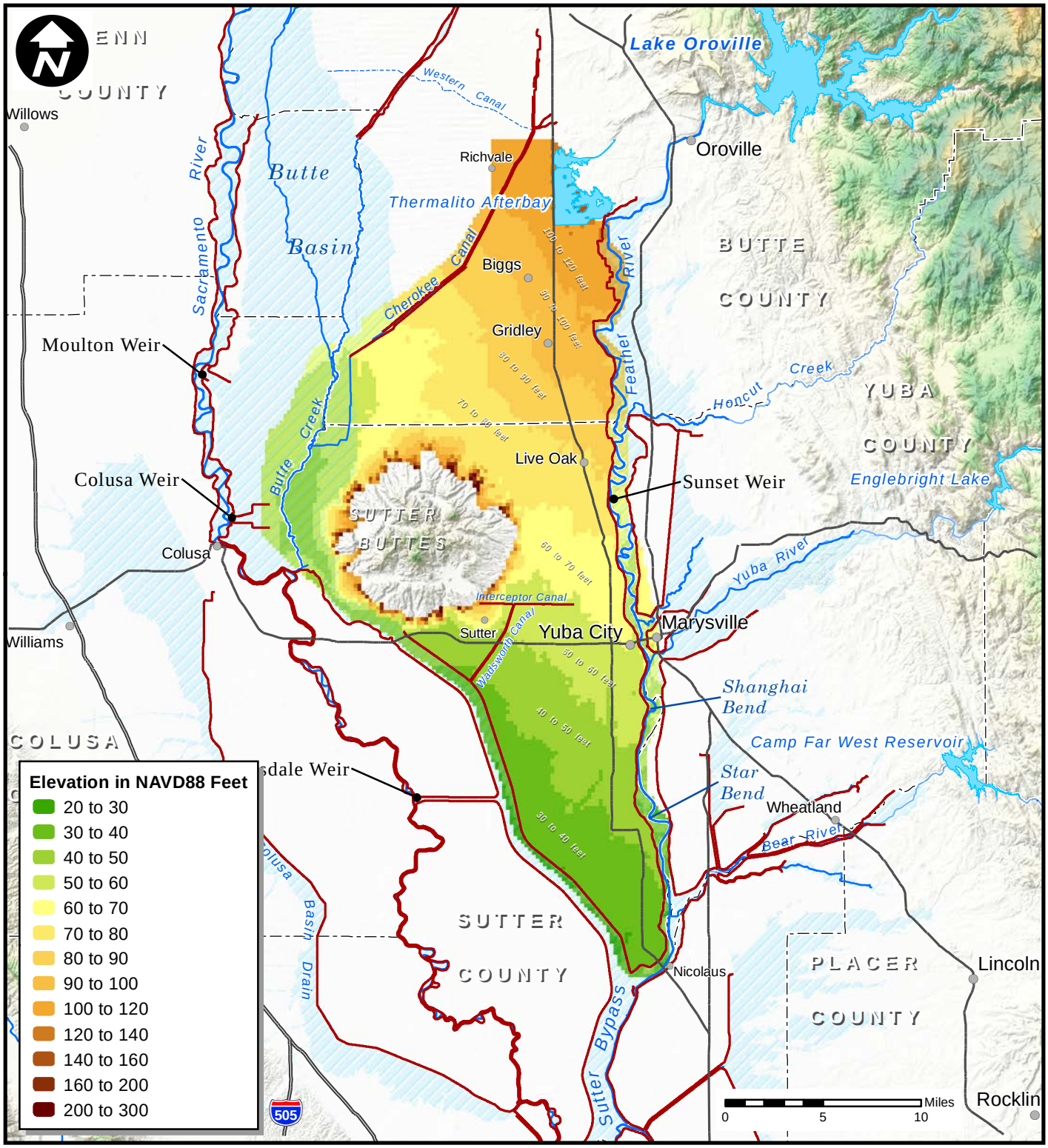
SACRAMENTO RIVER WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 1



Legend

- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

STUDY AREA TOPOGRAPHY

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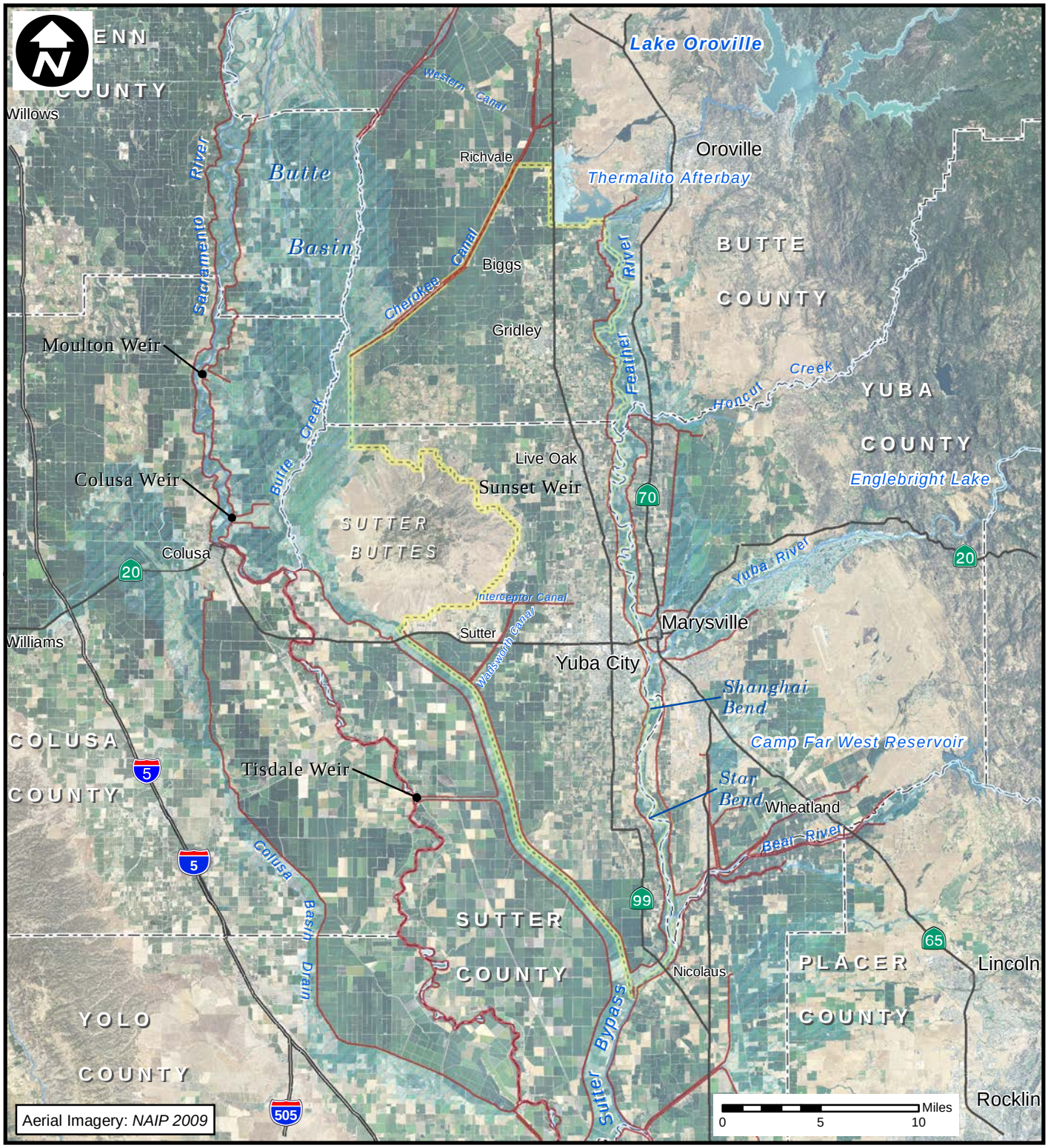
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 2



Legend

- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

STUDY AREA AERIAL IMAGERY

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SACRAMENTO DISTRICT

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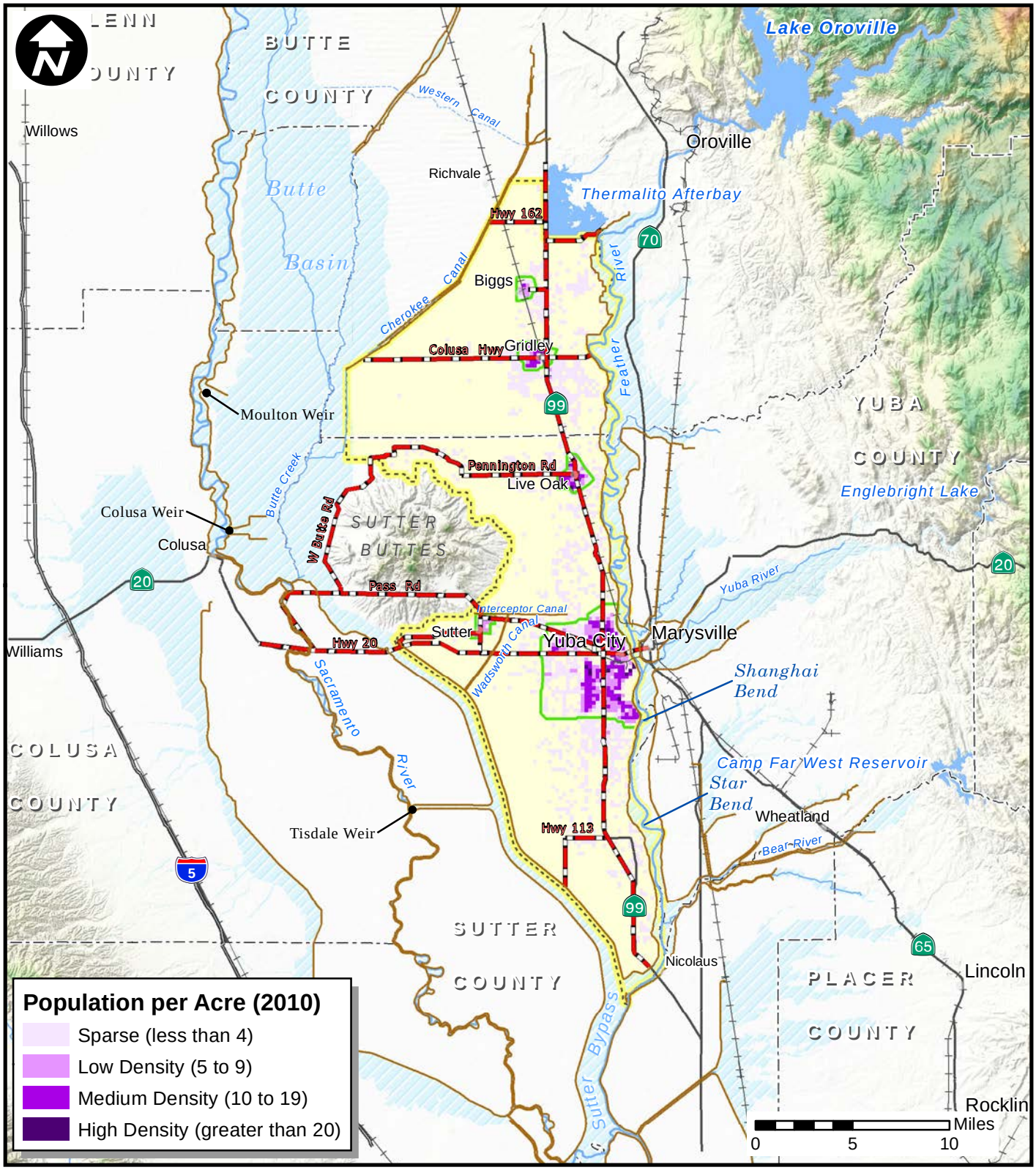
PLATE 3



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Evacuation Routes
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

POPULATION DENSITY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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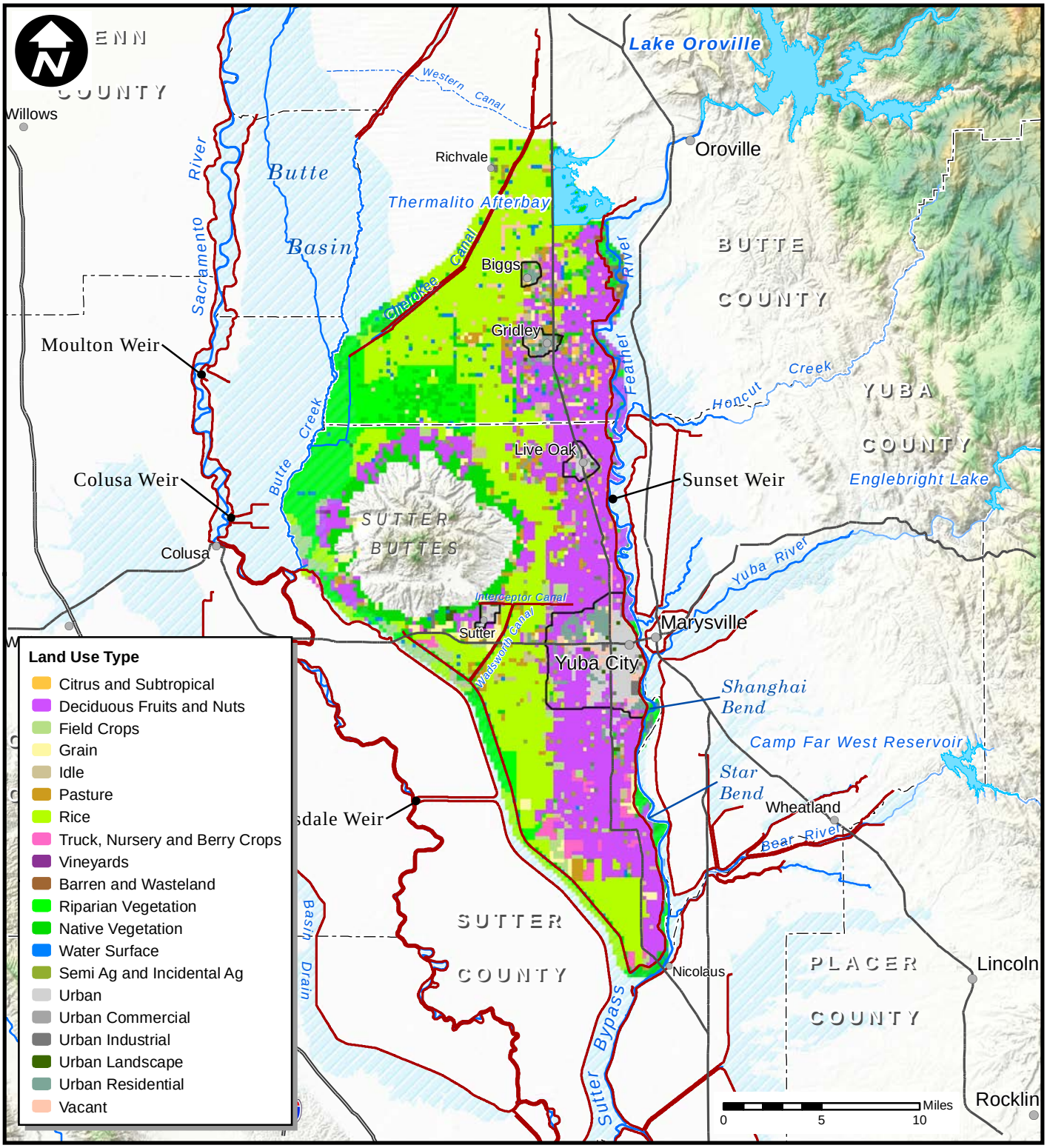
PLATE 4



Legend

- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

LAND USE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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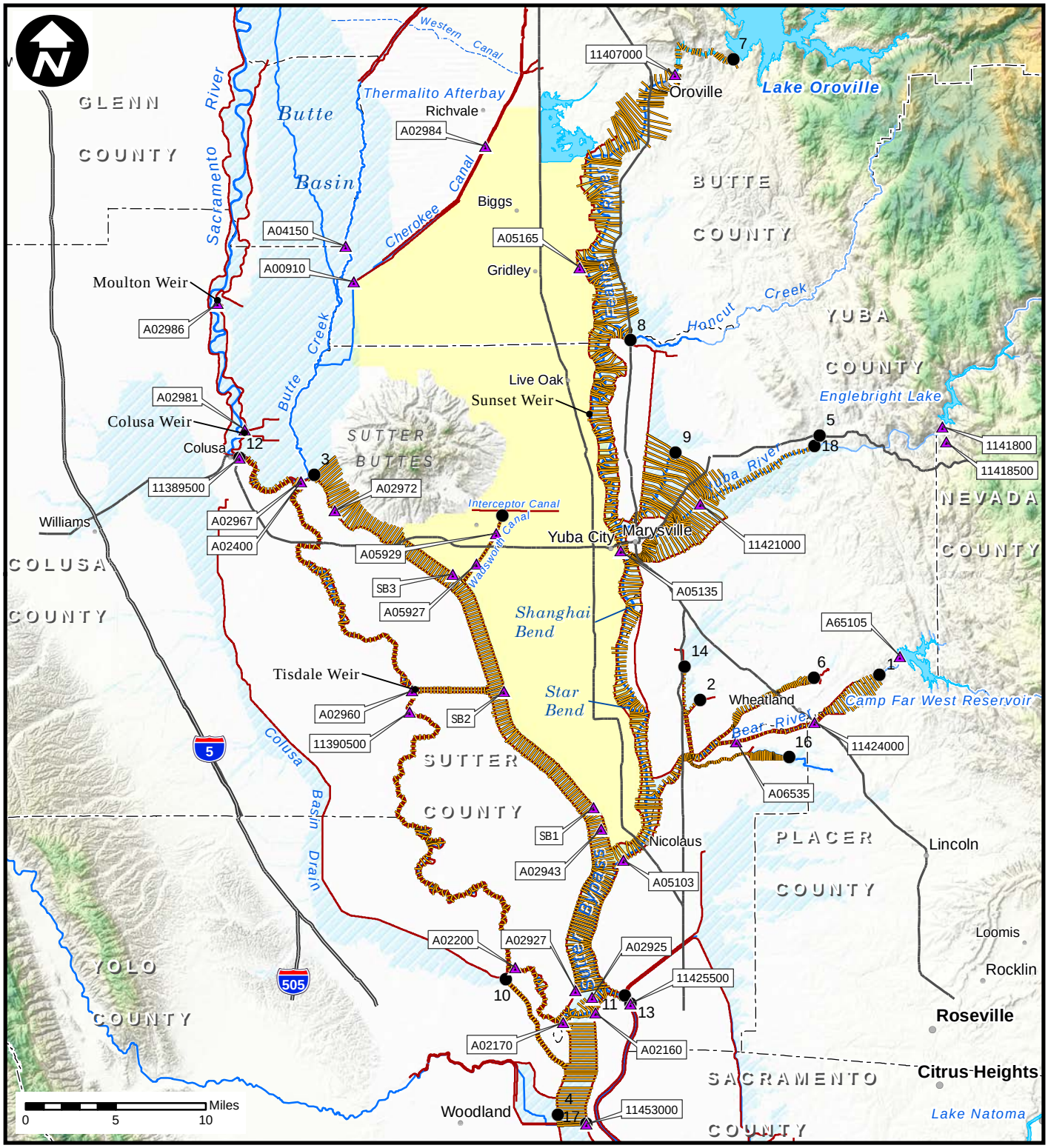
PLATE 5



Legend

- Stream Gage
- Model Boundaries
- Model Cross Sectios
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: See Table 1 and 2 for Model Boundary Name

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

HEC-RAS HYDRAULIC MODEL BOUNDARY CONDITIONS AND STREAM GAGES

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SACRAMENTO DISTRICT

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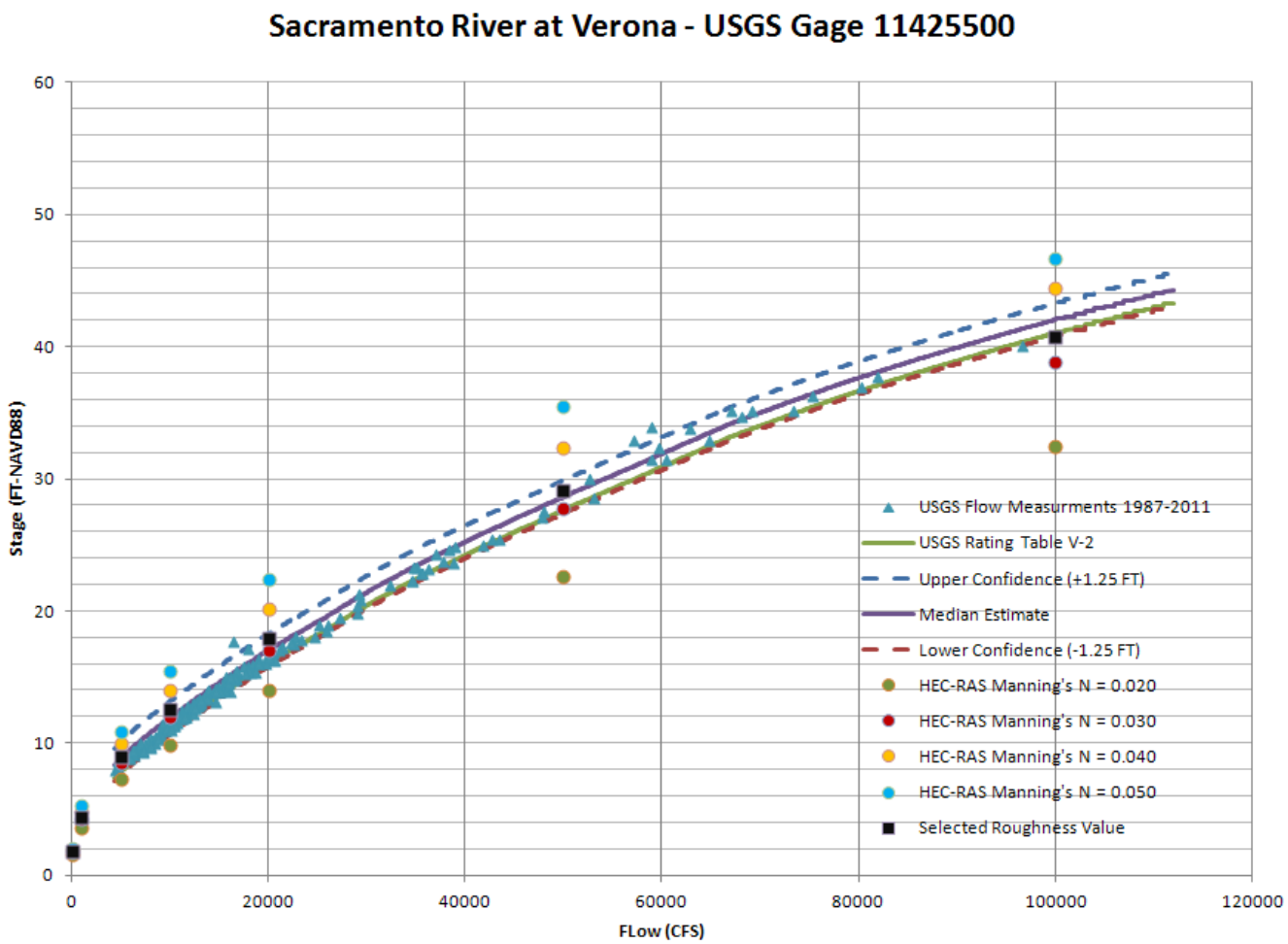
PLATE 6

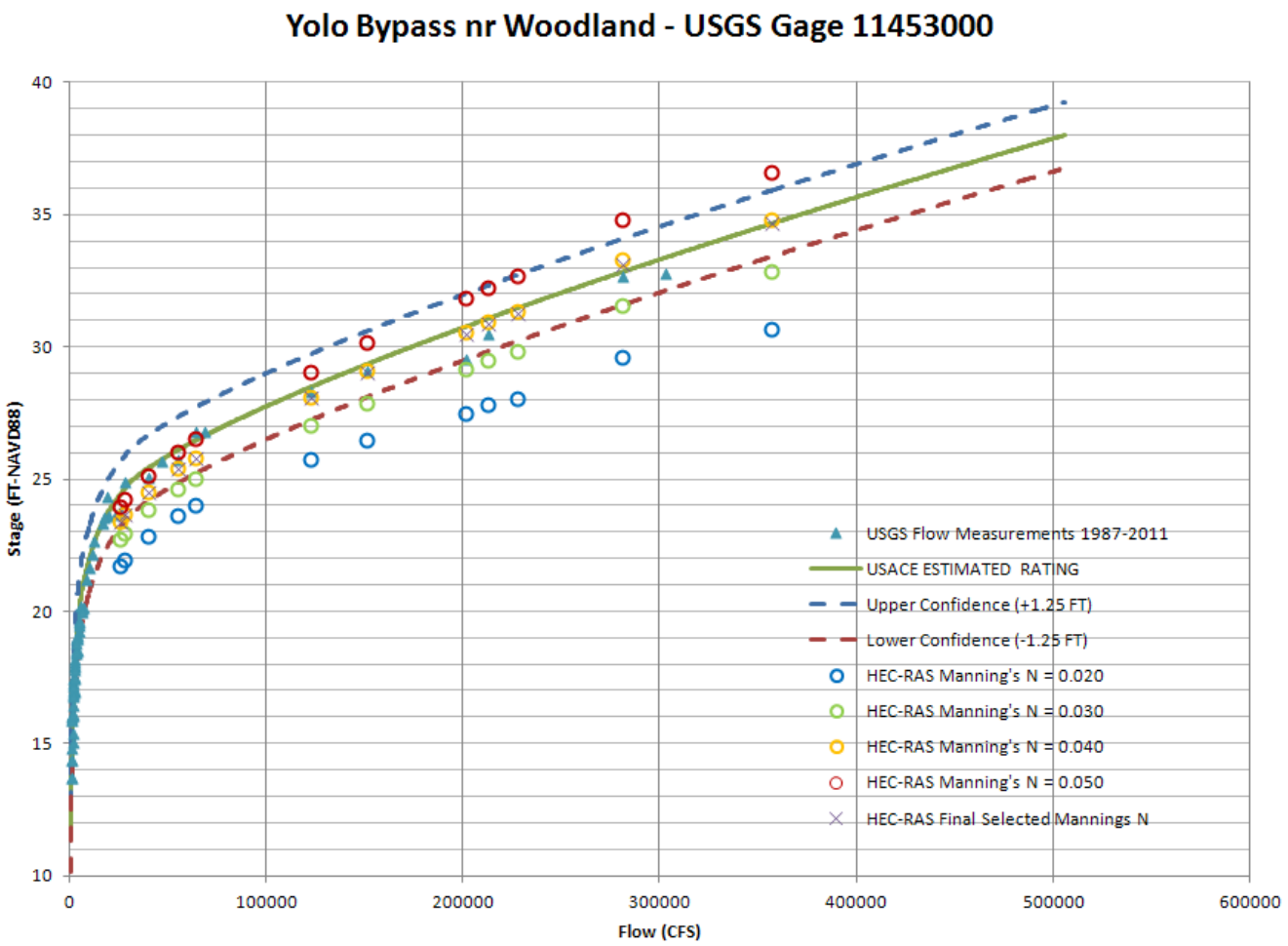


Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE-DISCHARGE CURVE
SACRAMENTO RIVER AT VERONA
WITHOUT PROJECT CONDITIONS

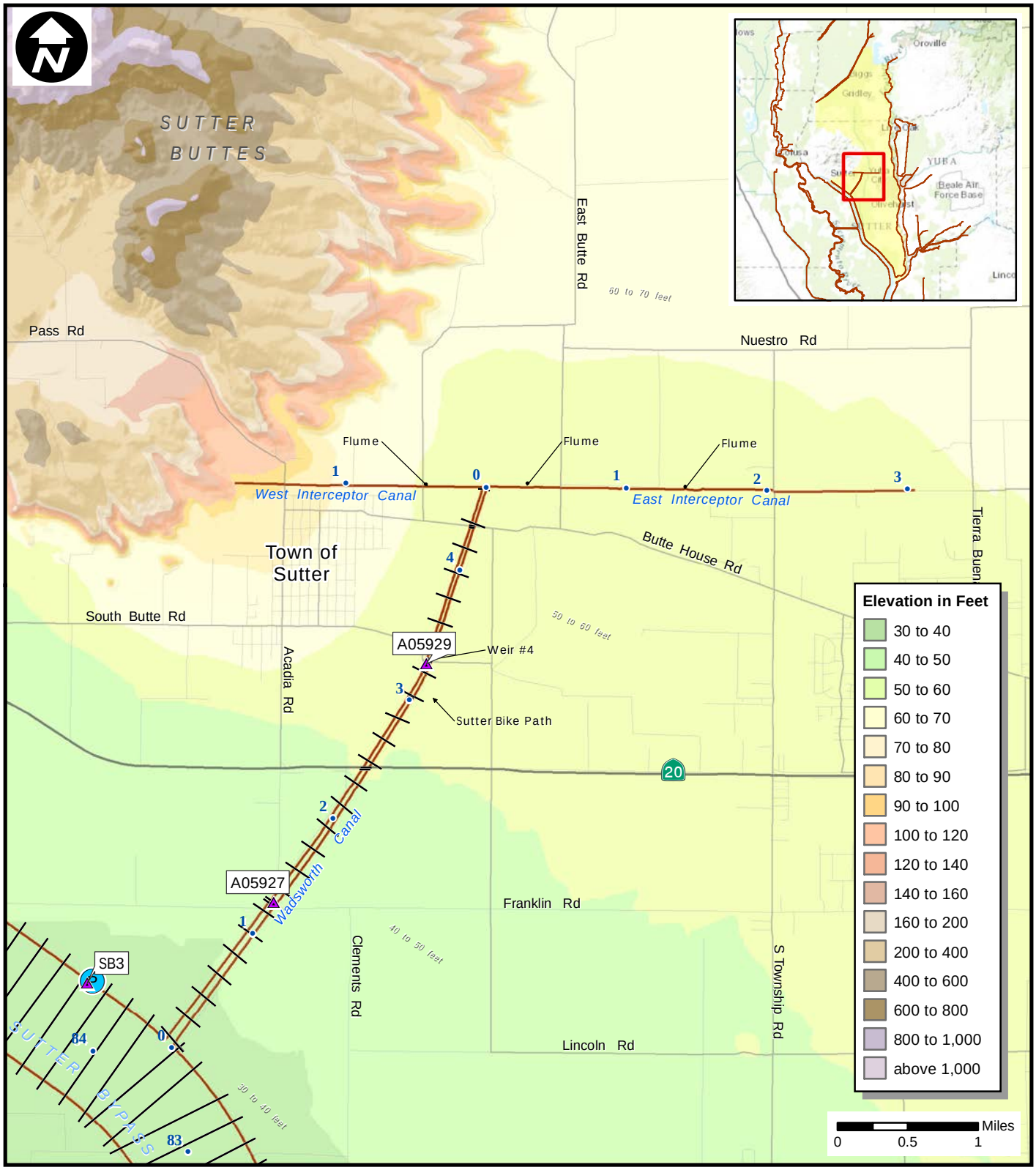
U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE-DISCHARGE CURVE
YOLO BYPASS AT WOODLAND
WITHOUT PROJECT CONDTIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Legend

- Model Cross Sectios
- Federal Levee
- Pump Station
- Comp Study River Mile

Note: Topography data is from the USGS DEM and is in NAVD88

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

WADSWORTH AND INTERCEPTOR CANALS TOPOGRAPHY

U.S. ARMY CORPS OF ENGINEERS
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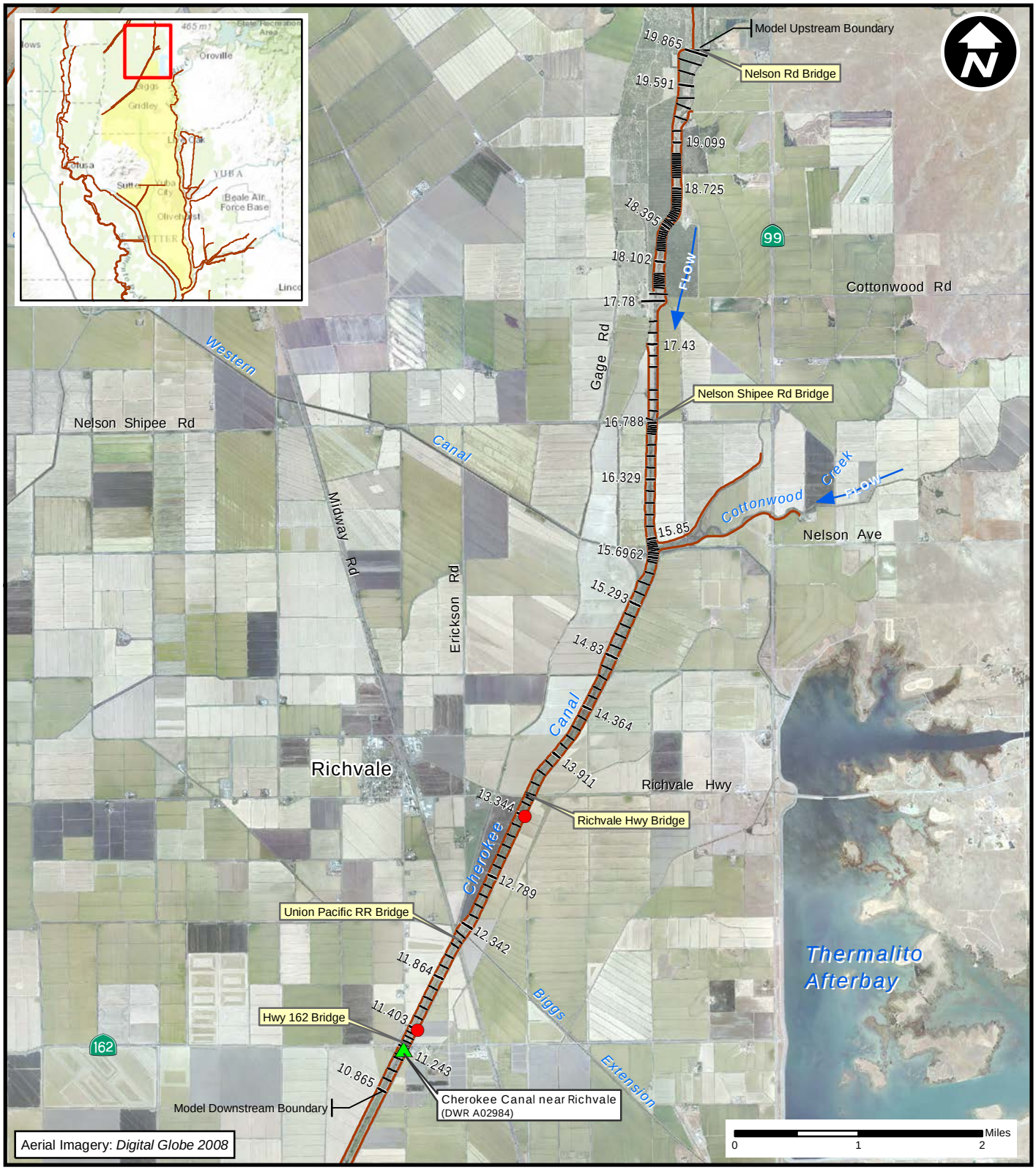
PLATE 9



Legend

- Stream Gage
- Breach Simulation Point
- Model Cross Sections
- Federal Levee

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

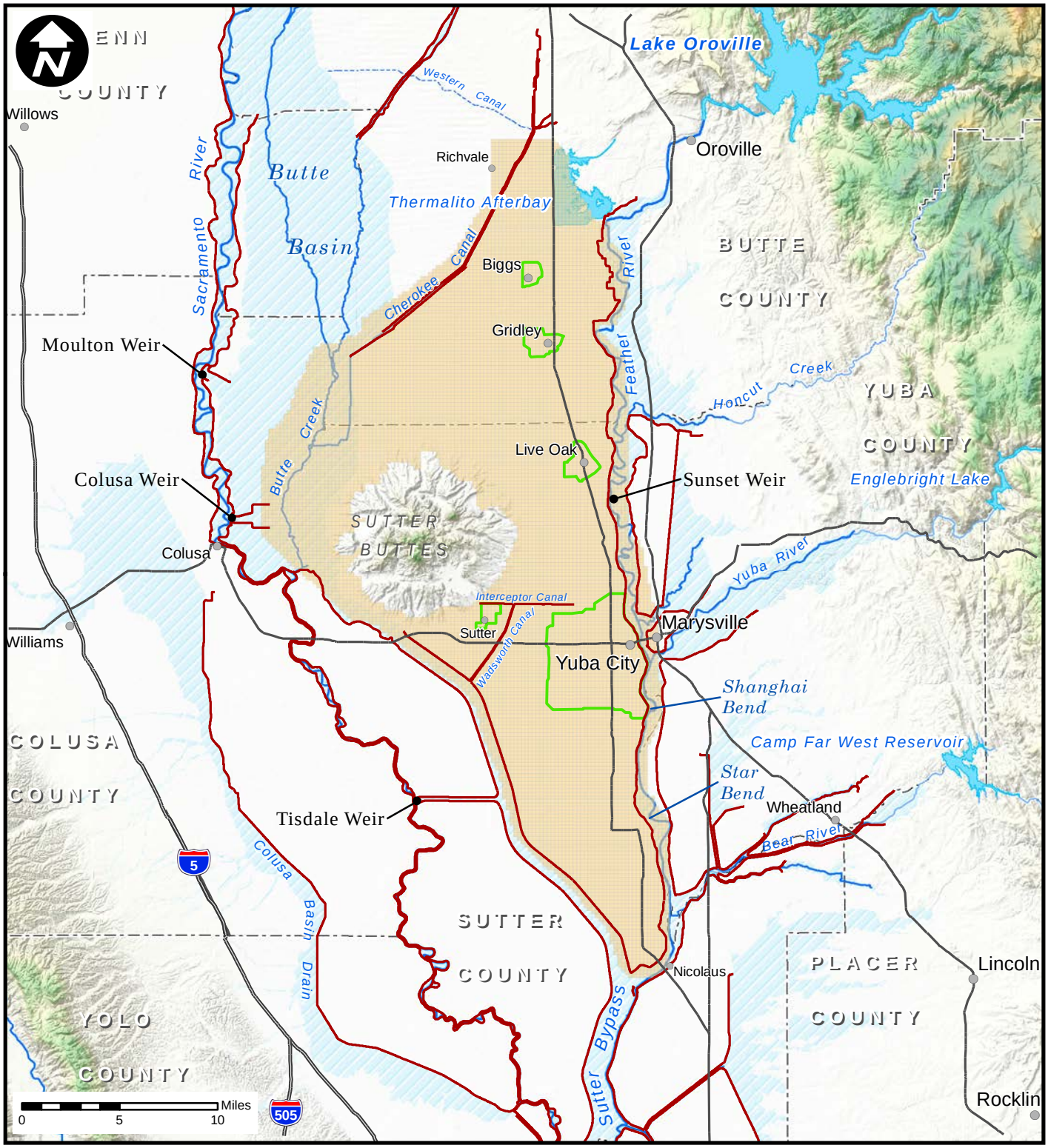
CHEROKEE CANAL HYDRAULIC MODEL

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAR 2013

PLATE 10



Legend

- FLO2D Grid - 1000 ft
- Designated Floodways
- Lake or Reservoir
- Economic Evaluation Area
- River or Stream
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

FLO2D MODEL GRID

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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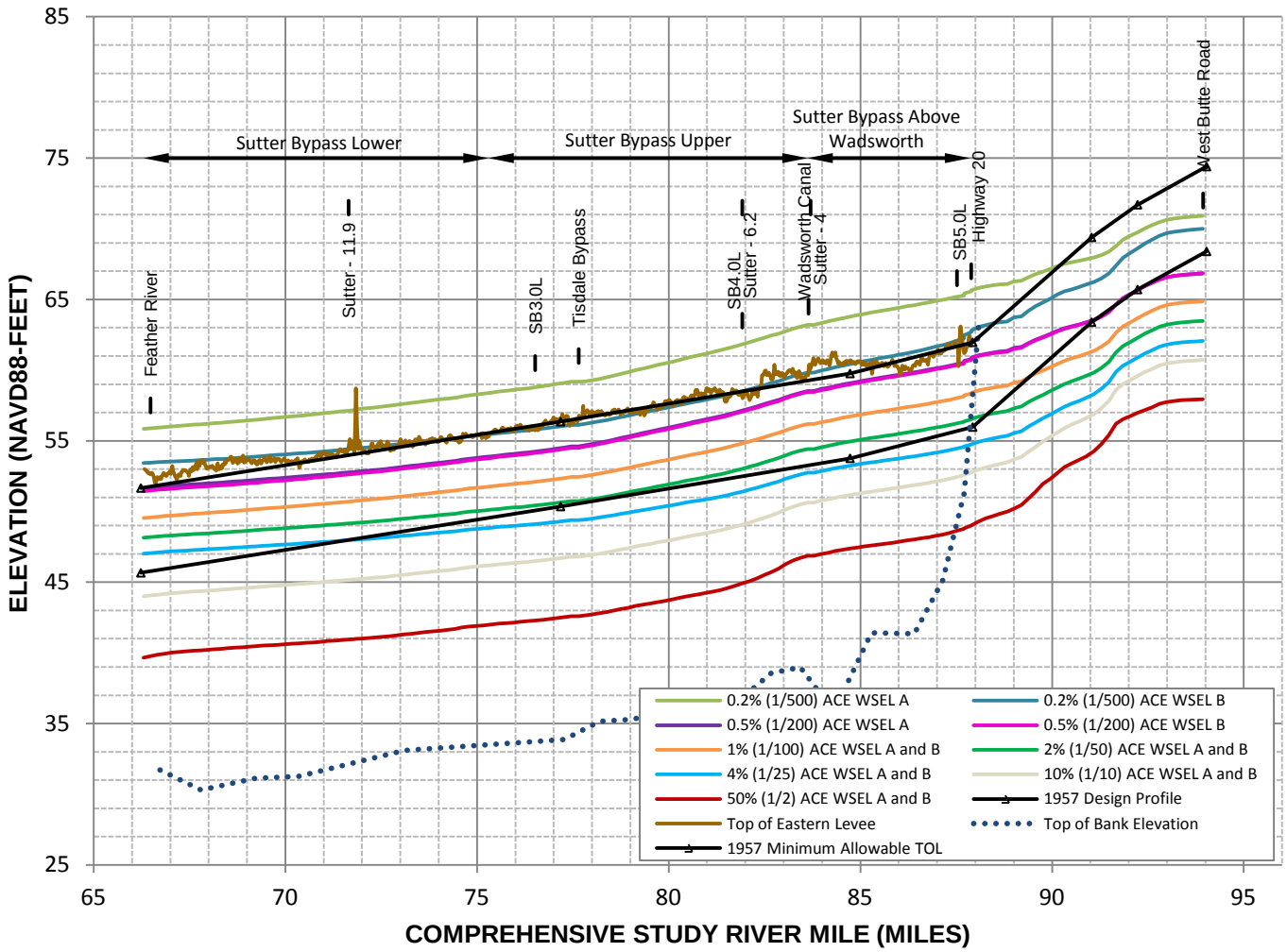
PLATE 11



Note:

Water Surface Profile A assumes infinite levee height, no overtopping

Water Surface Profile B assumes overtopping only, no failure

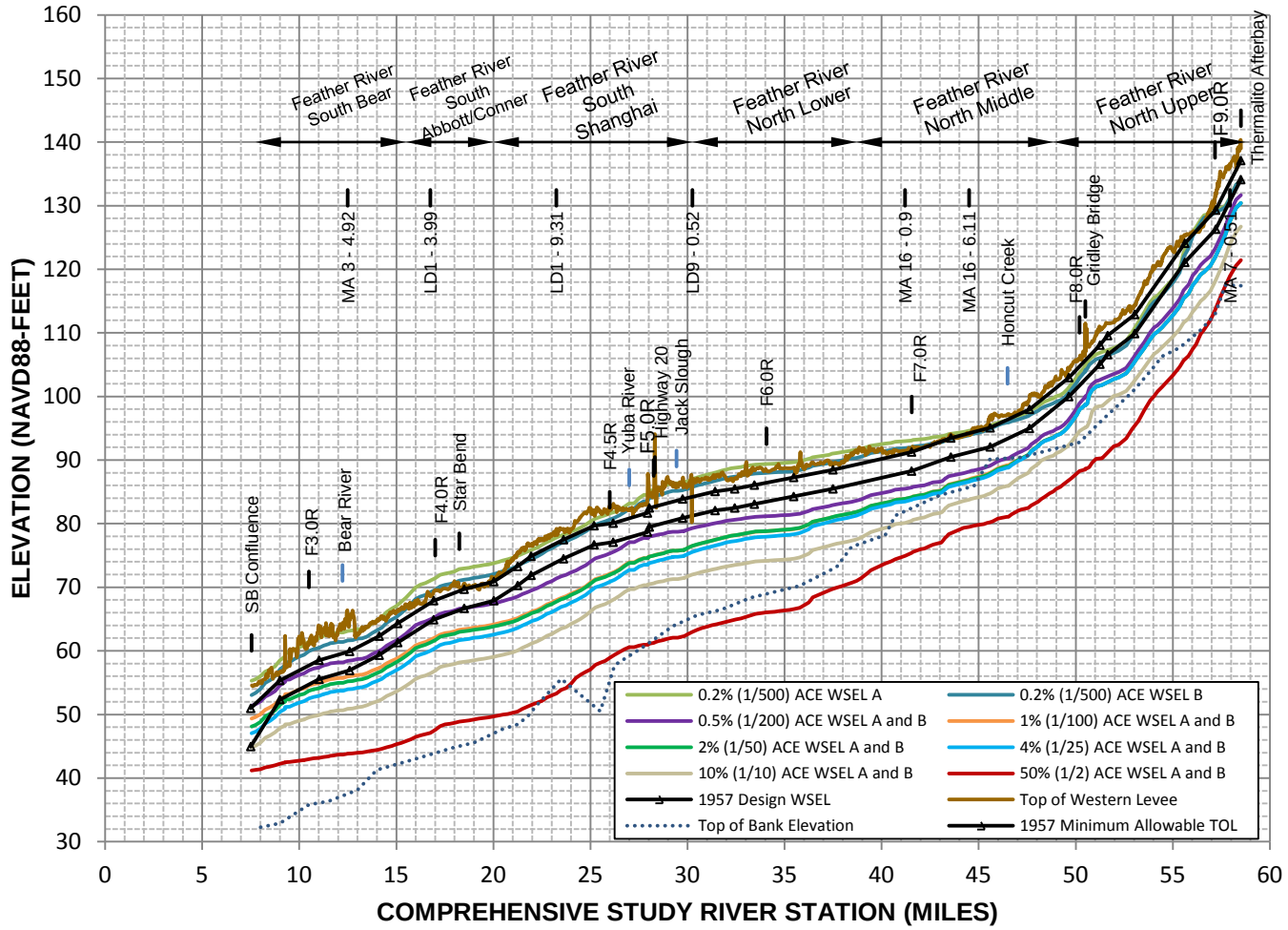
WSEL = Water Surface Elevation

Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

SUTTER BYPASS
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Note:

Water Surface Profile A assumes infinite levee height, no overtopping

Water Surface Profile B assumes overtopping only, no failure

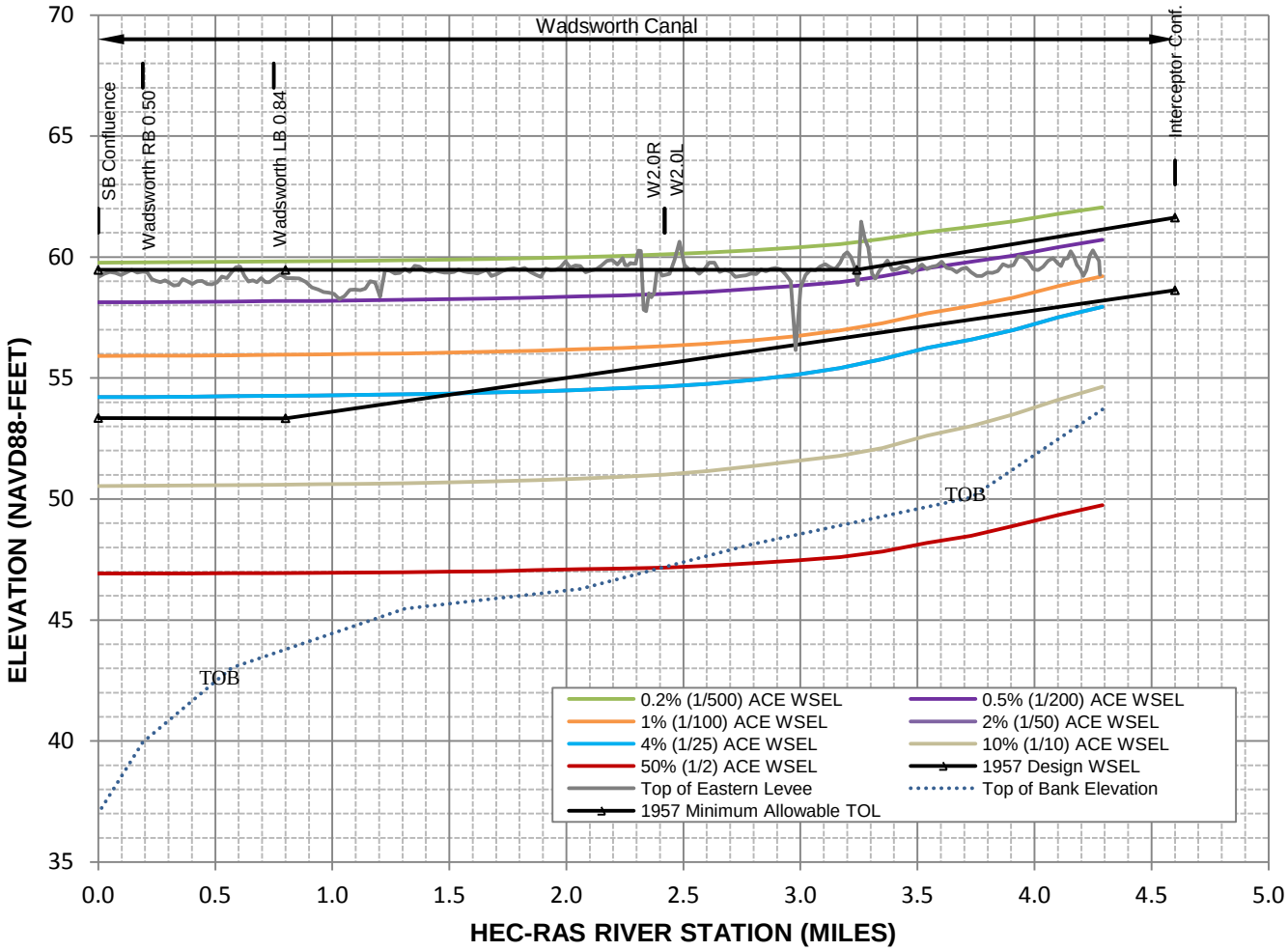
WSEL = Water Surface Elevation

Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

FEATHER RIVER
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Note:

Water Surface Profile A assumes infinite levee height, no overtopping

Overtopping, no failure was not created for Wadsworth Canal

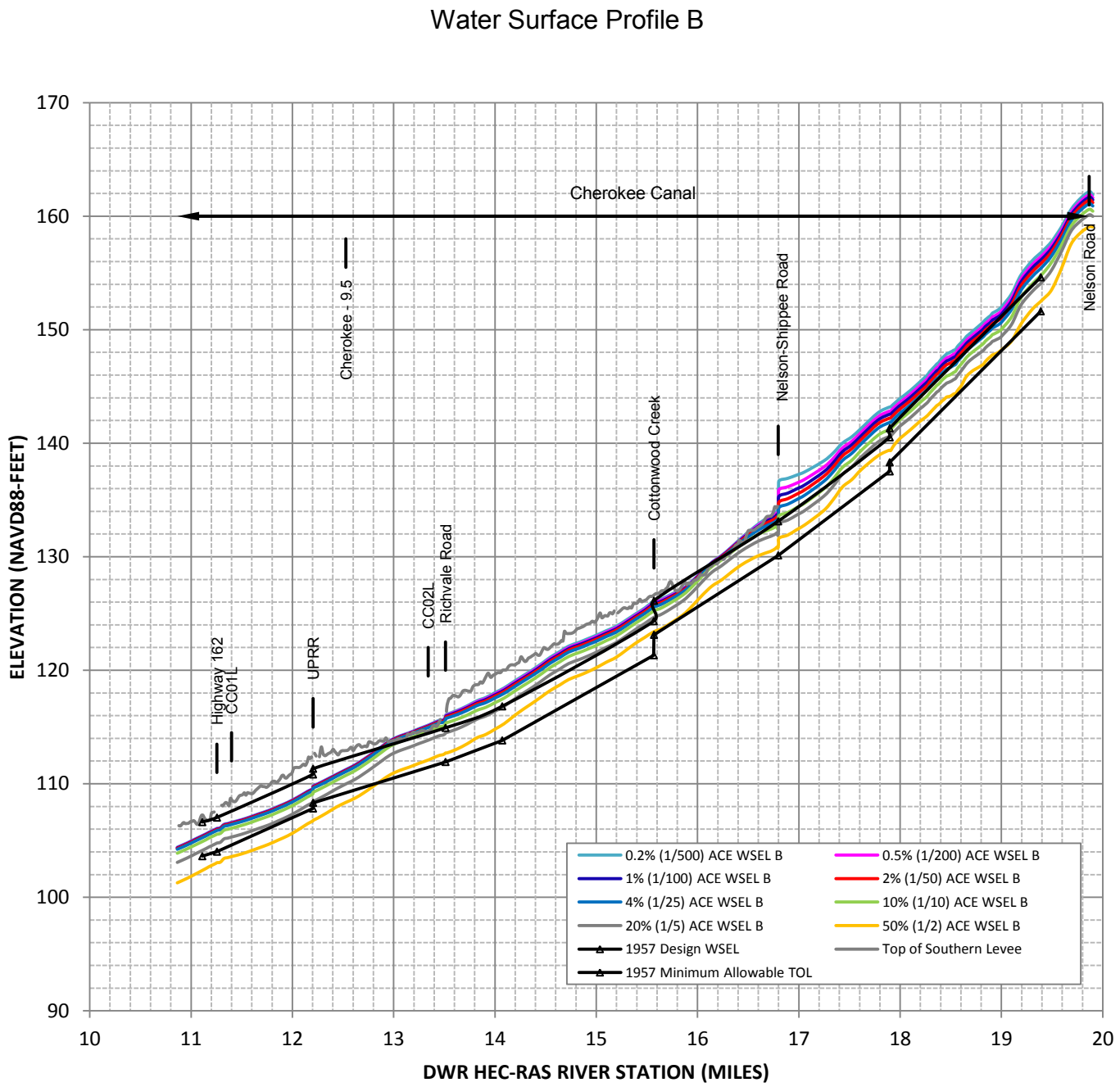
WSEL = Water Surface Elevation

Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

WADSWORTH CANAL
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Notes:

Water Surface Profile B assumes overtopping only, no failure.

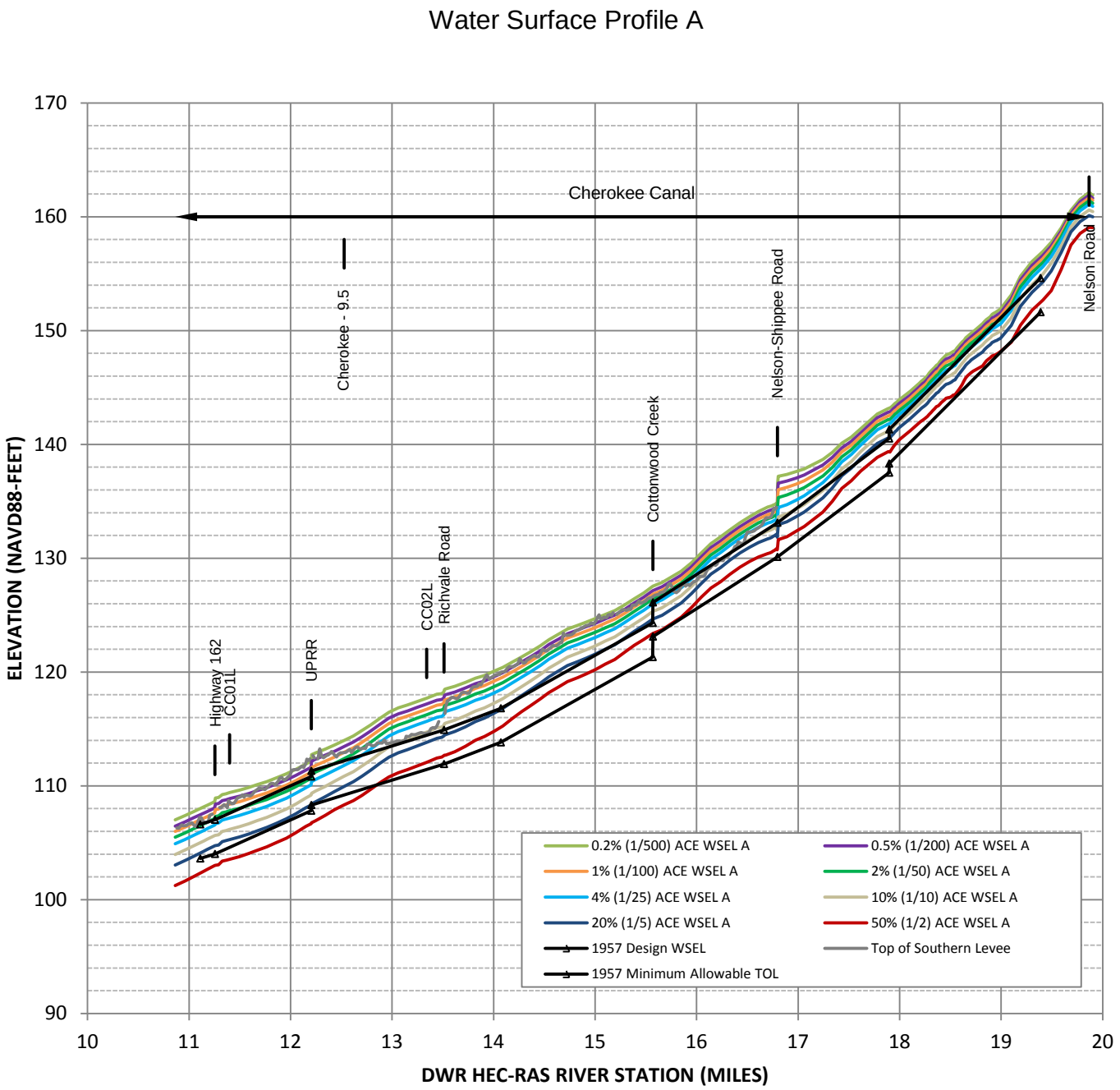
WSEL = Water Surface Elevation

Source:

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

CHEROKEE CANAL
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Notes:

Water Surface Profile A assumes infinite levee height, no overtopping.

WSEL = Water Surface Elevation

Source:

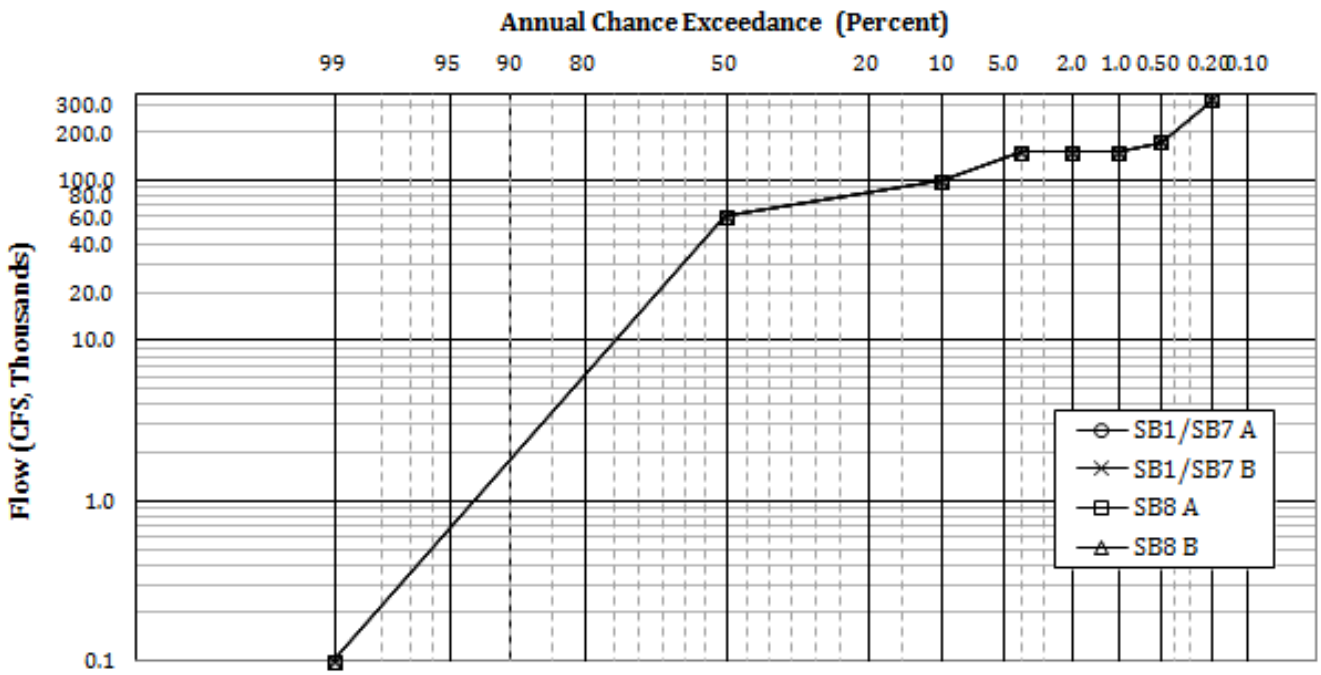
SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

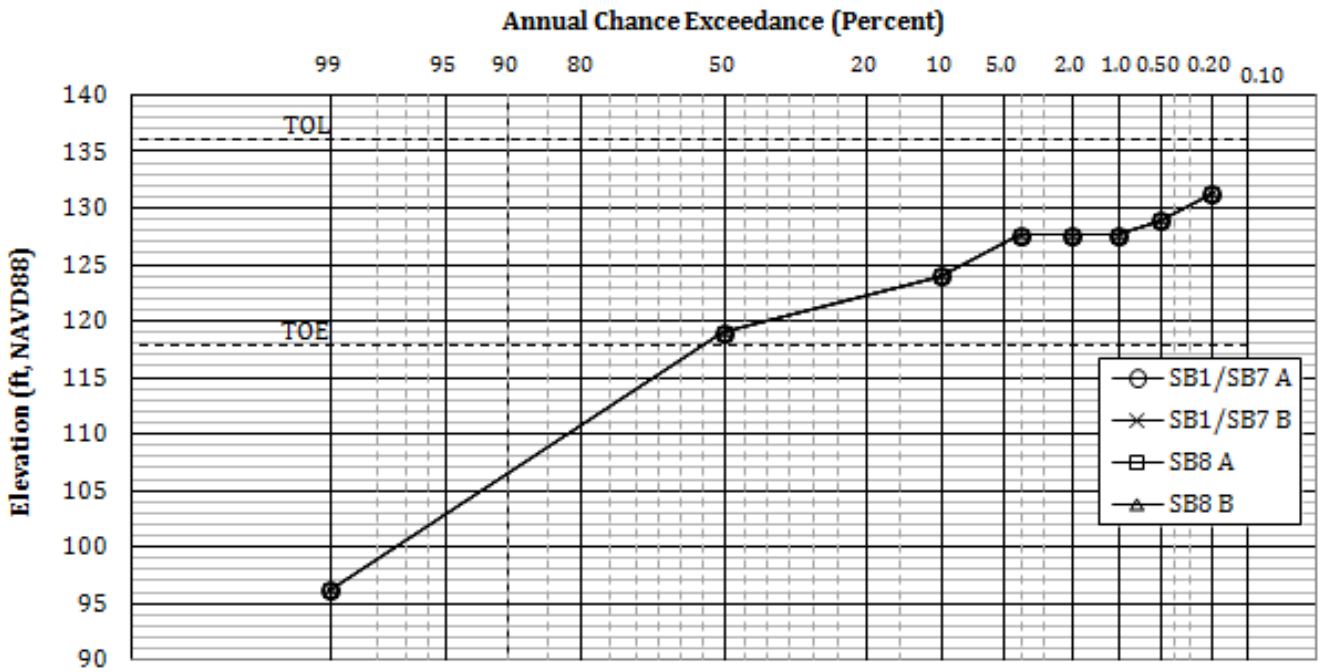
CHEROKEE CANAL
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013

PLATE 16





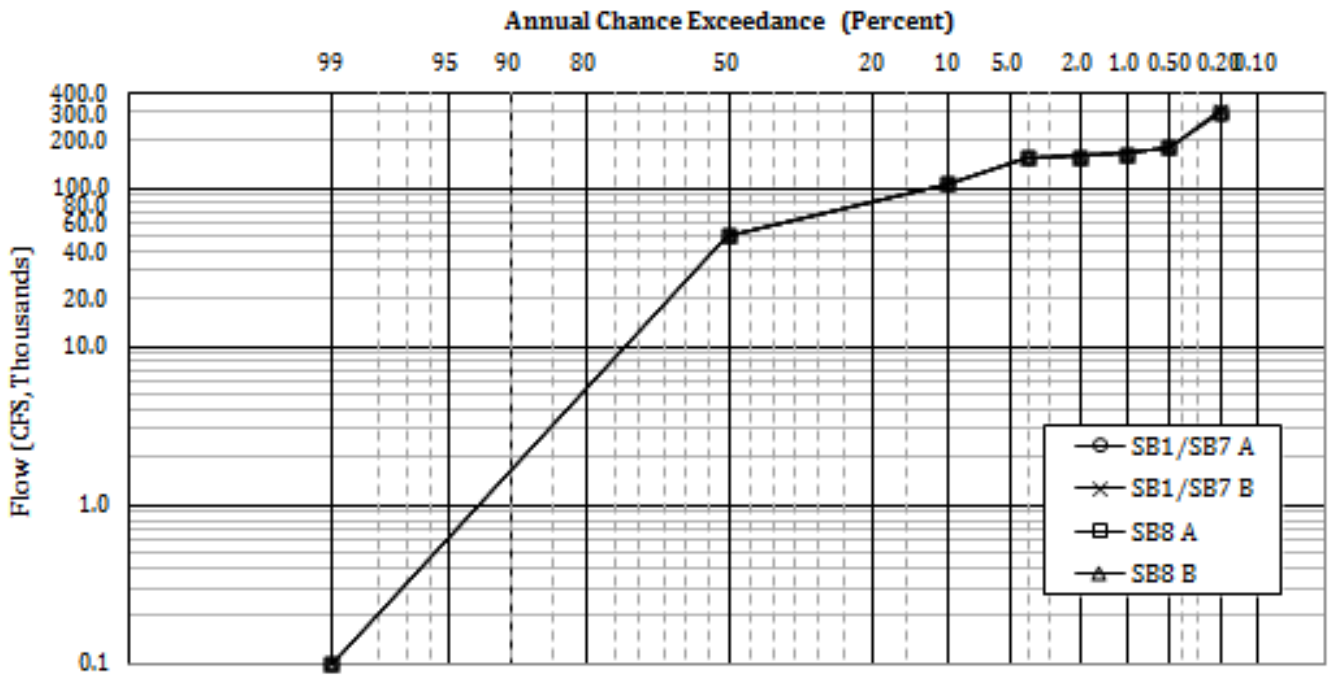
NOTES:
Feather River at Comp Study RM 57.95 refers to Geotechnical index location MA7 – 0.51
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

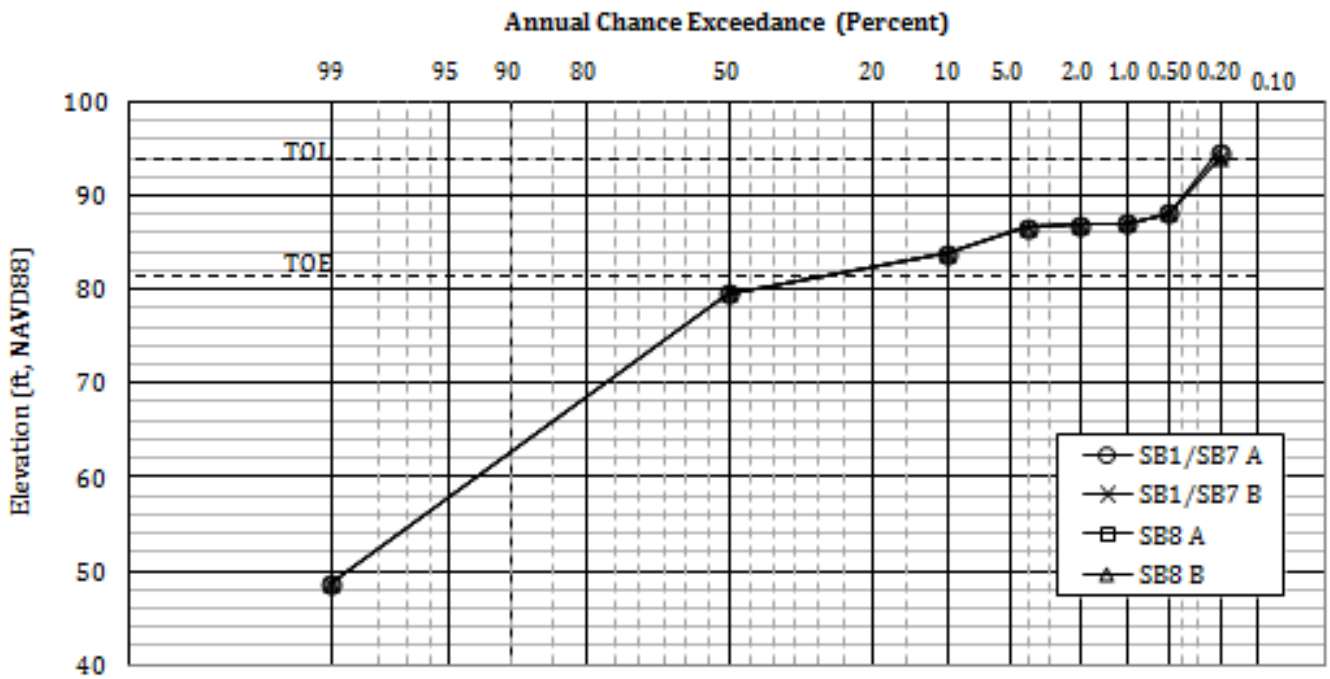
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
FEATHER RIVER AT RM 57.95

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





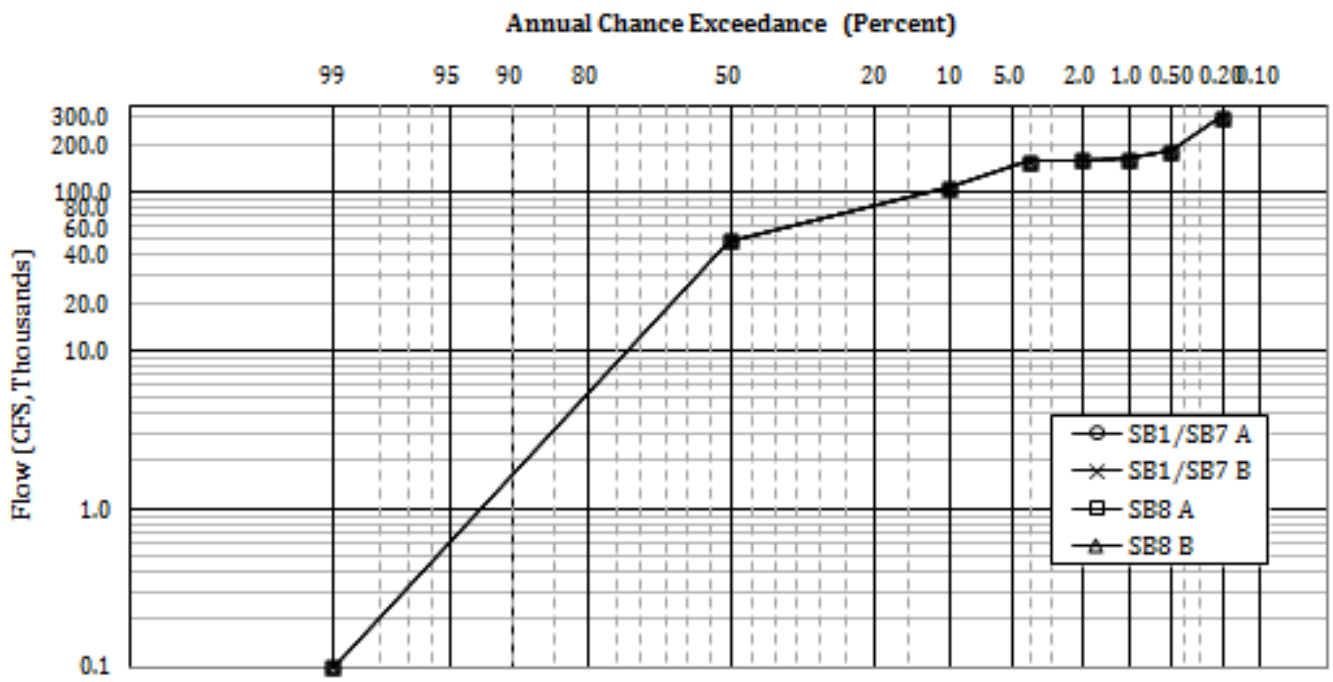
NOTES:
Feather River at Comp Study RM 44.5 refers to Geotechnical index location MA 16 – 2.9
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

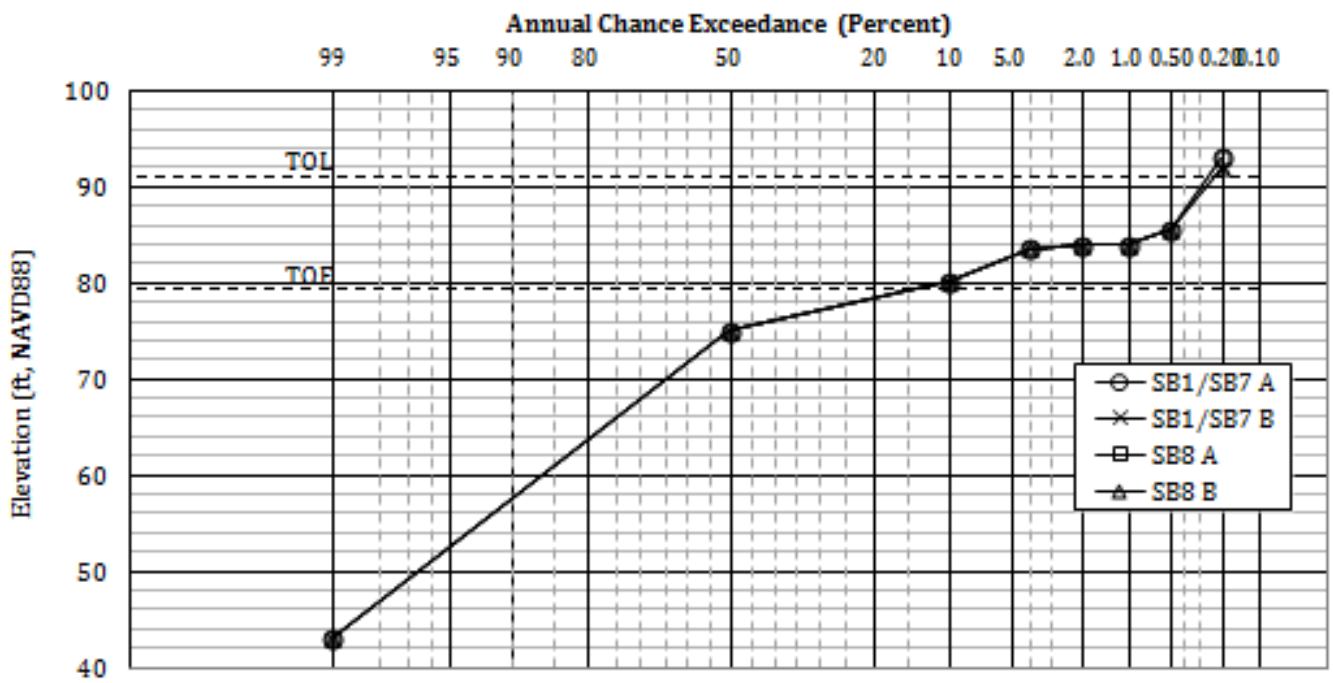
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
FEATHER RIVER AT RM 44.5

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





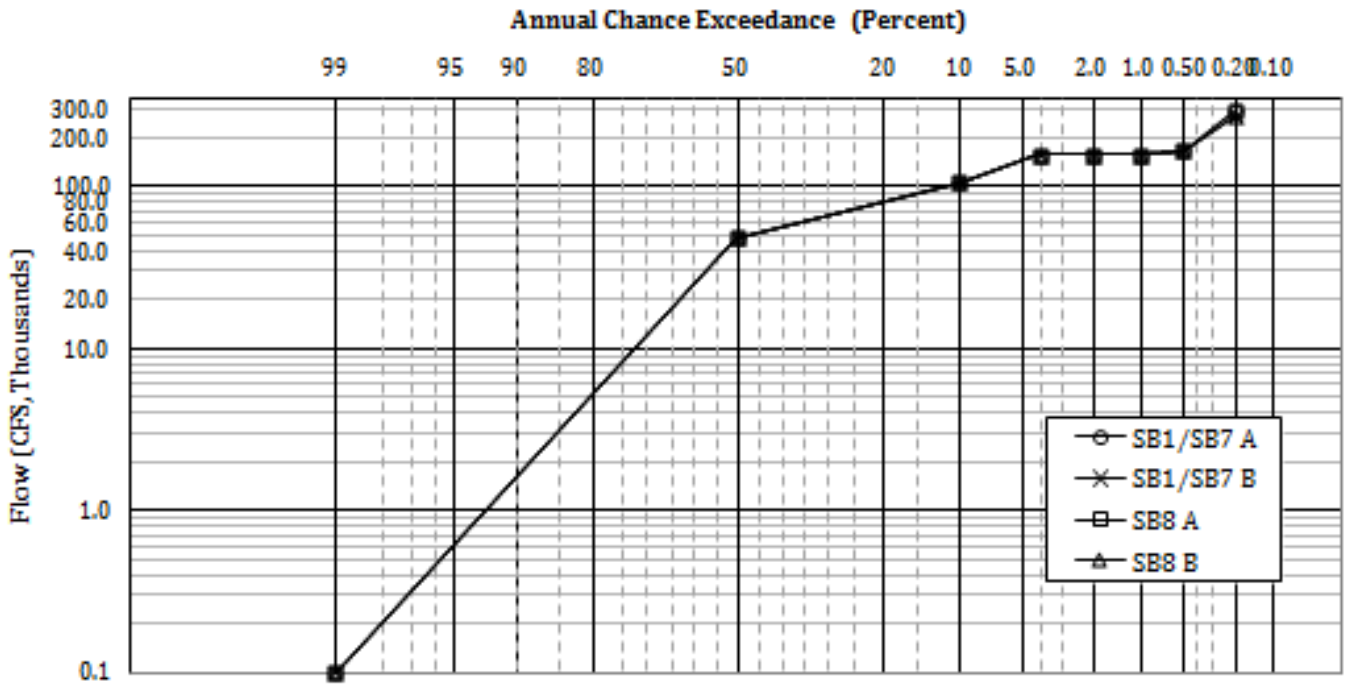
NOTES:
Feather River at Comp Study RM 41.2 refers to Geotechnical index location MA 16 – 0.9
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

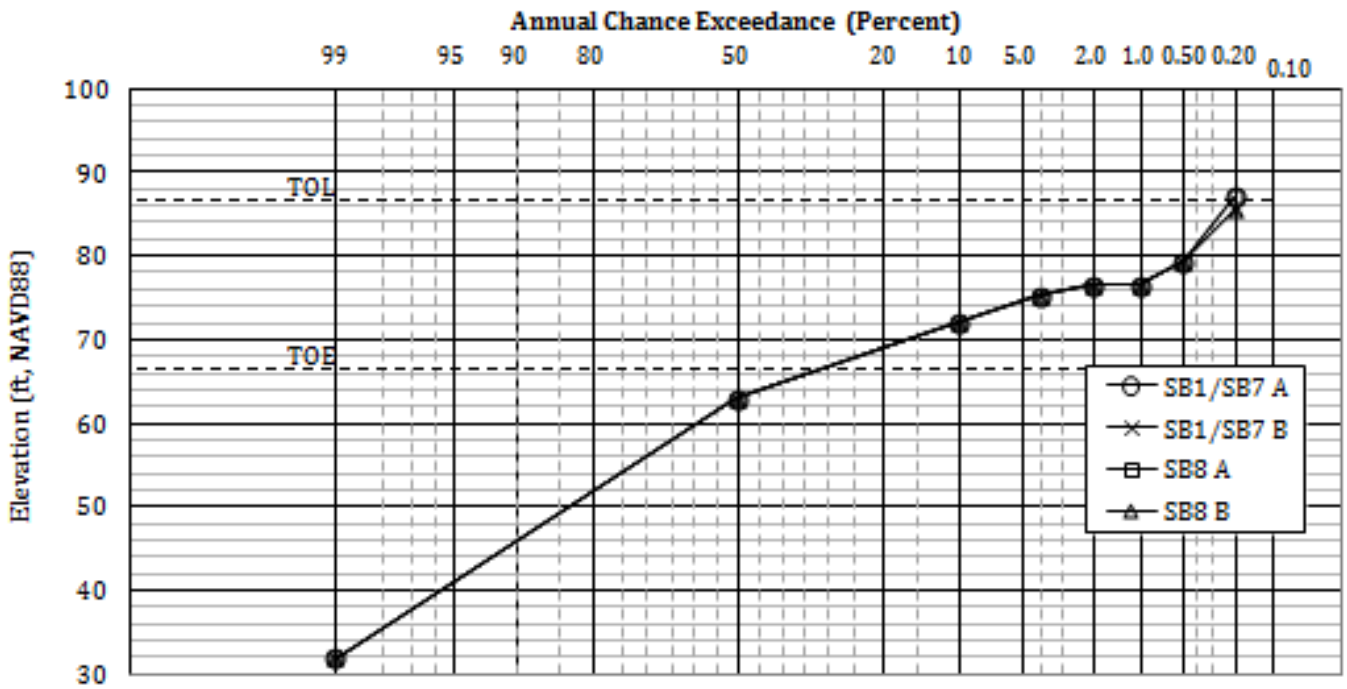
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
FEATHER RIVER AT RM 41.2

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





NOTES:
Feather River at Comp Study RM 30.25 refers to Geotechnical index location LD9 – 0.52
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

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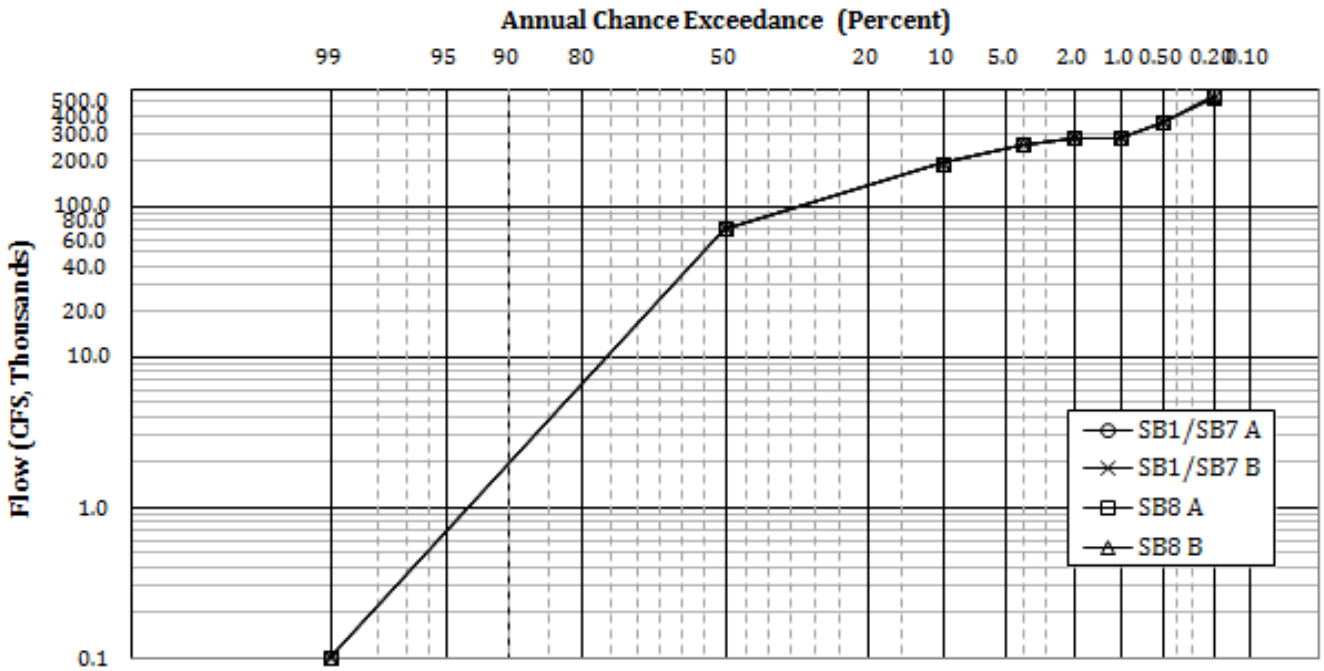
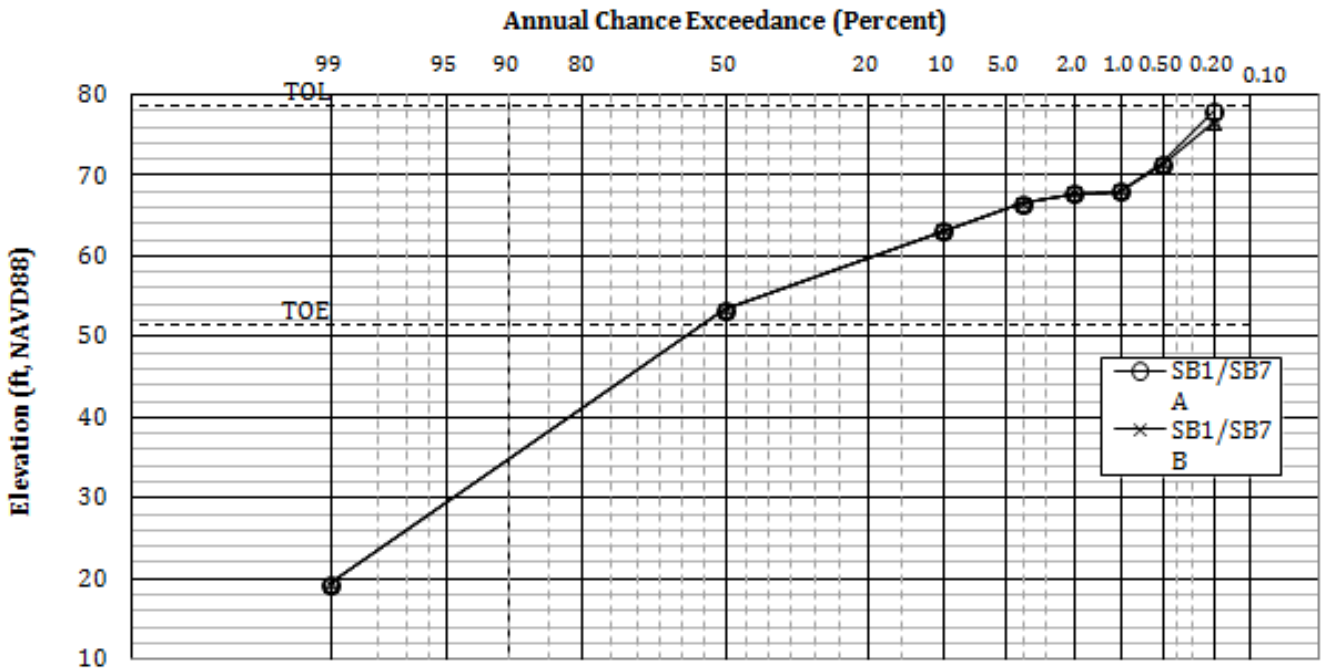
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
FEATHER RIVER AT RM 30.25

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





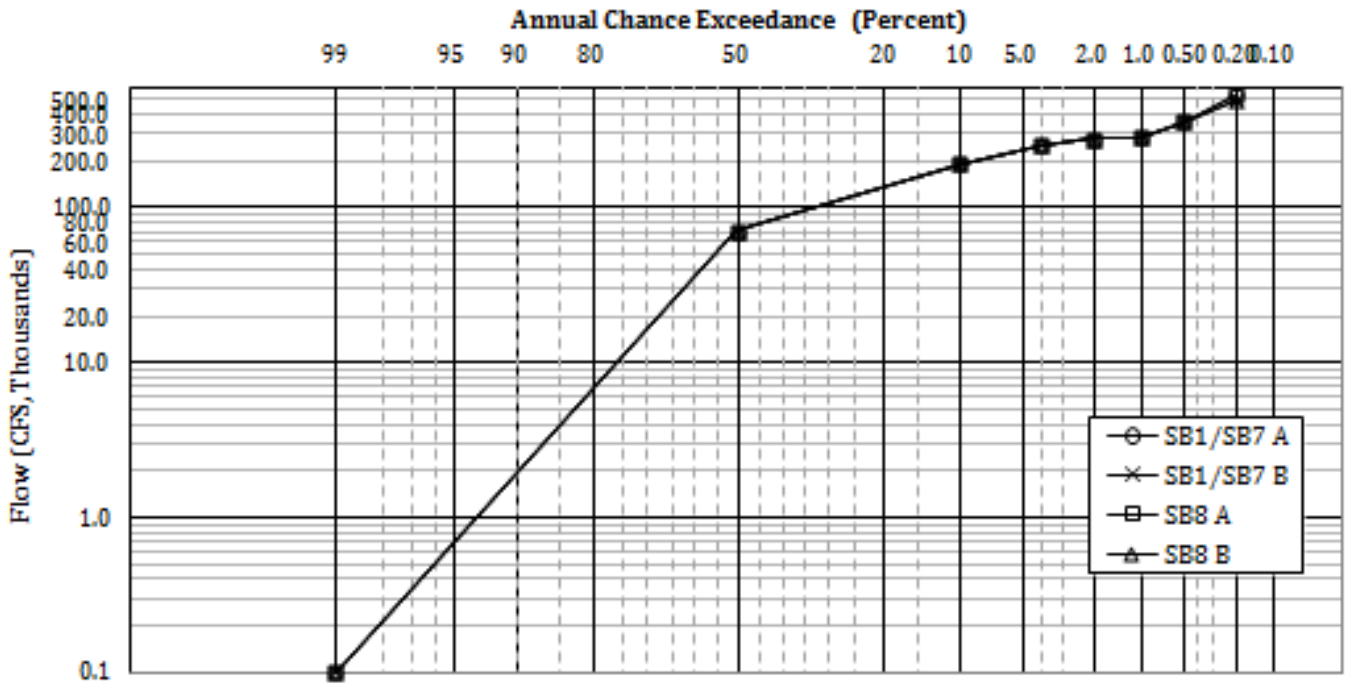
NOTES:
Feather River at Comp Study RM 23.25 refers to Geotechnical index location LD1 – 9.31
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

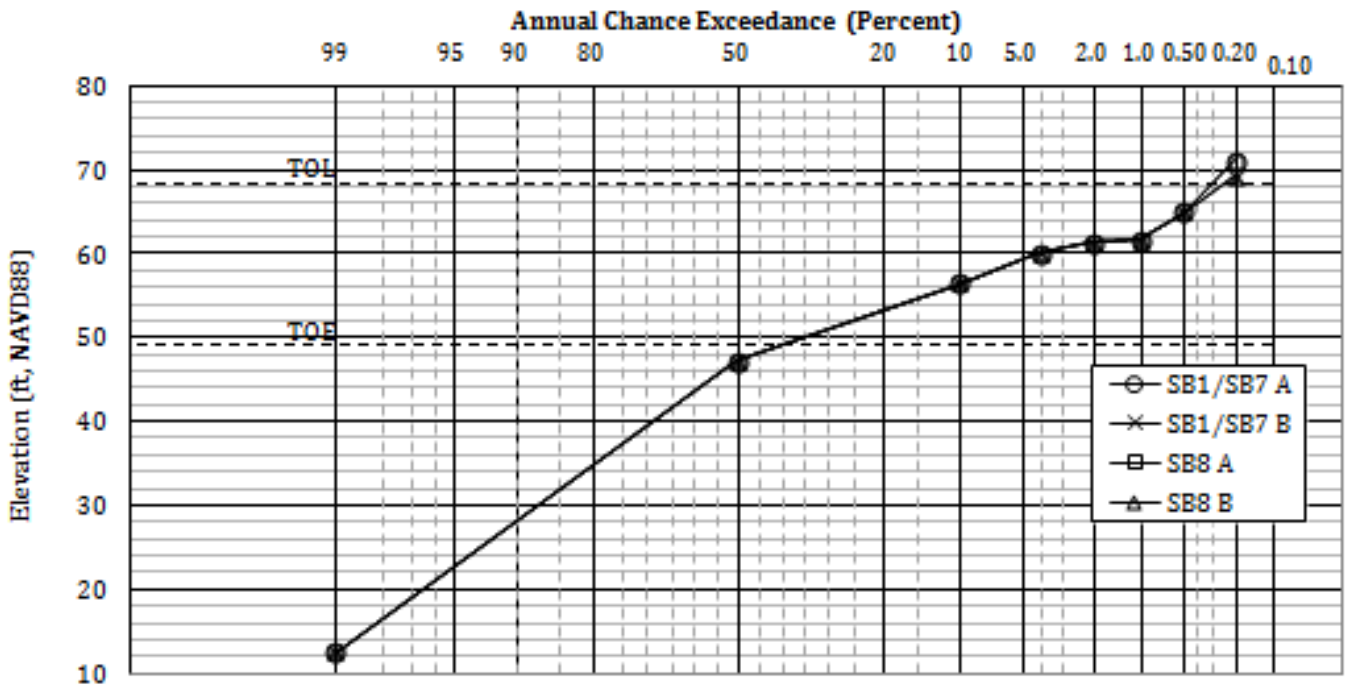
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
FEATHER RIVER AT RM 23.25

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





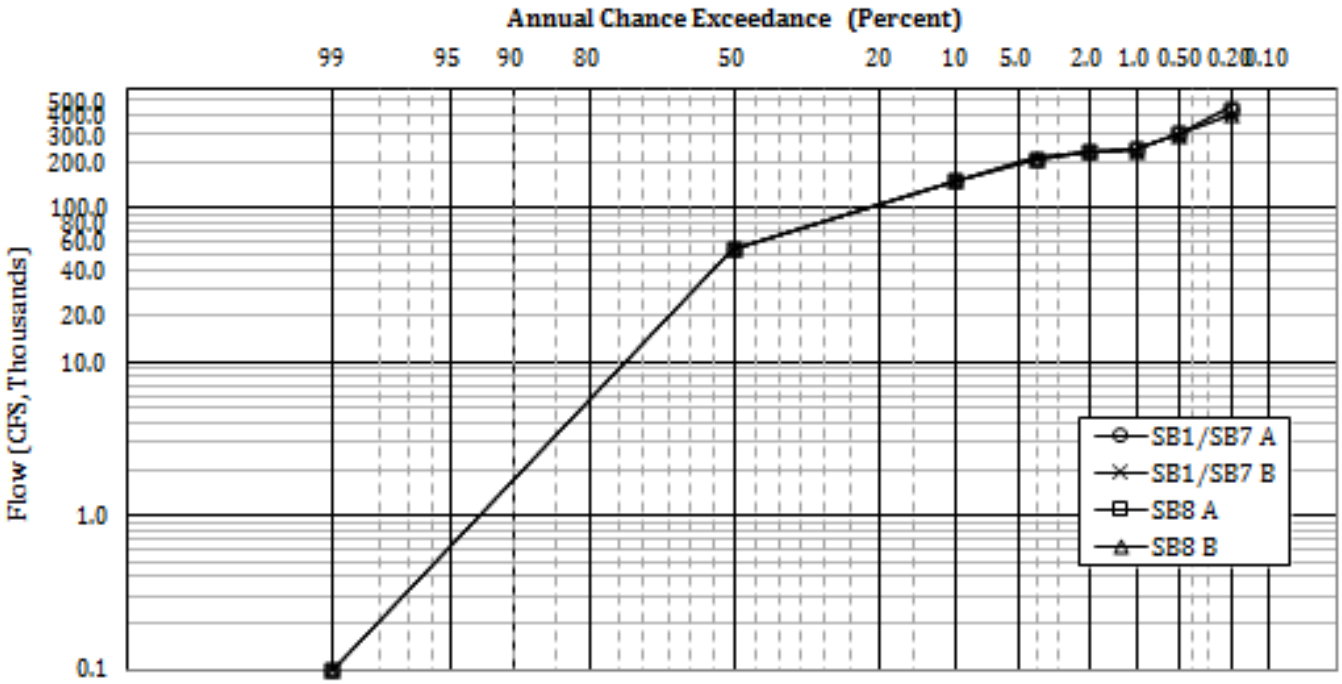
NOTES:
Feather River at Comp Study RM 16.75 refers to Geotechnical index location LD1 – 3.99
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

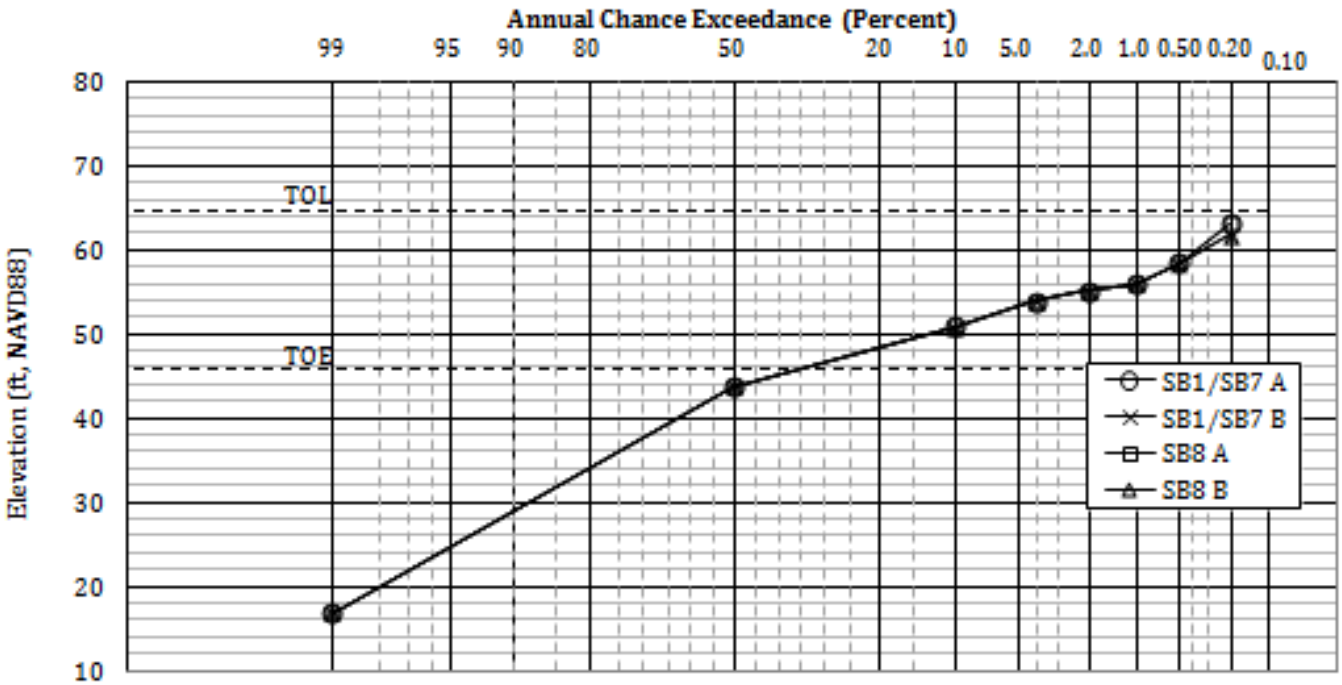
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
FEATHER RIVER AT RM 16.75

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





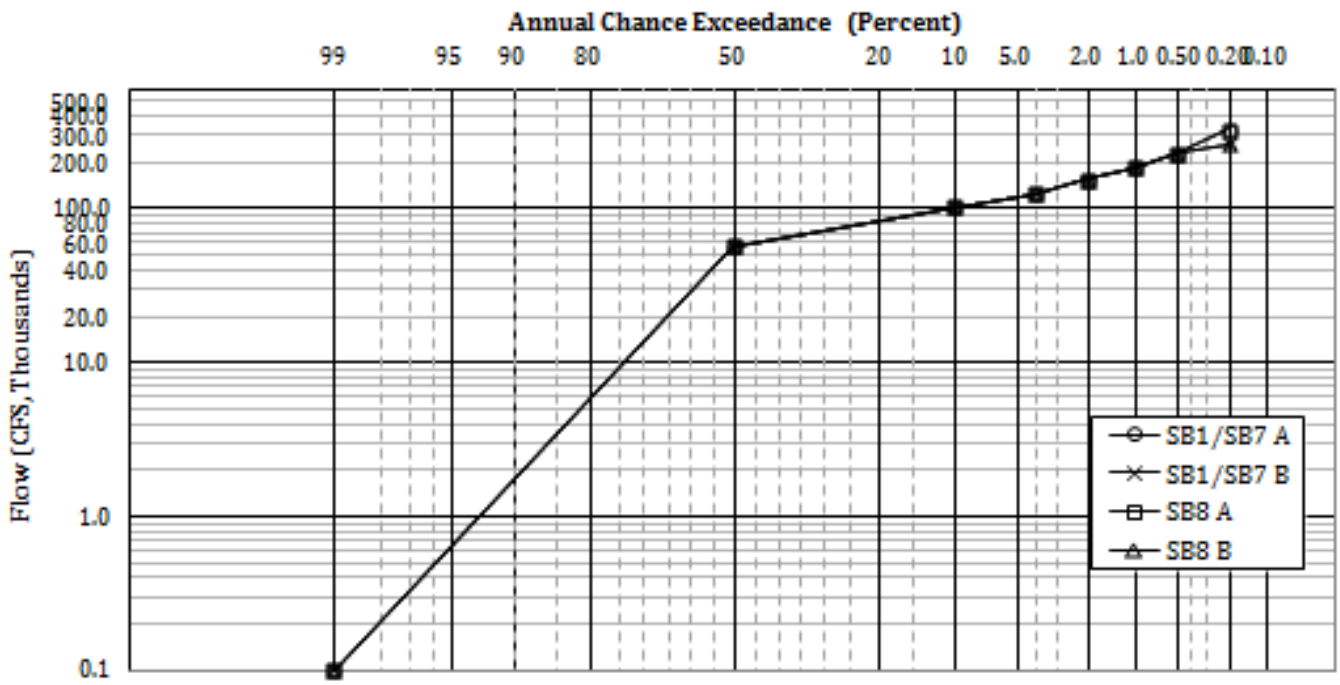
NOTES:
Feather River at Comp Study RM 12.5 refers to Geotechnical index location MA3 – 4.92
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

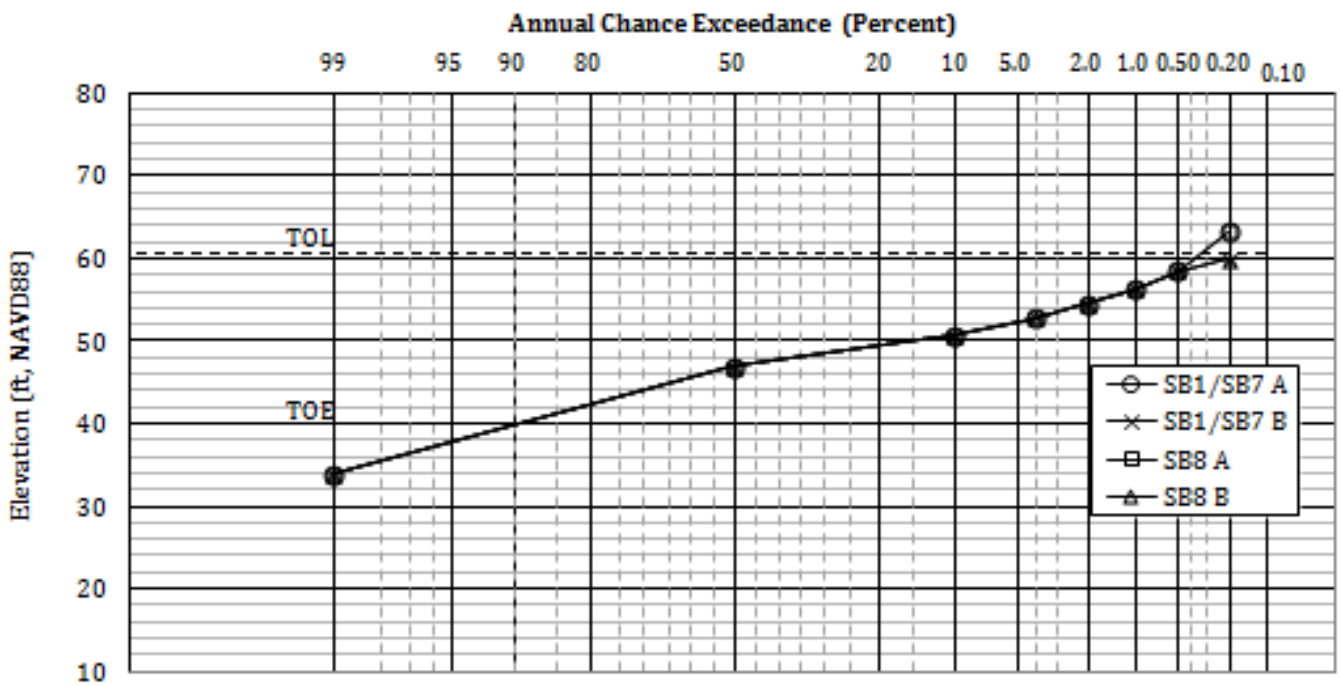
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
FEATHER RIVER AT RM 12.5

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





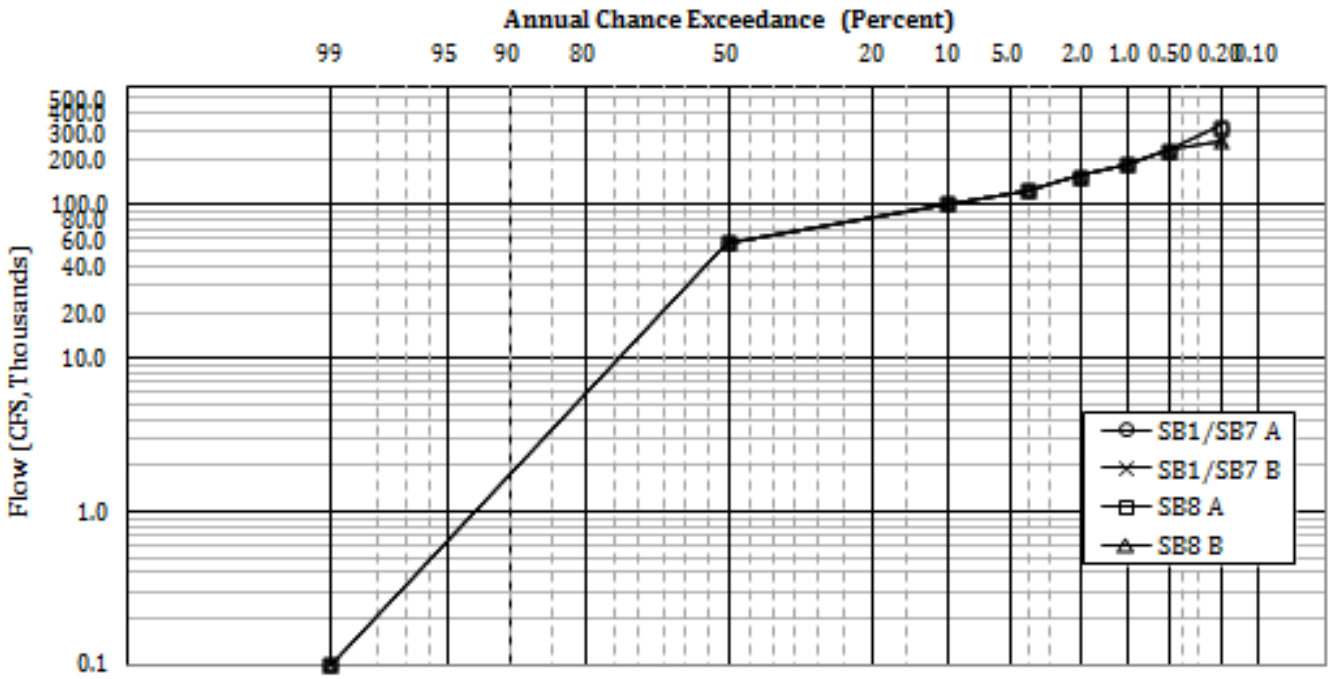
NOTES:
Sutter Bypass at Comp Study RM 83.79 refers to Geotechnical index location SUTTER – 4
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

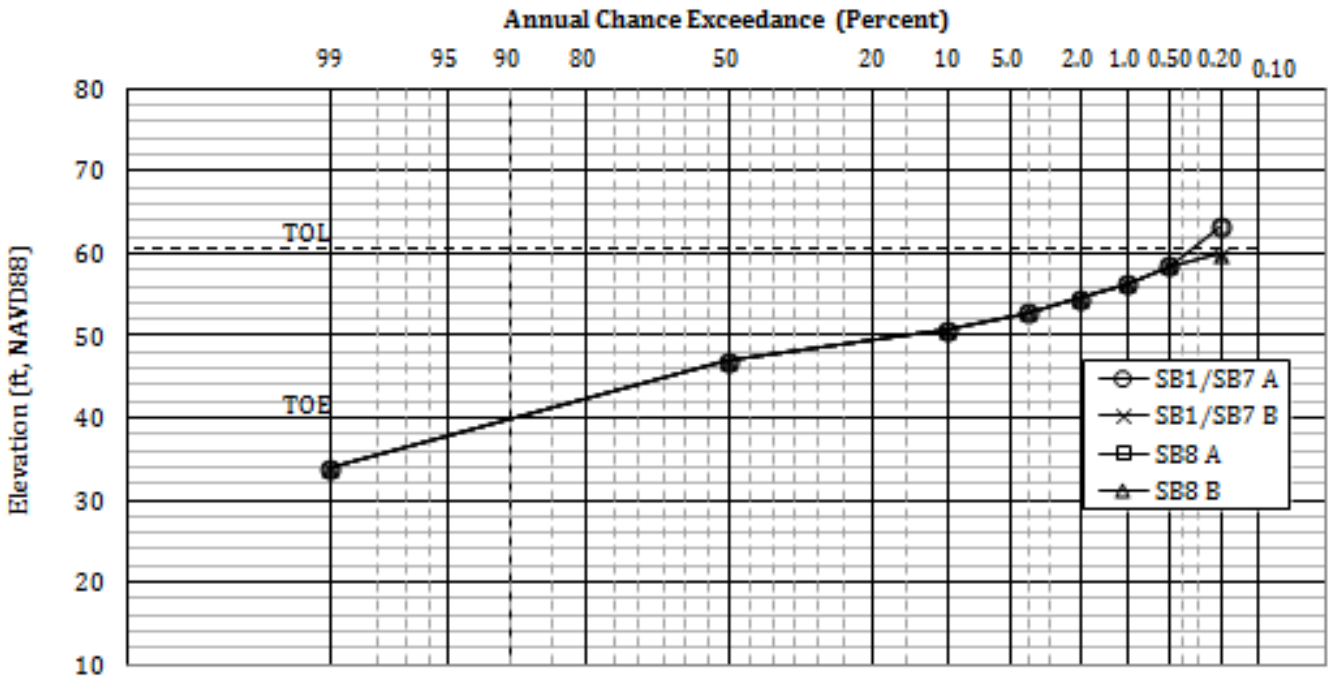
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
SUTTER BYPASS AT RM 83.79

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





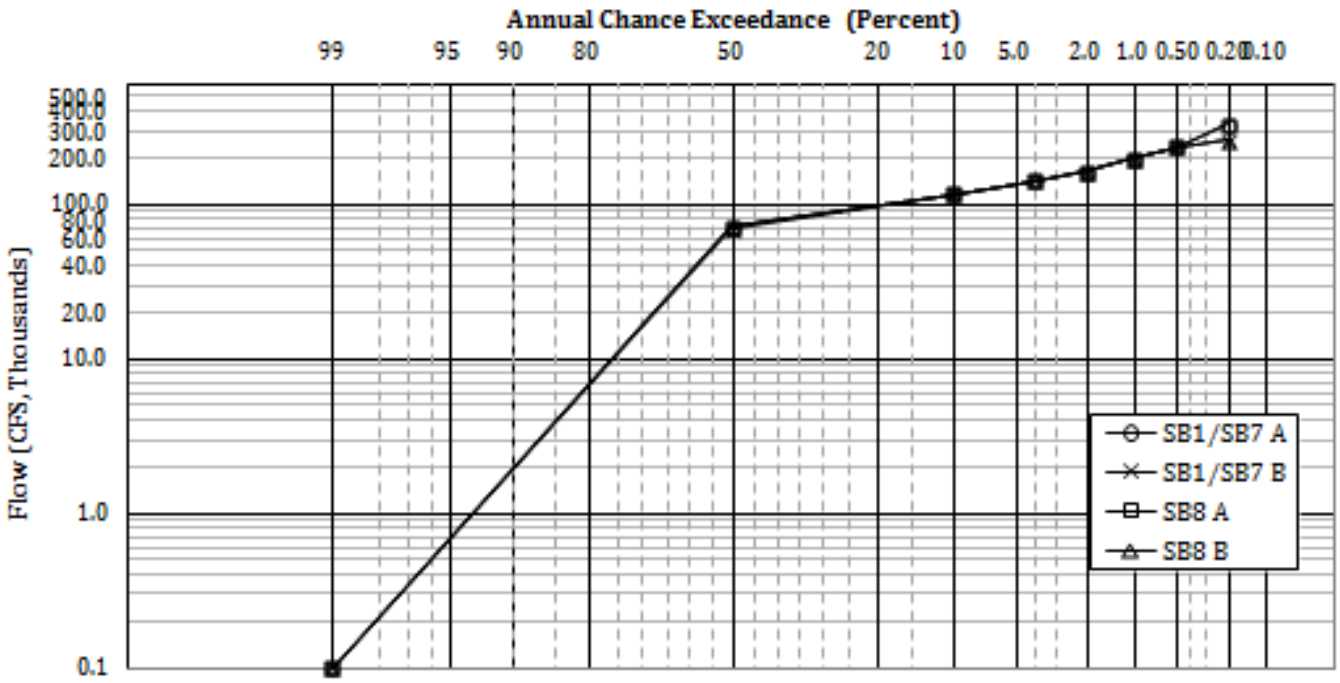
NOTES:
Sutter Bypass at Comp Study RM 81.93 refers to Geotechnical index location SUTTER – 6.2
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

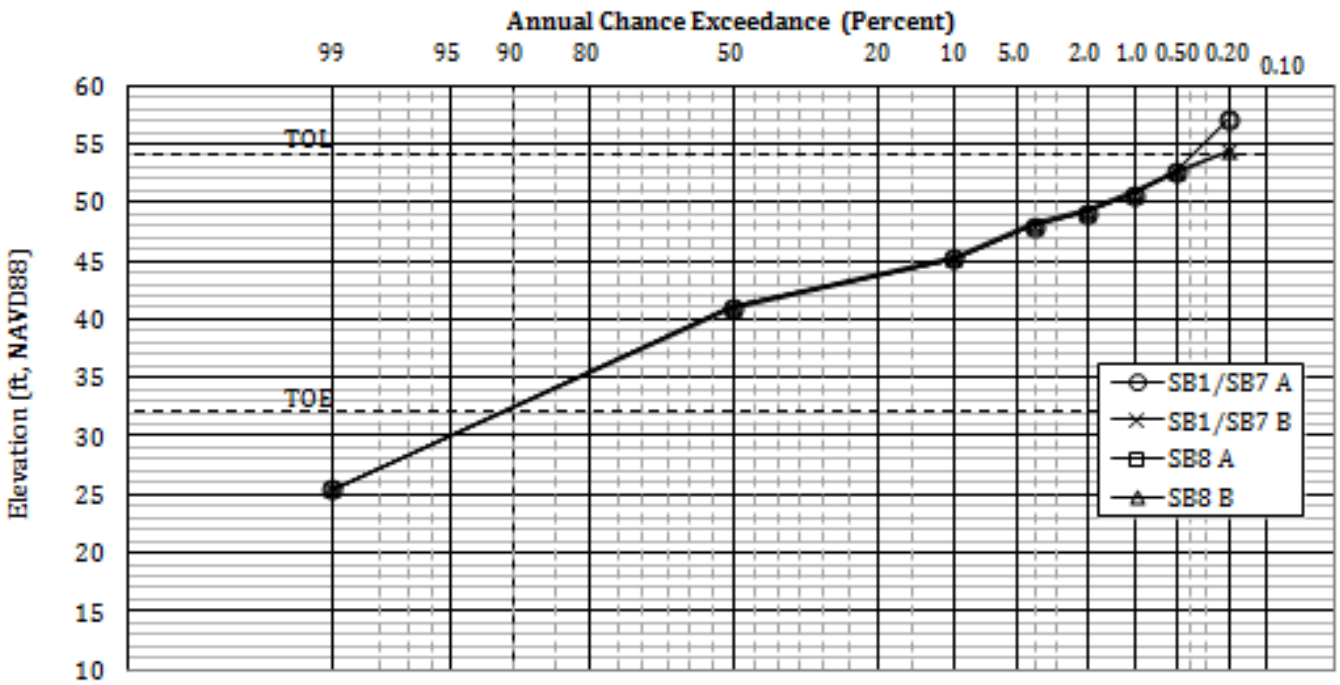
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
SUTTER BYPASS AT RM 81.93

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





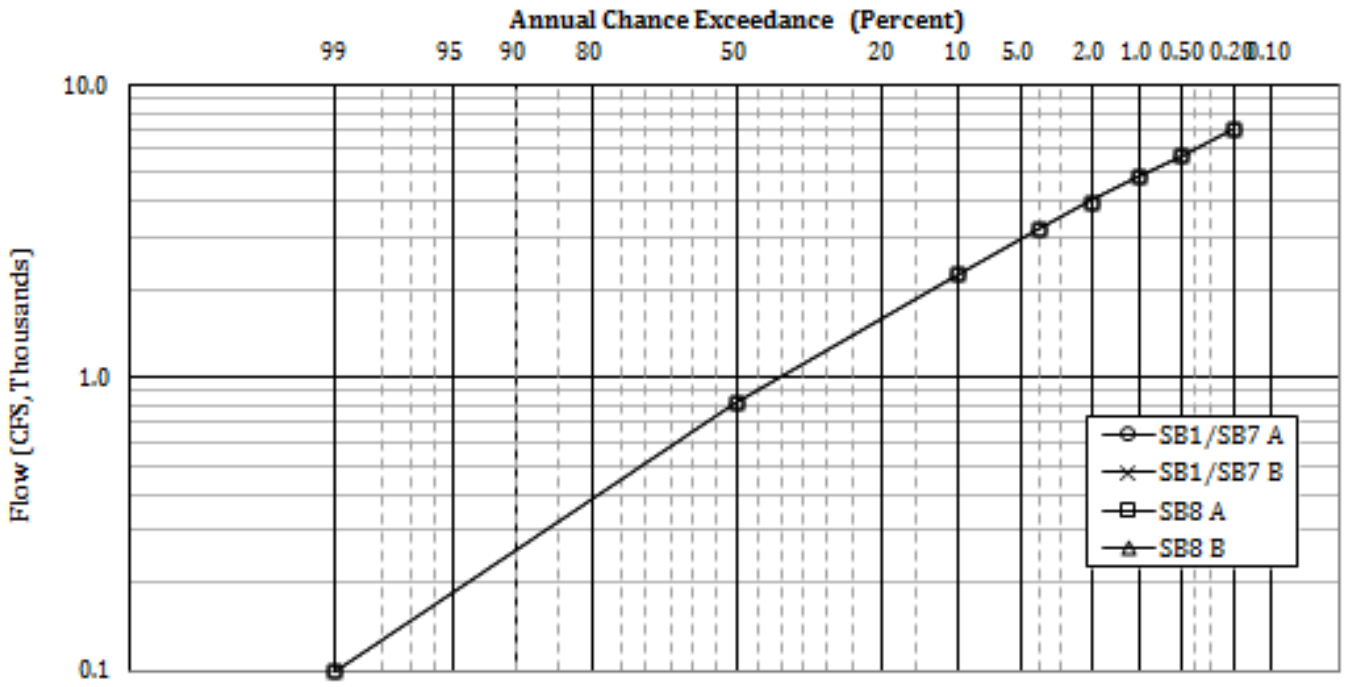
NOTES:
Sutter Bypass at Comp Study RM 71.65 refers to Geotechnical index location SUTTER – 17.3
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

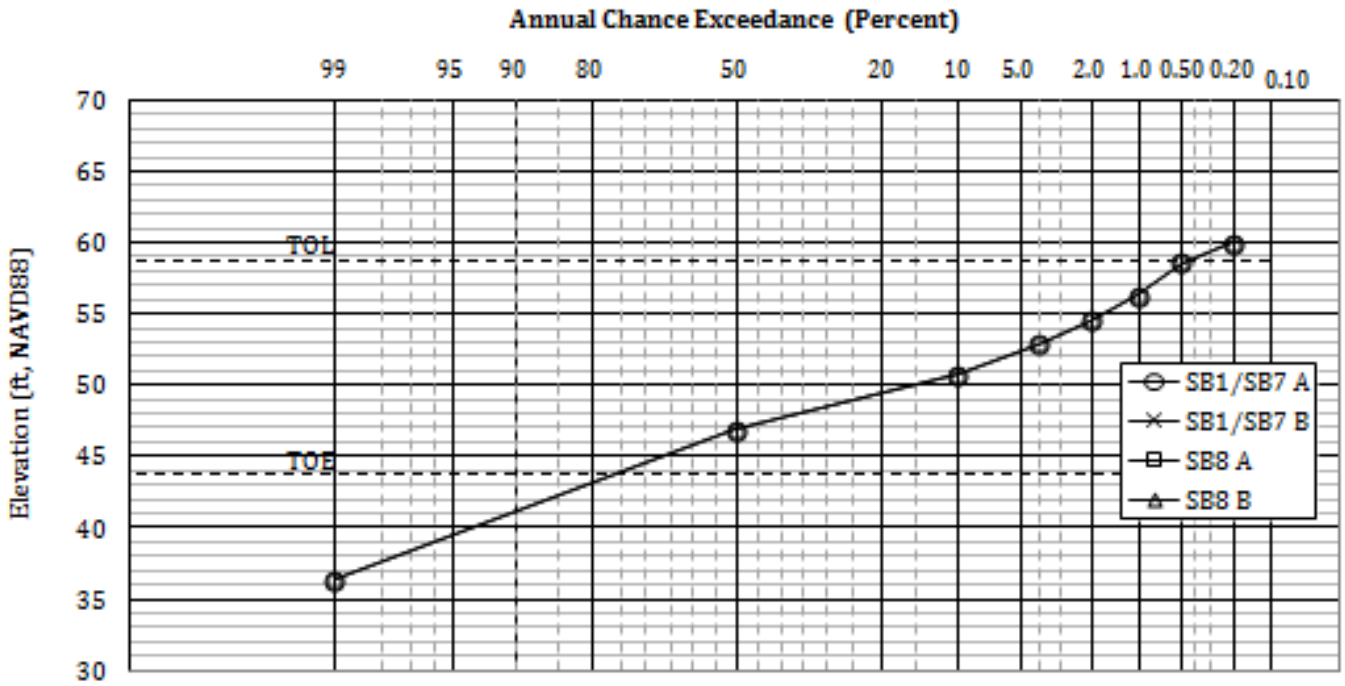
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
SUTTER BYPASS AT RM 71.65

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





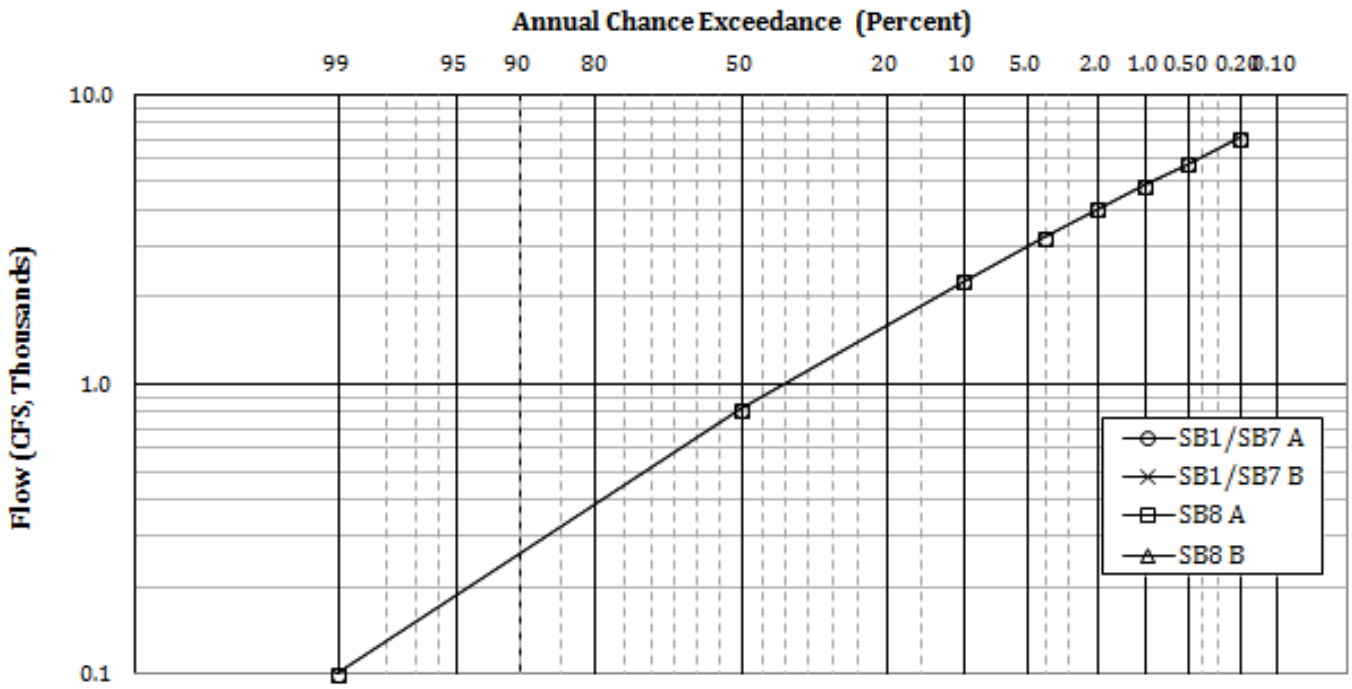
NOTES:
Wadsworth Canal at RM 0.81 refers to Geotechnical index location WADSWORTH – 0.84
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

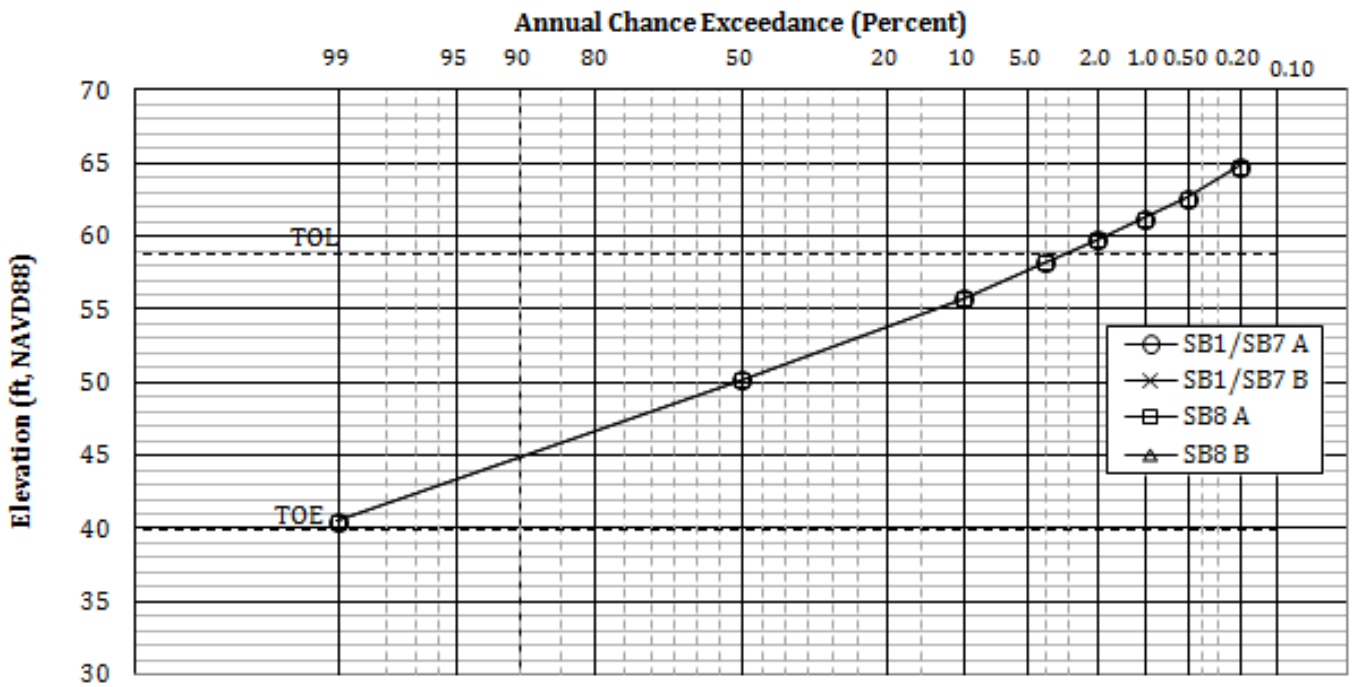
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
WADSWORTH CANAL AT RM 0.81

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





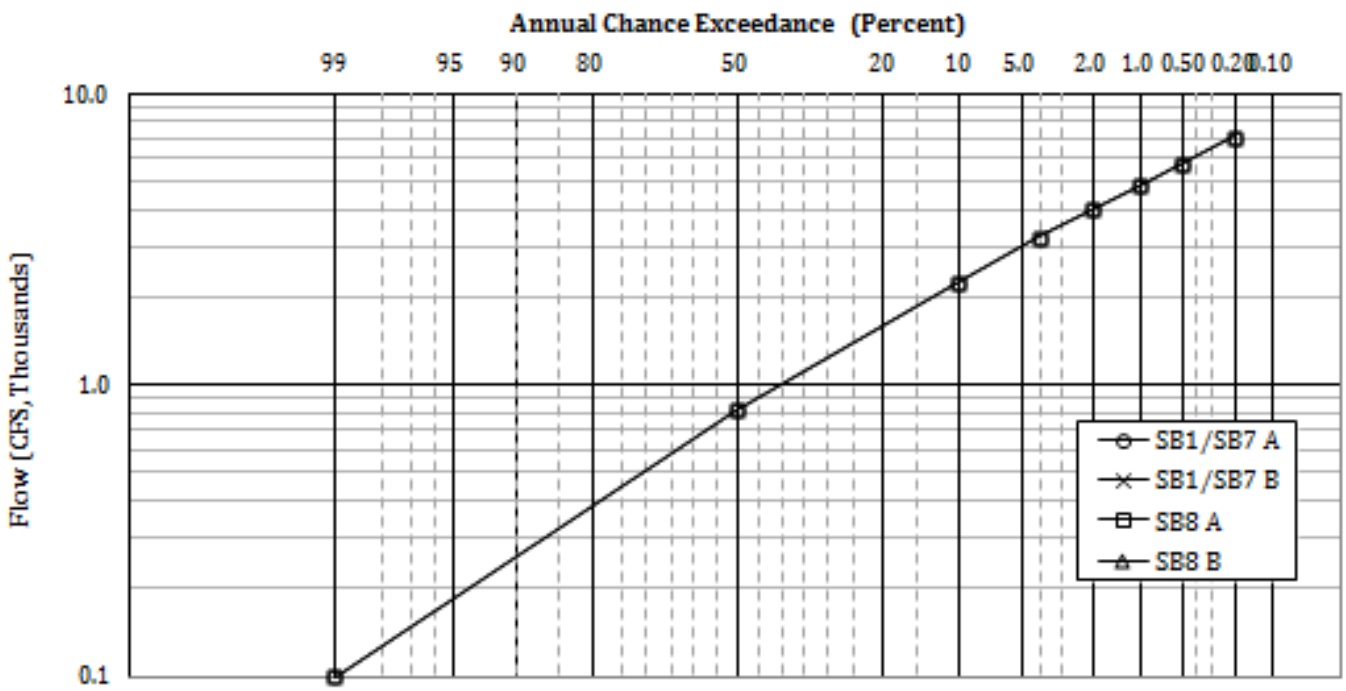
NOTES:
Wadsworth Canal at RM 4.54 defines the upstream capacity prior to overtopping
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

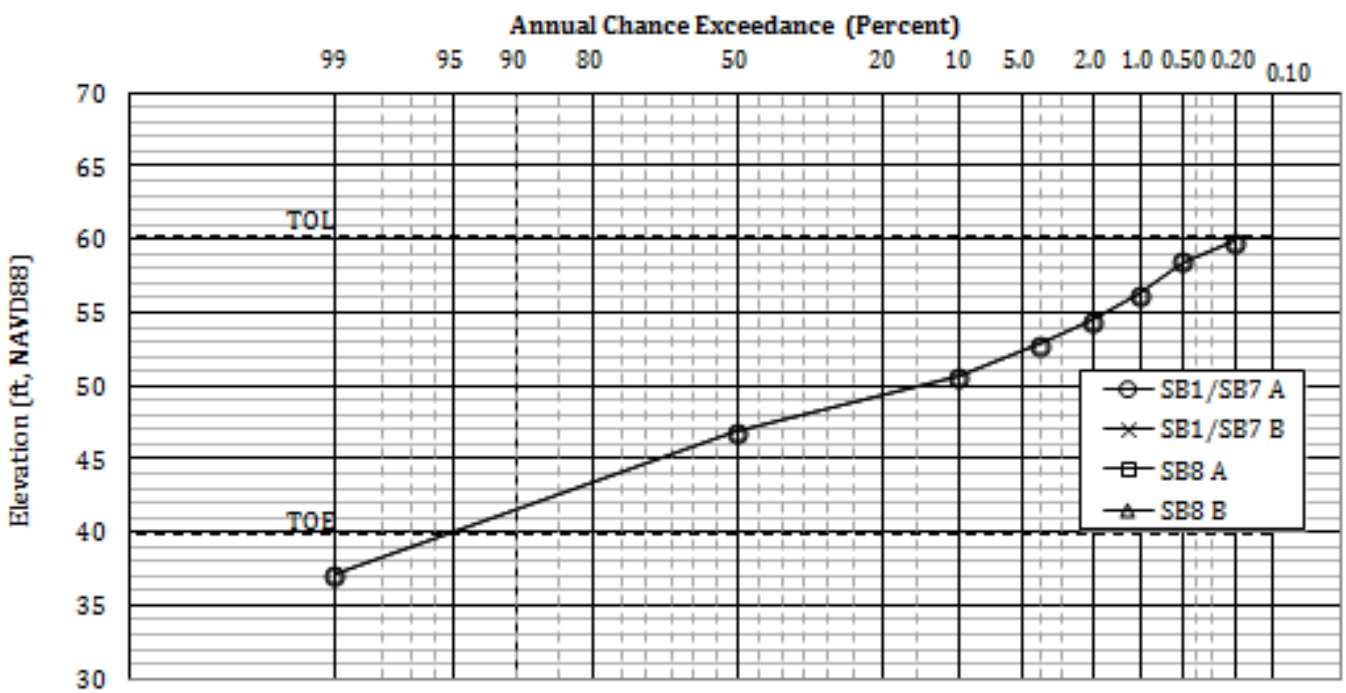
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
WADSWORTH CANAL AT RM 4.54

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





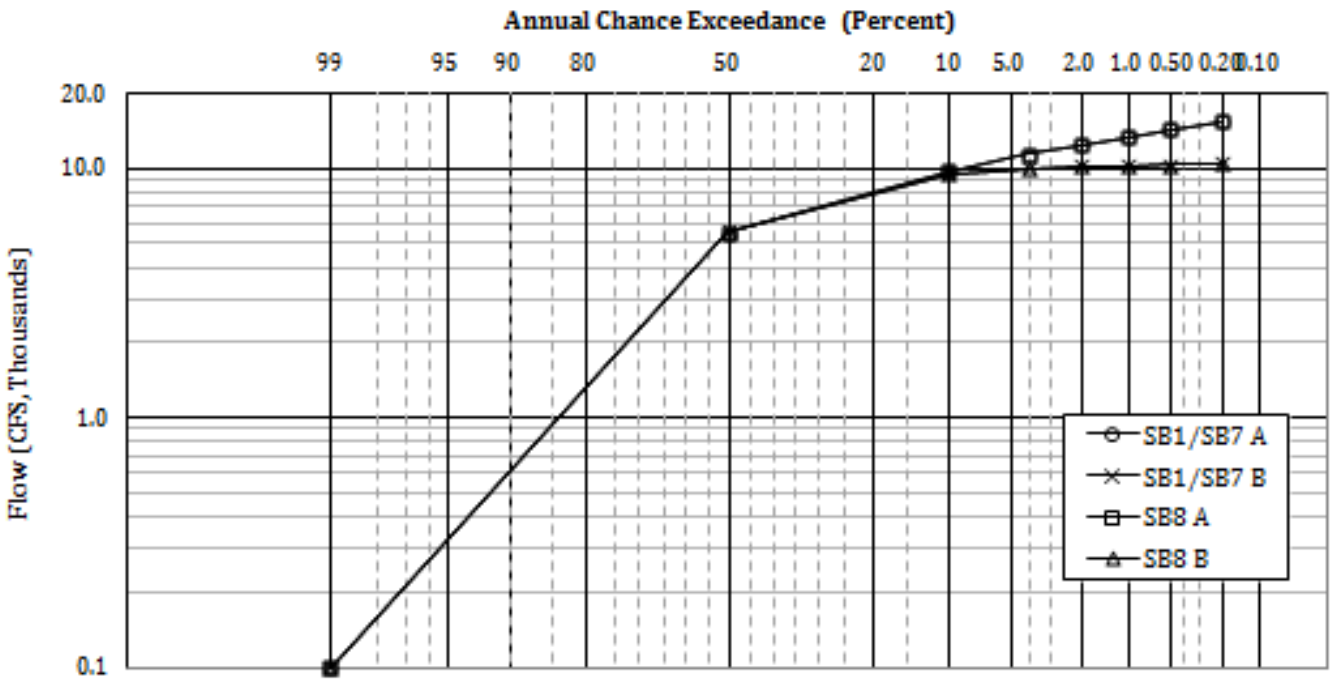
NOTES:
Wadsworth Canal at Comp Study RM 0.25 refers to Geotechnical Index location WADSWORTH – 0.5
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

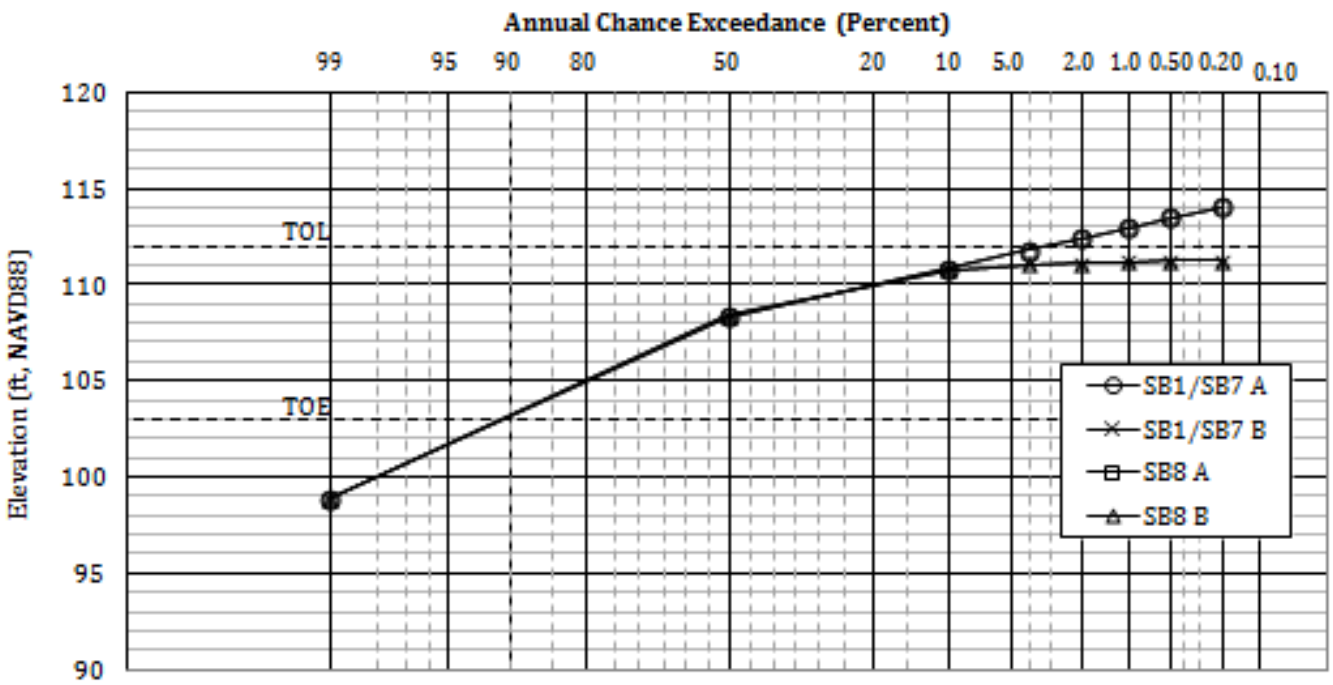
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
WADSWORTH CANAL AT RM 0.25

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





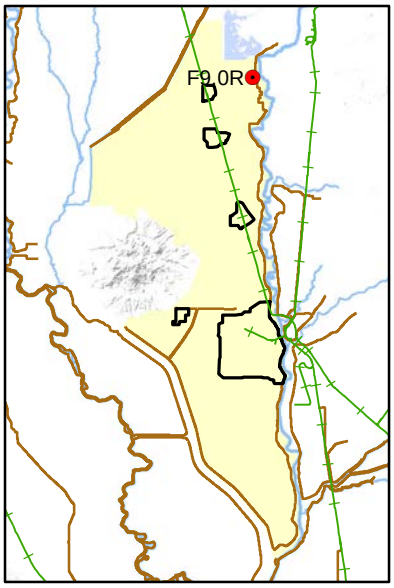
NOTES:
Cherokee Canal at DWR HEC-RAS RM 12.529 refers to Geotechnical index location CHEROKEE – 9.5
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
CHEROKEE CANAL AT RM 12.529

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



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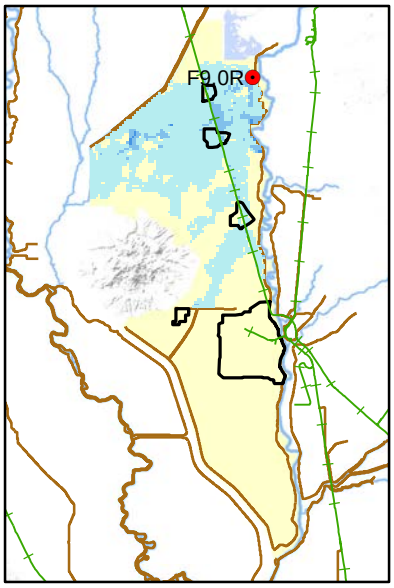
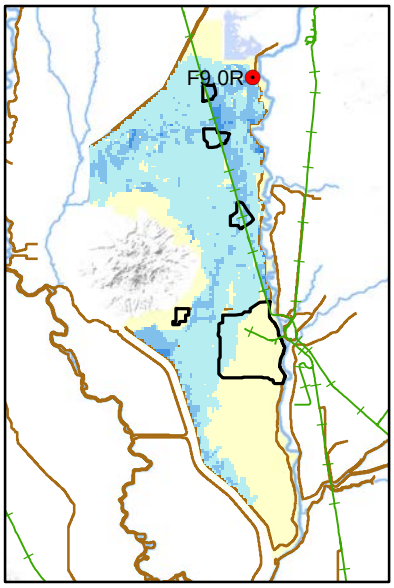
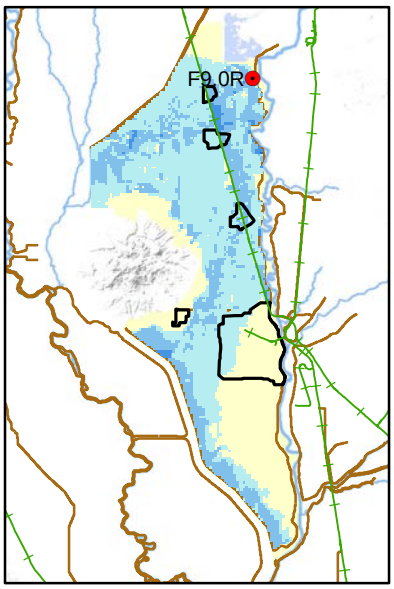


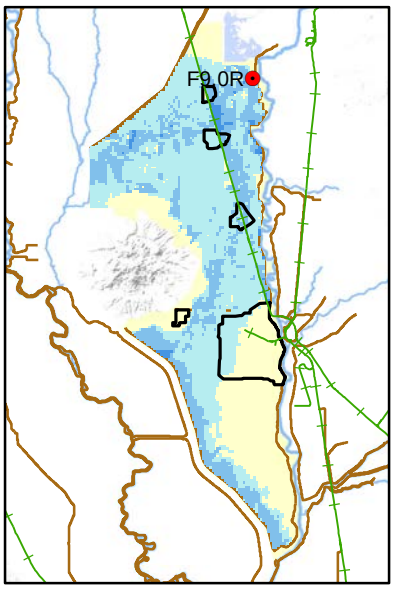
10% (1/10) ACE



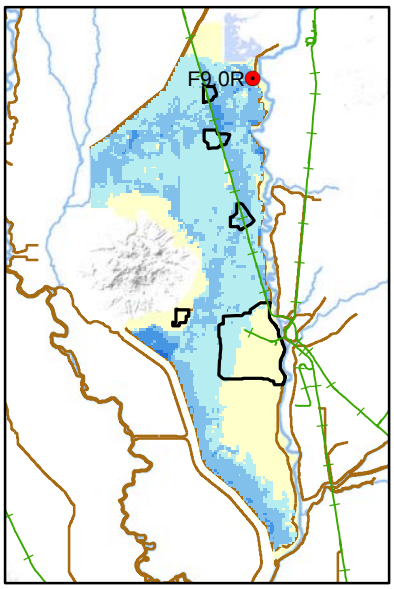
4% (1/25) ACE



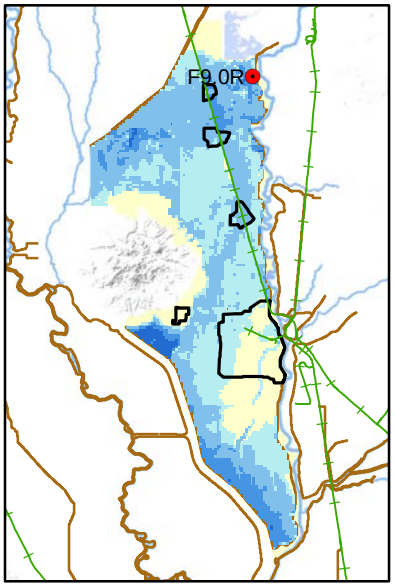
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

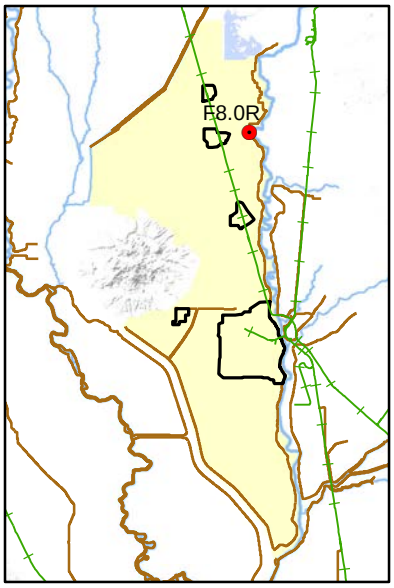
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F9.0R

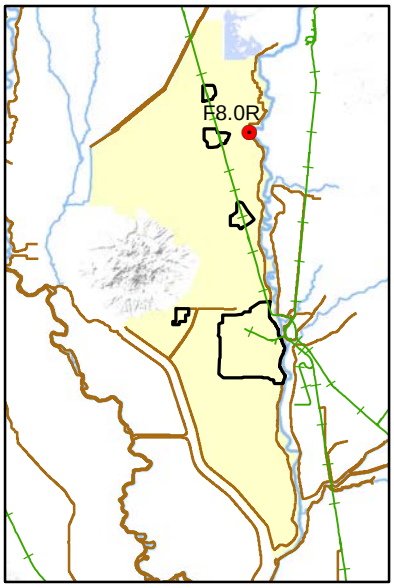
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

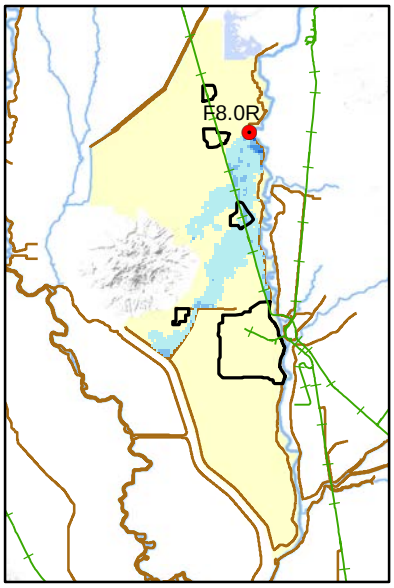
FEB 2013



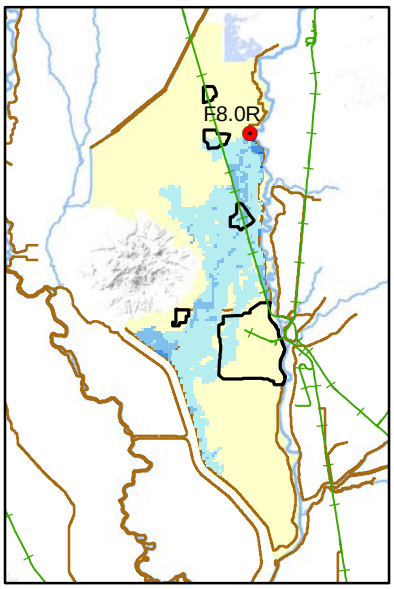
50% (1/2) ACE



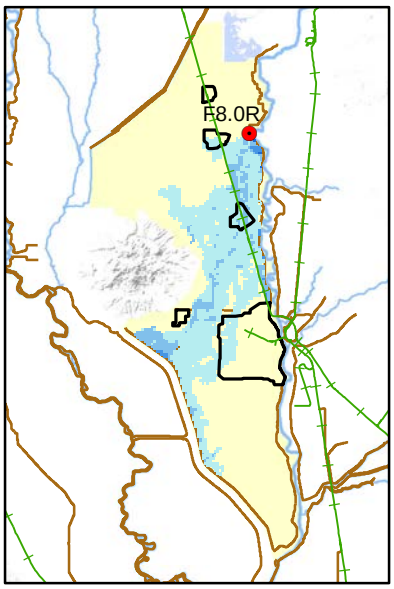
10% (1/10) ACE



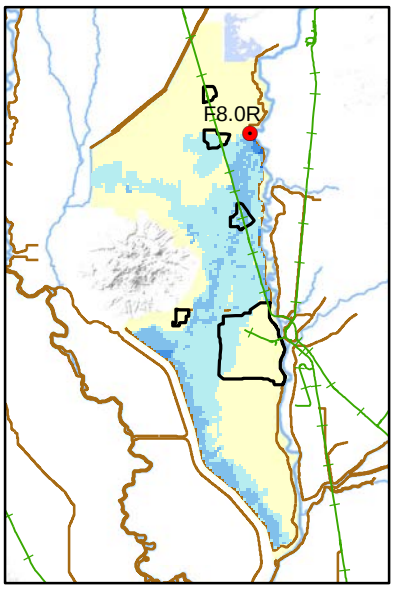
4% (1/25) ACE



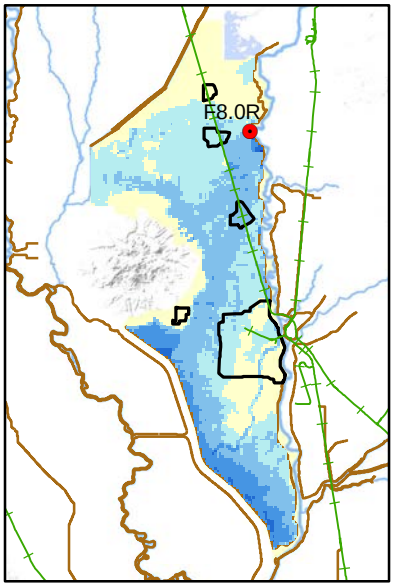
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F8.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

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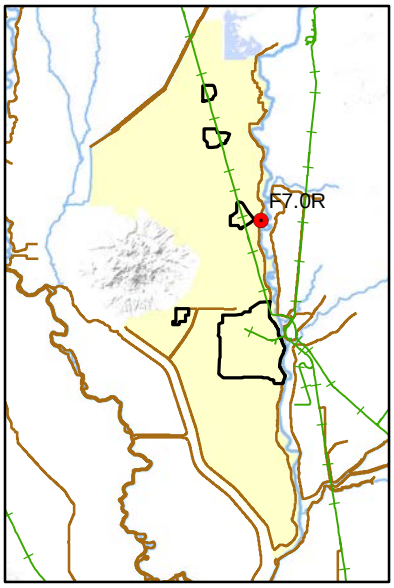
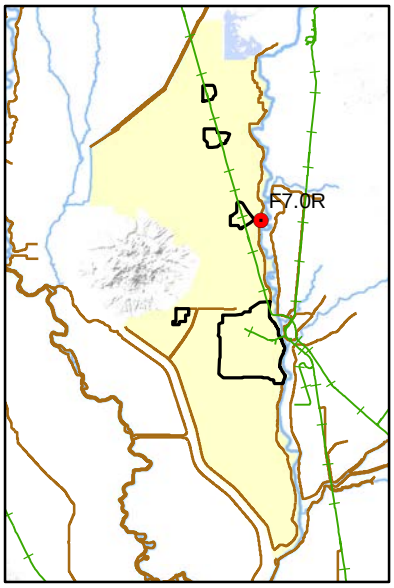
PLATE 32



50% (1/2) ACE



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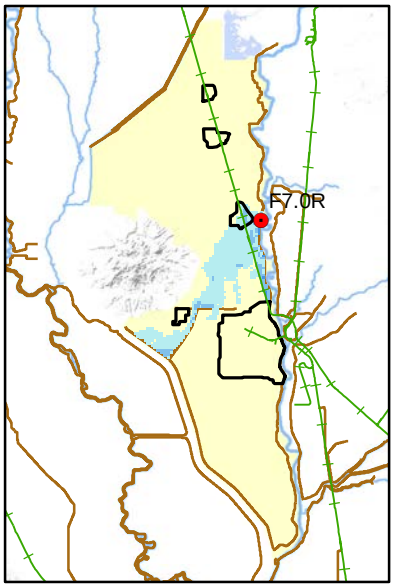
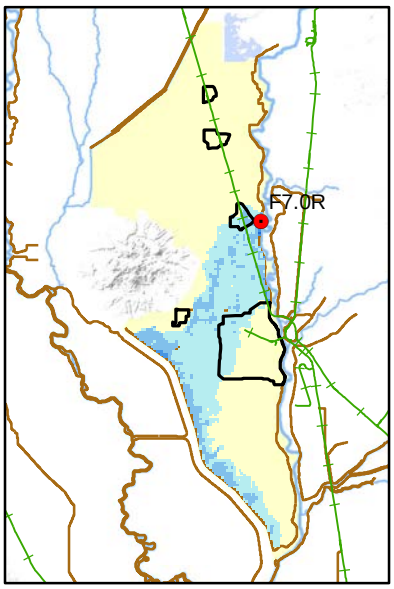
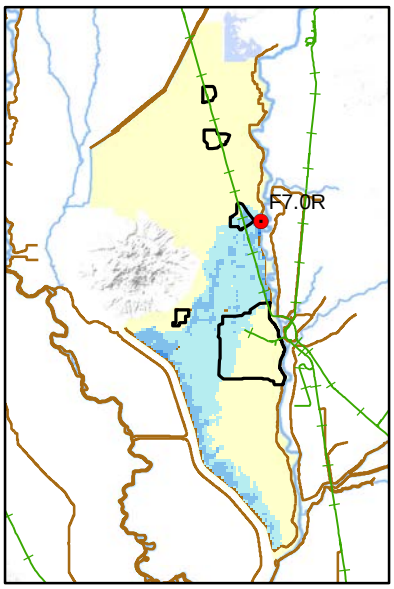


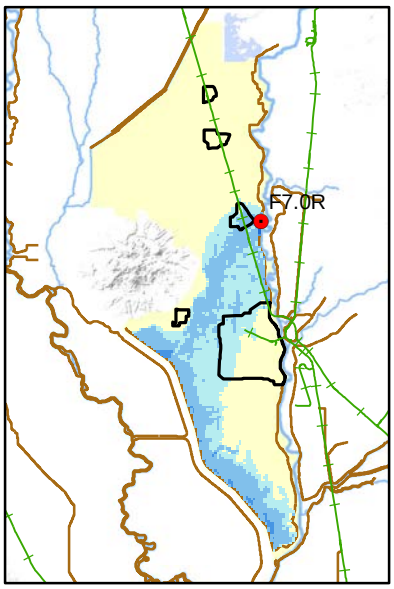
4% (1/25) ACE



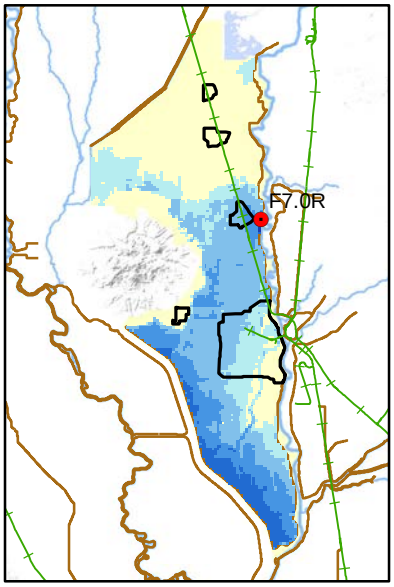
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

0 10 20 Miles

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F7.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

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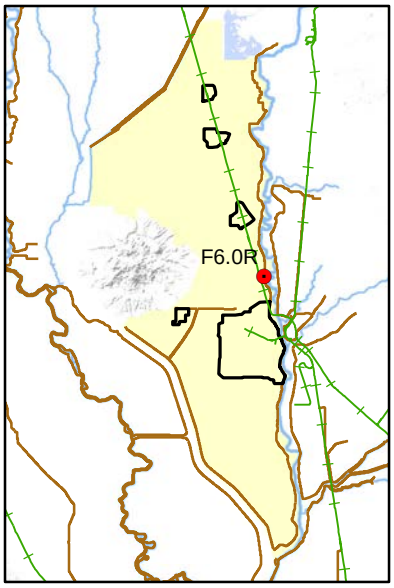
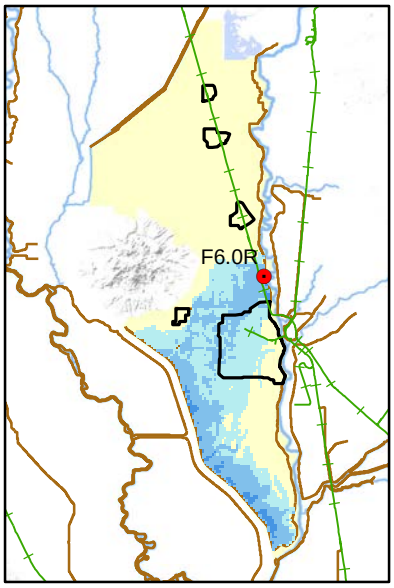
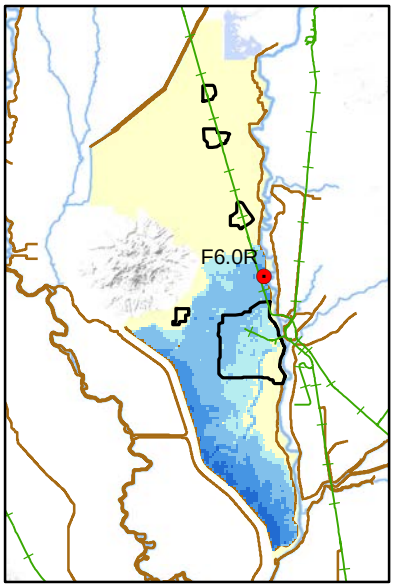
PLATE 33



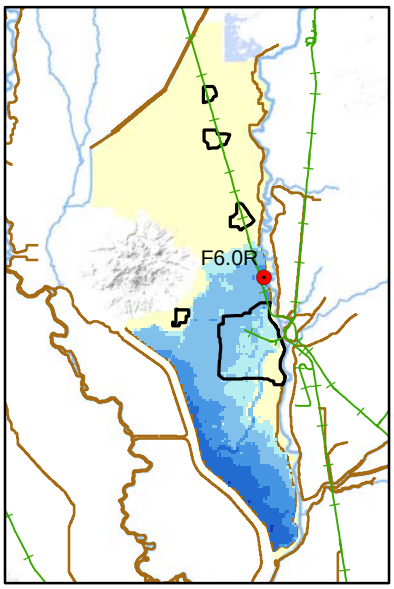
50% (1/2) ACE



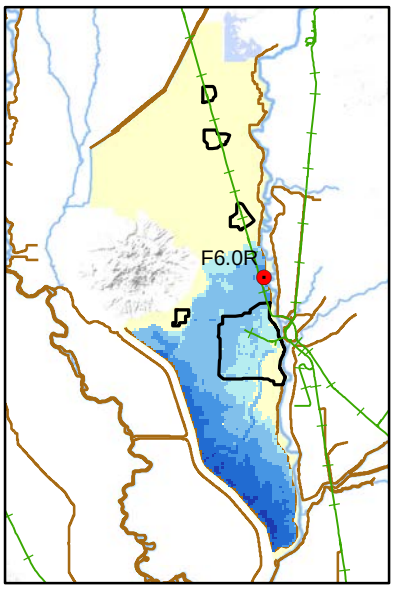
10% (1/10) ACE



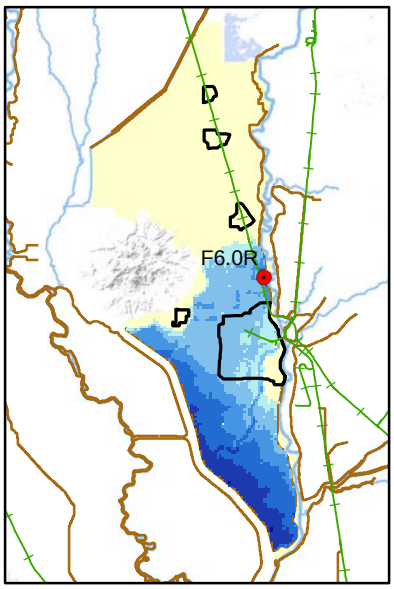
4% (1/25) ACE



2% (1/50) ACE



1% (1/100) ACE



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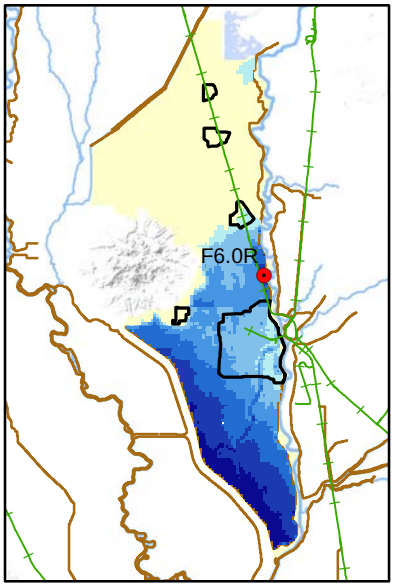

0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F6.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

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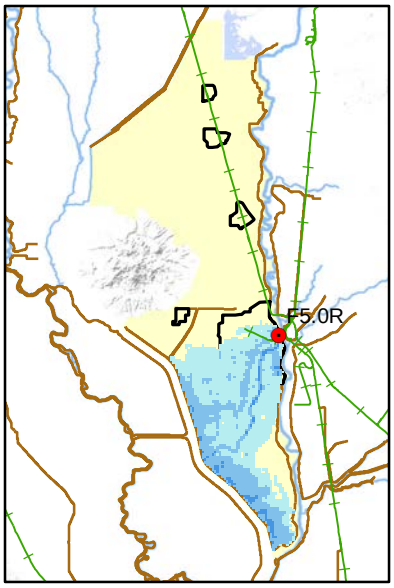
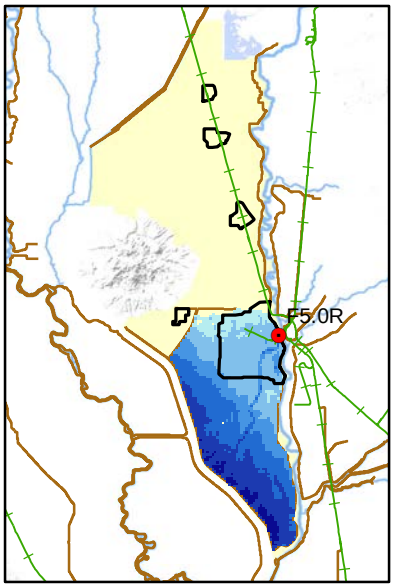
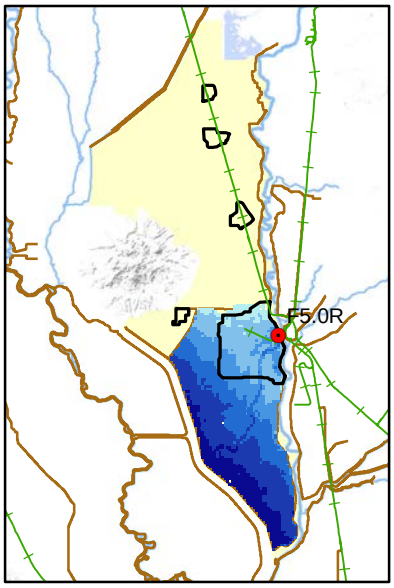
PLATE 34



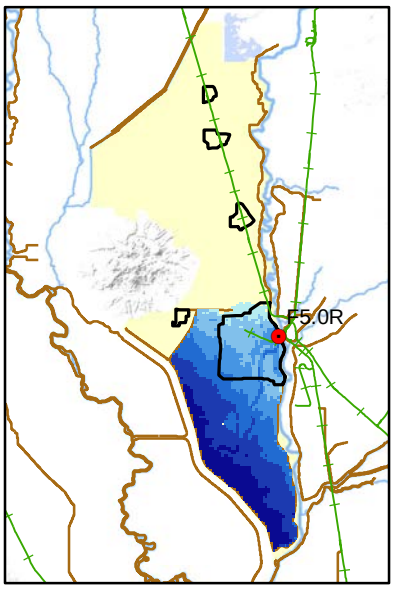
50% (1/2) ACE



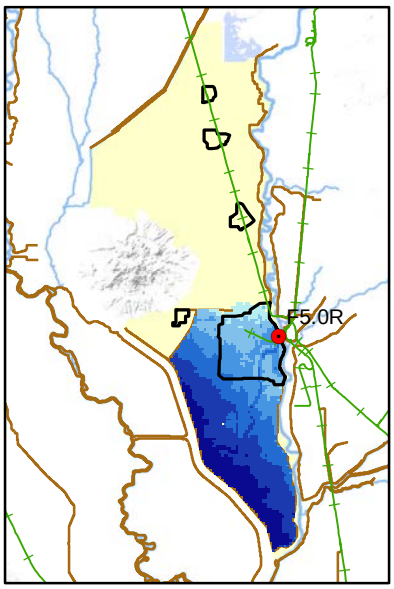
10% (1/10) ACE



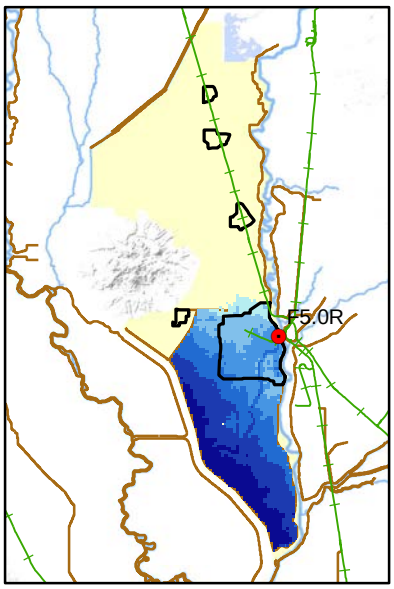
4% (1/25) ACE



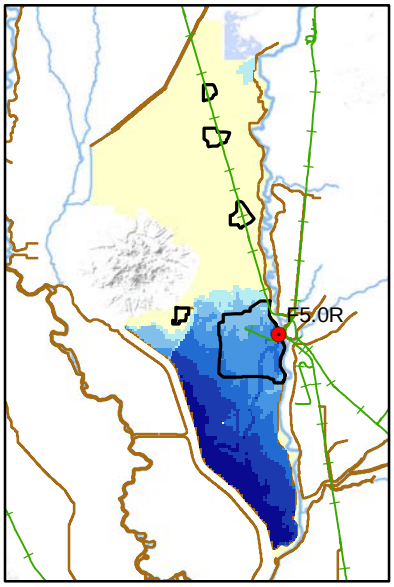
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F5.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

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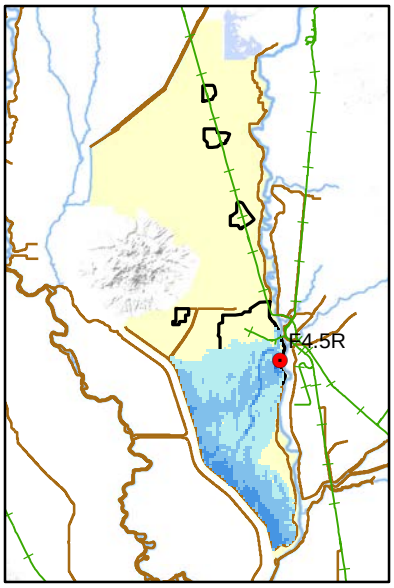
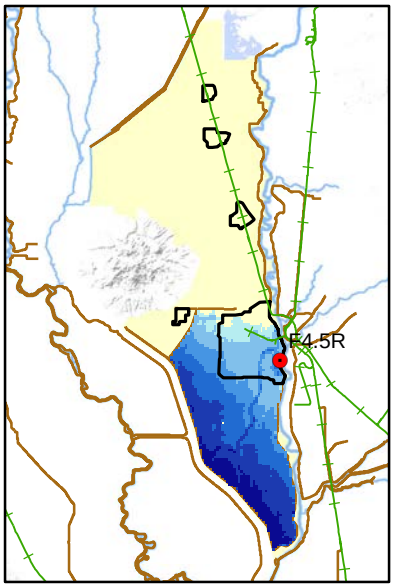
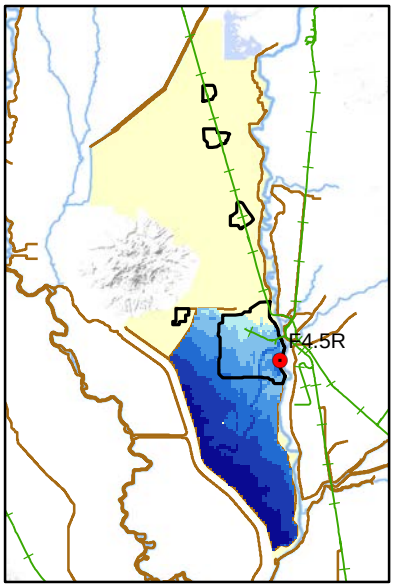
PLATE 35



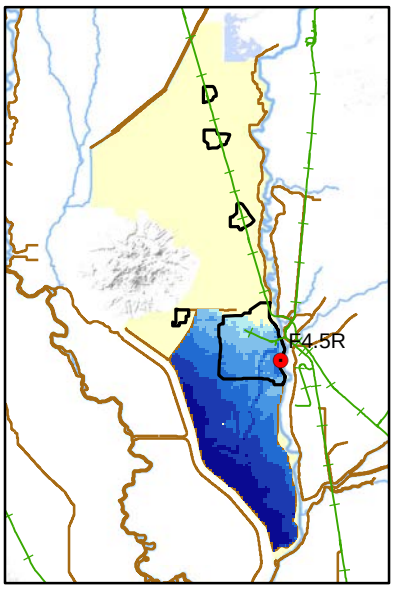
50% (1/2) ACE



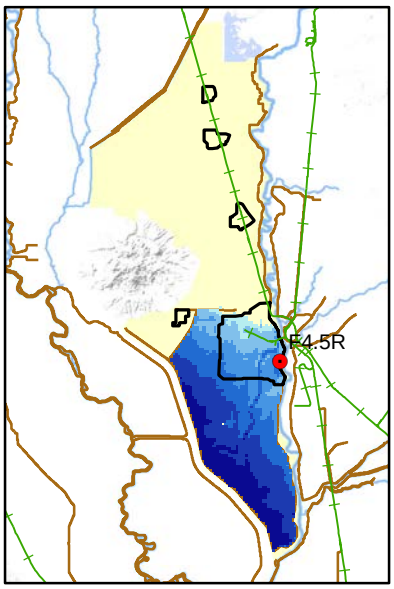
10% (1/10) ACE



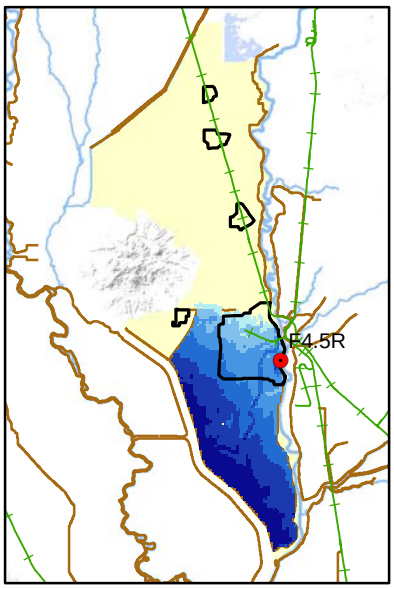
4% (1/25) ACE



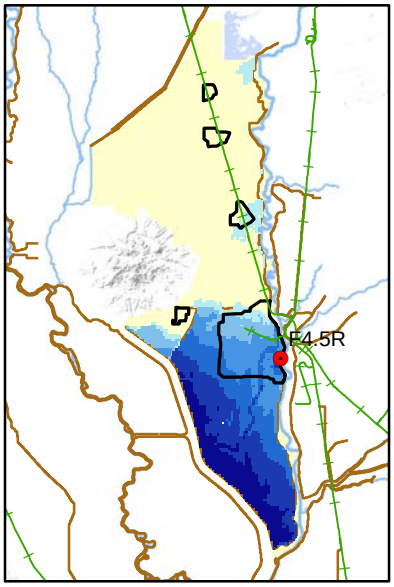
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

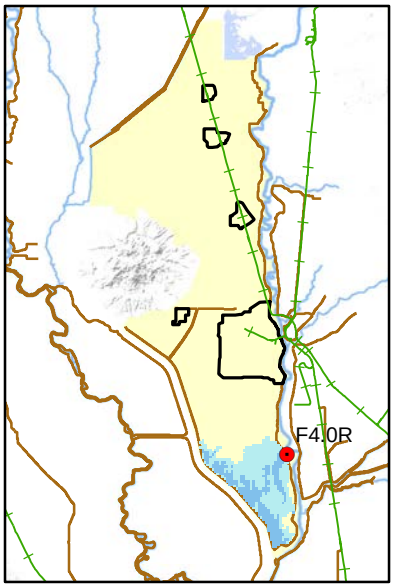
BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F4.5R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

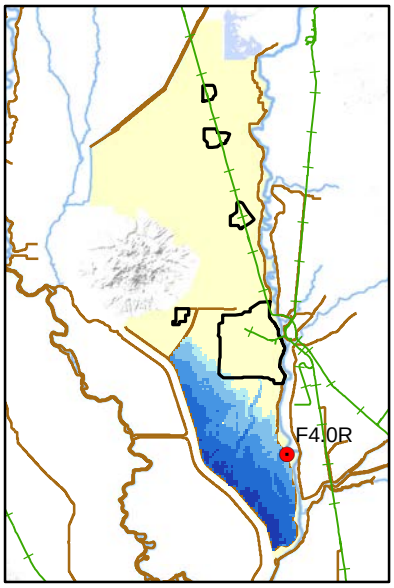
Prepared by T. Hatch

FEB 2013

PLATE 36



50% (1/2) ACE



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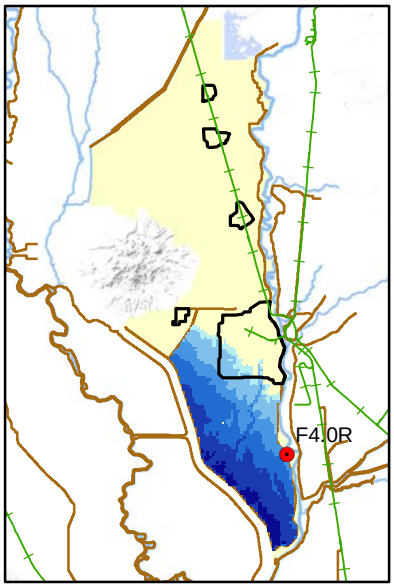
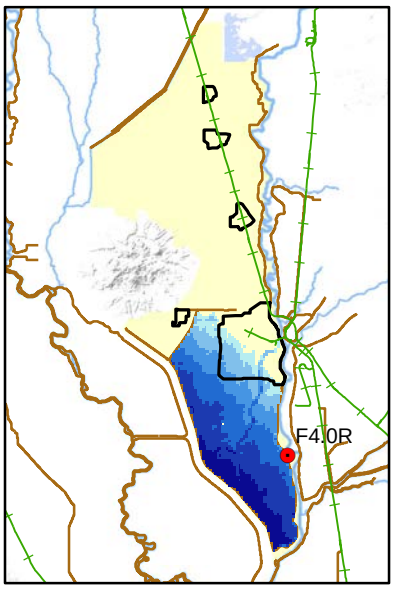
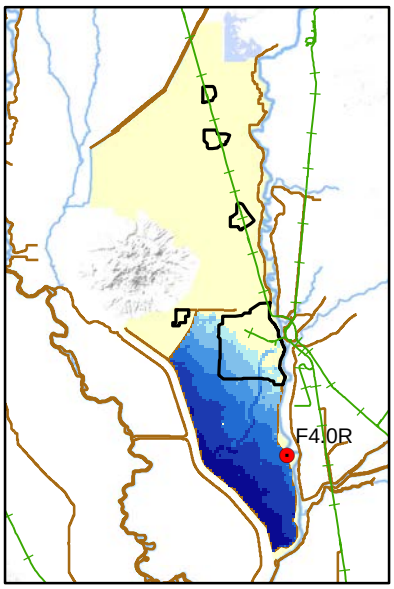


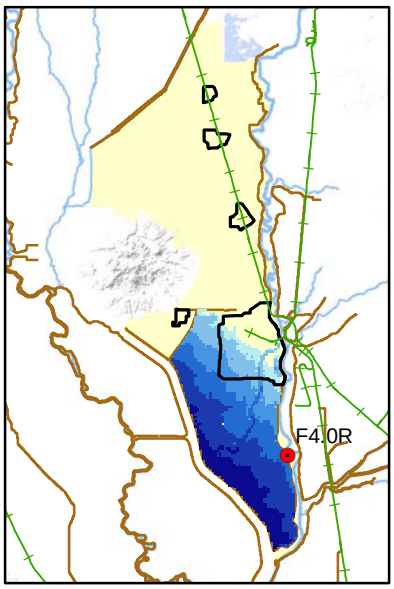
4% (1/25) ACE



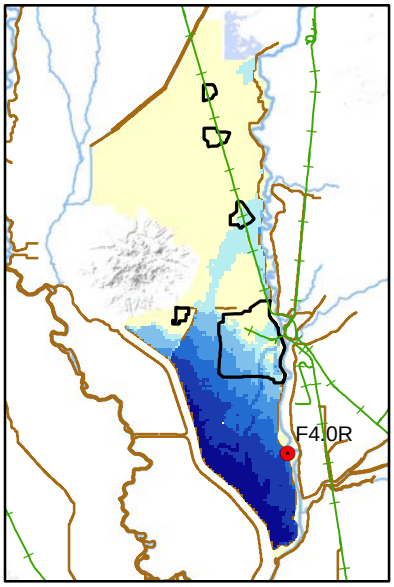
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

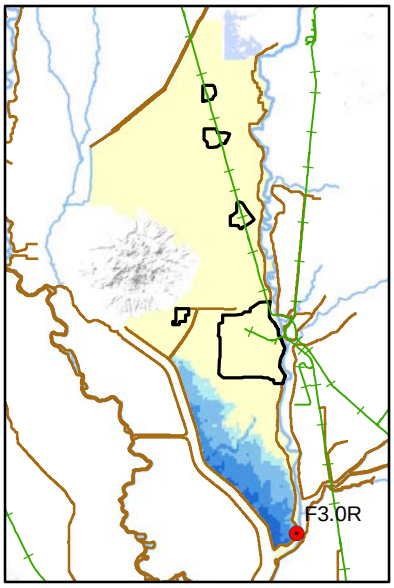
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F4.0R

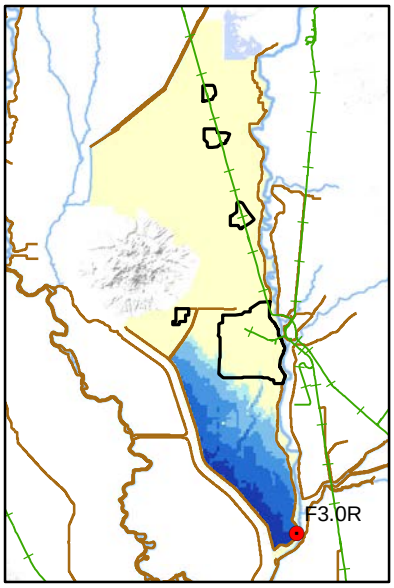
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

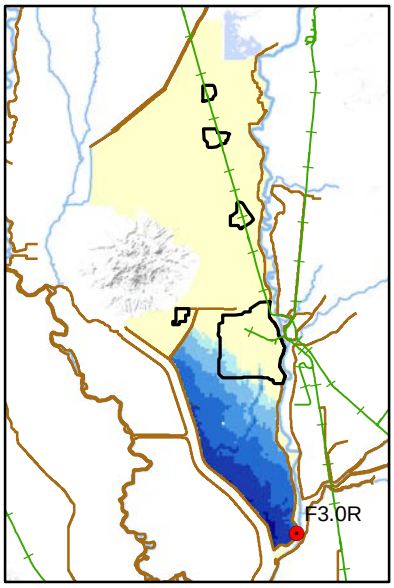
FEB 2013



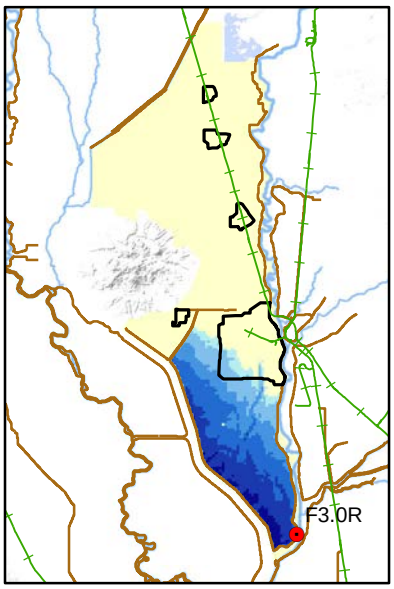
50% (1/2) ACE



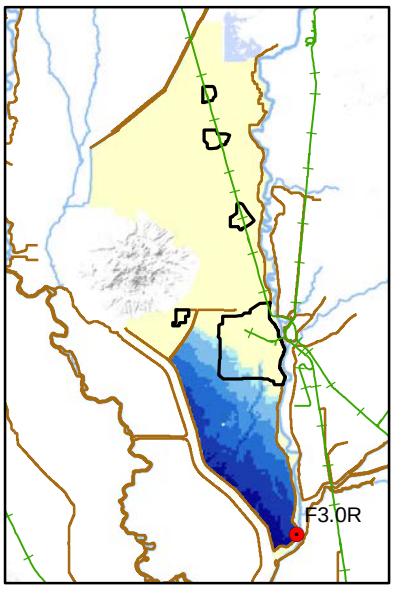
10% (1/10) ACE



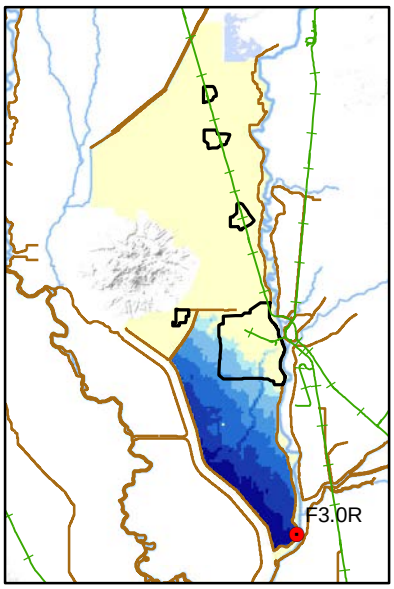
4% (1/25) ACE



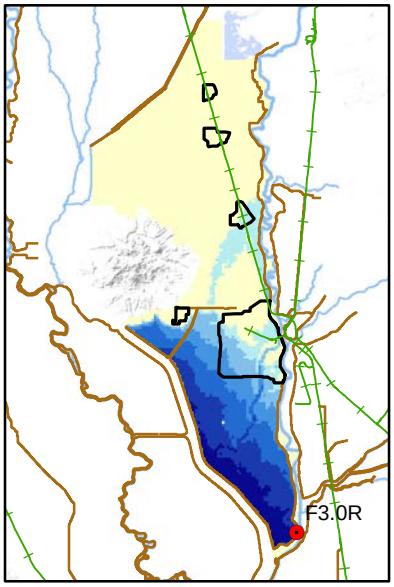
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 25

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F3.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

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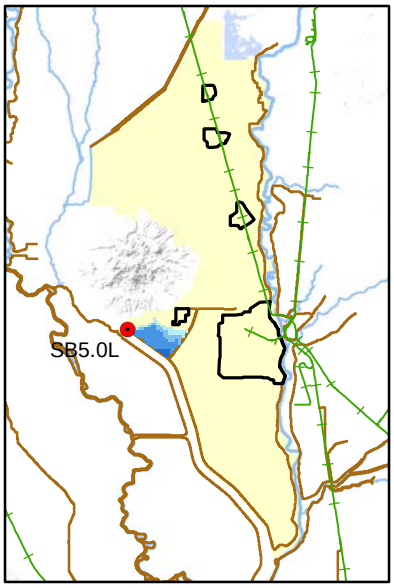
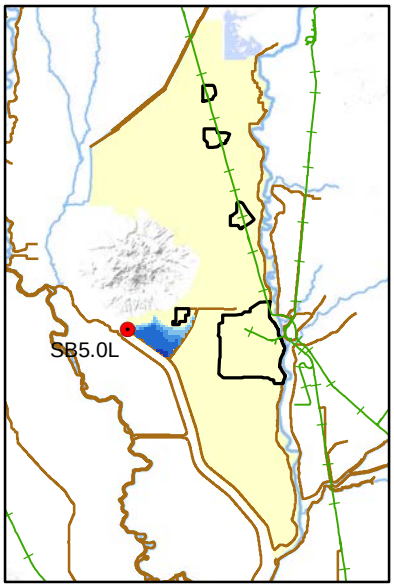
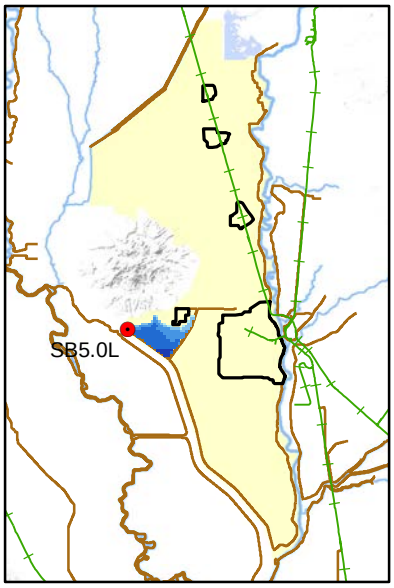
PLATE 38



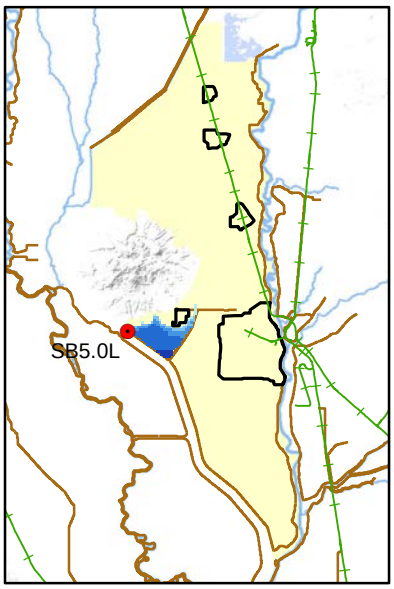
50% (1/2) ACE



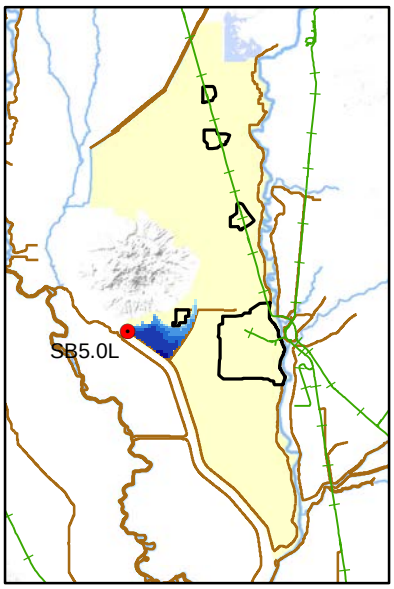
10% (1/10) ACE



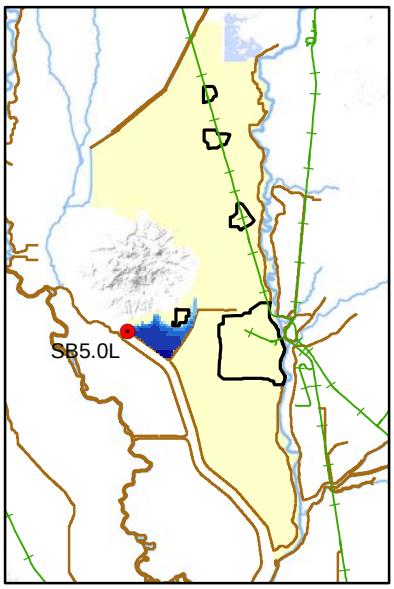
4% (1/25) ACE



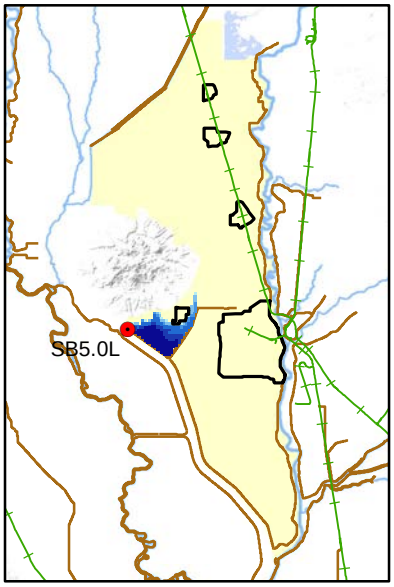
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 SUTTER BYPASS EAST LEVEE LOCATION SB5.0L

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

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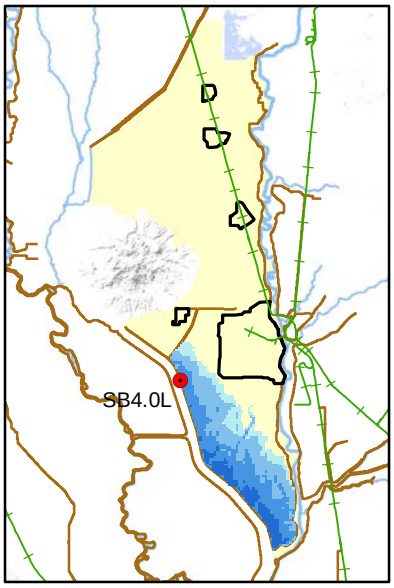
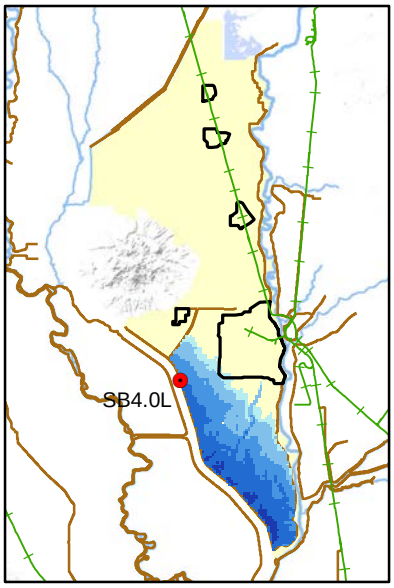
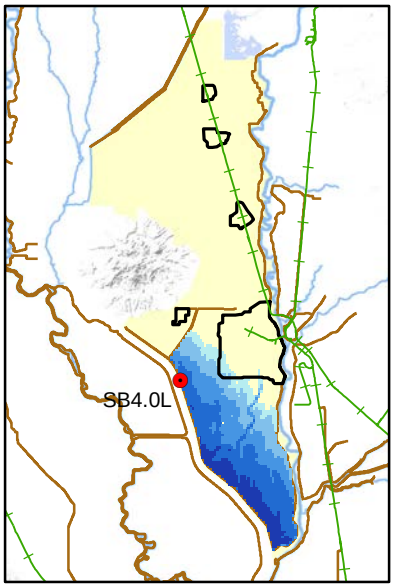
PLATE 39



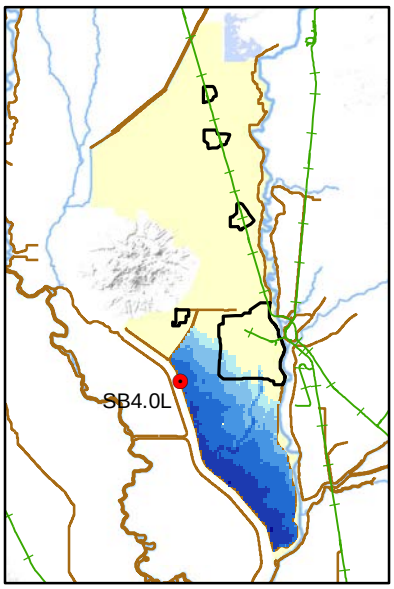
50% (1/2) ACE



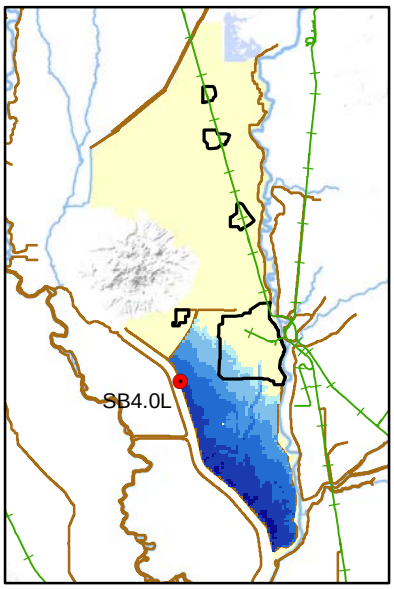
10% (1/10) ACE



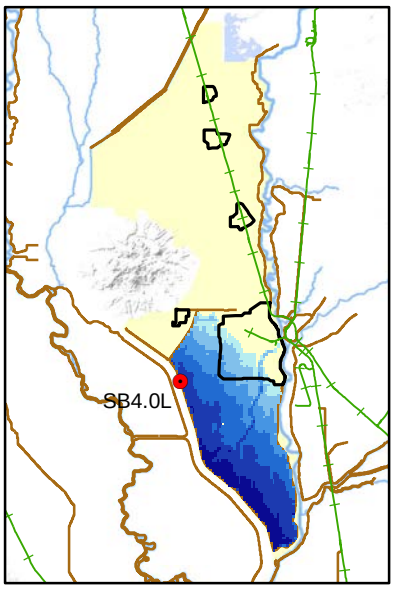
4% (1/25) ACE



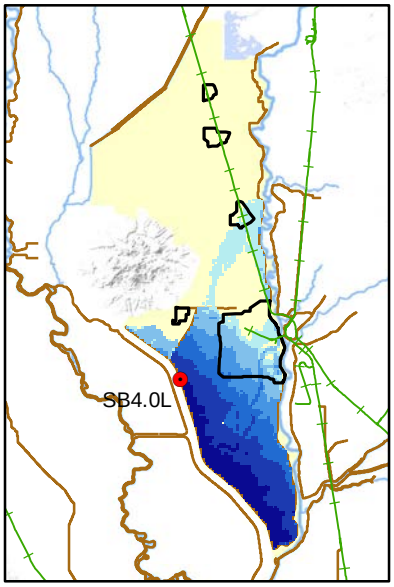
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

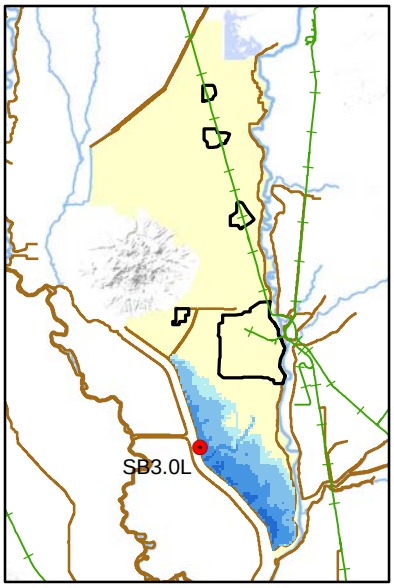
BREACH SIMULATION ALTERNATIVE SB-1 SUTTER BYPASS EAST LEVEE LOCATION SB4.0L

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

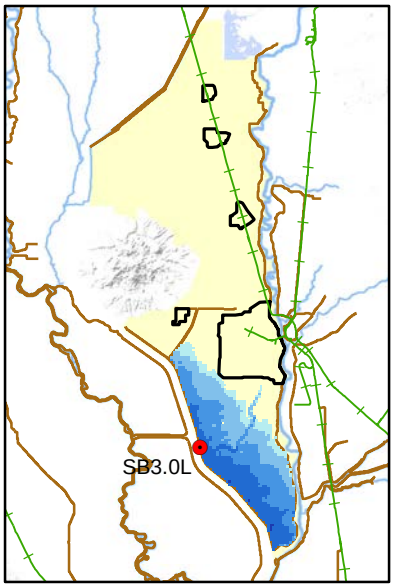
Prepared by T. Hatch

FEB 2013

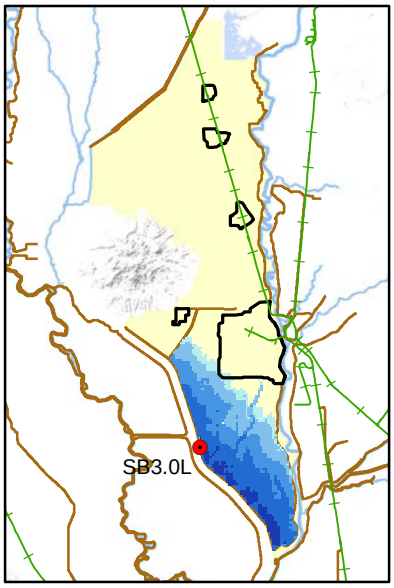
PLATE 40



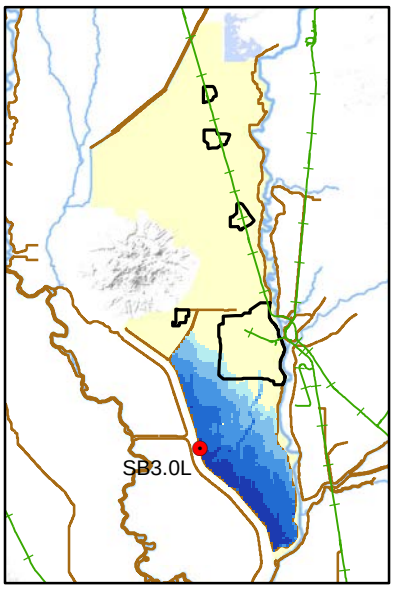
50% (1/2) ACE



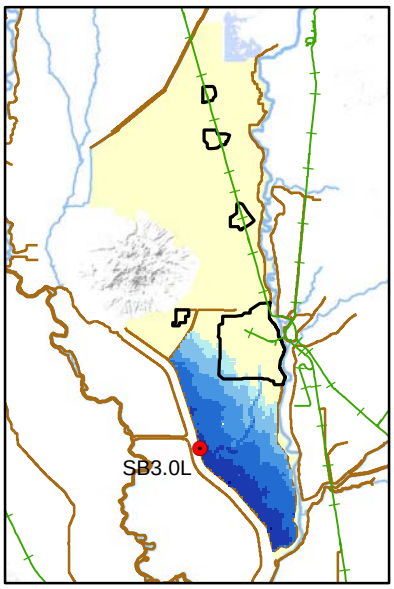
10% (1/10) ACE



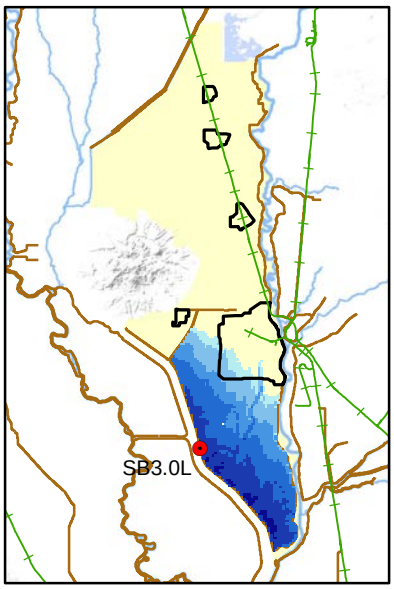
4% (1/25) ACE



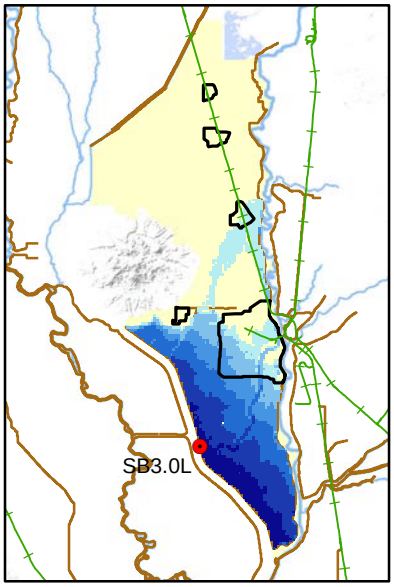
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

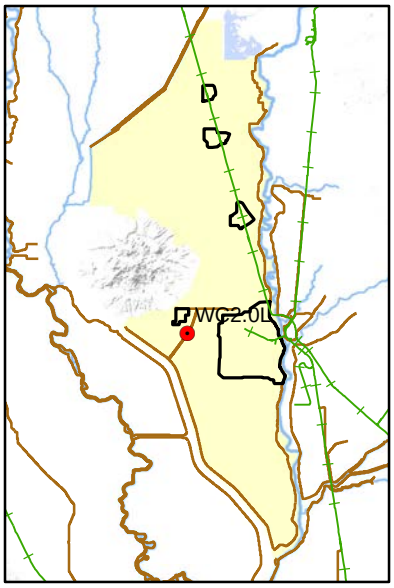
BREACH SIMULATION ALTERNATIVE SB-1 SUTTER BYPASS EAST LEVEE LOCATION SB3.0L

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

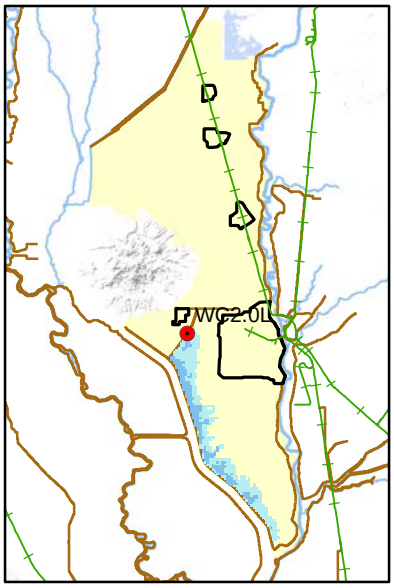
Prepared by T. Hatch

FEB 2013

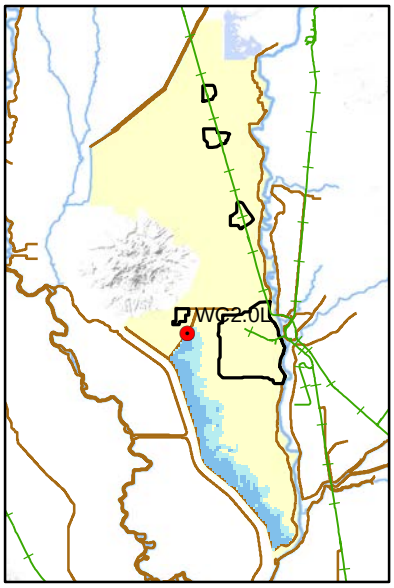
PLATE 41



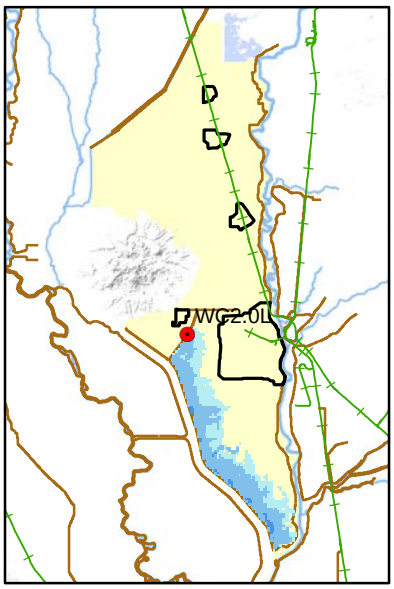
50% (1/2) ACE



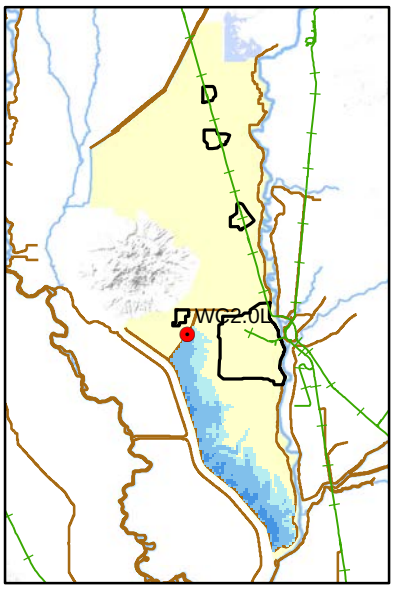
10% (1/10) ACE



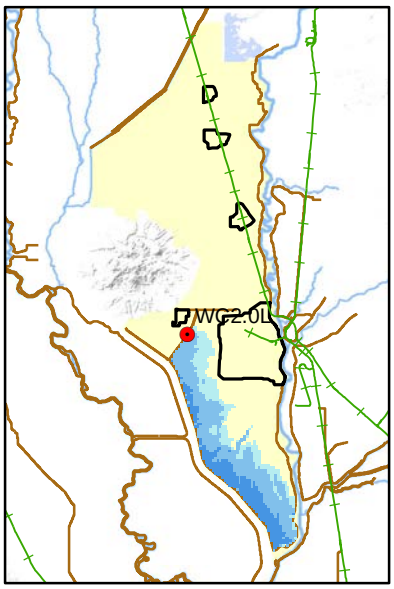
4% (1/25) ACE



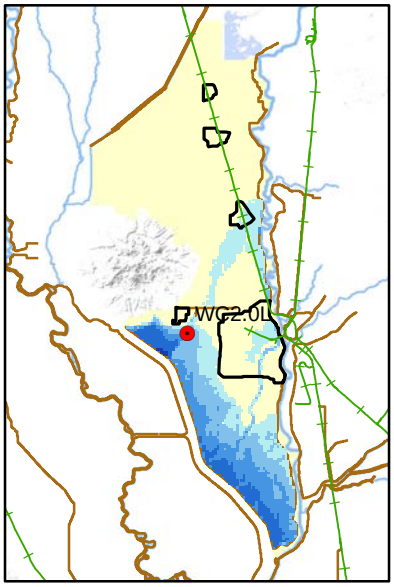
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

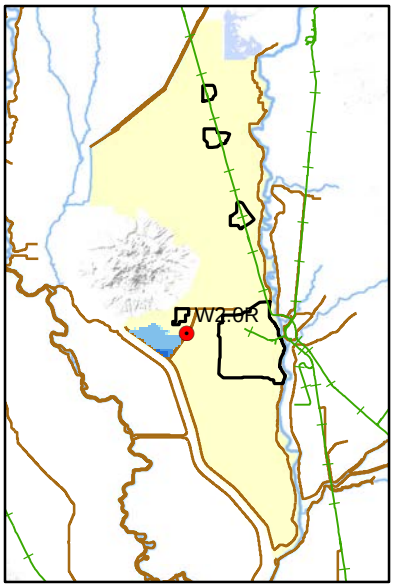
BREACH SIMULATION ALTERNATIVE SB-1 WADSWORTH CANAL SOUTH LEVEE LOCATION WC2.0L

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

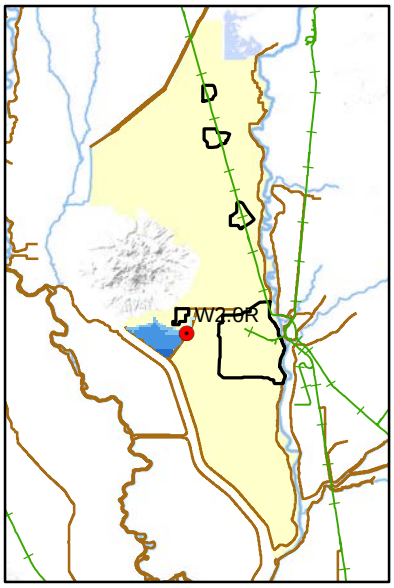
Prepared by T. Hatch

FEB 2013

PLATE 42



50% (1/2) ACE



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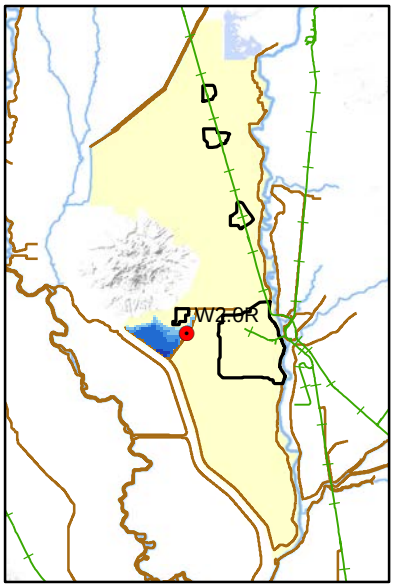
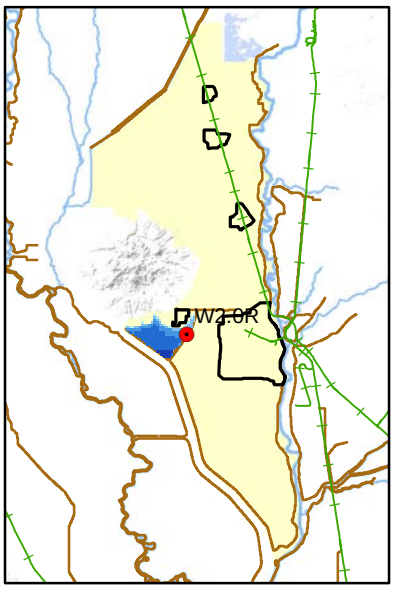
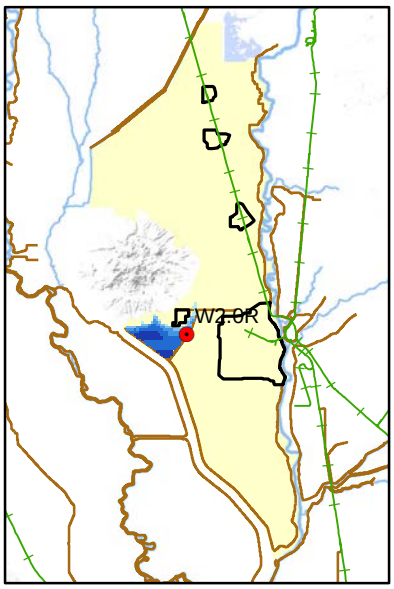


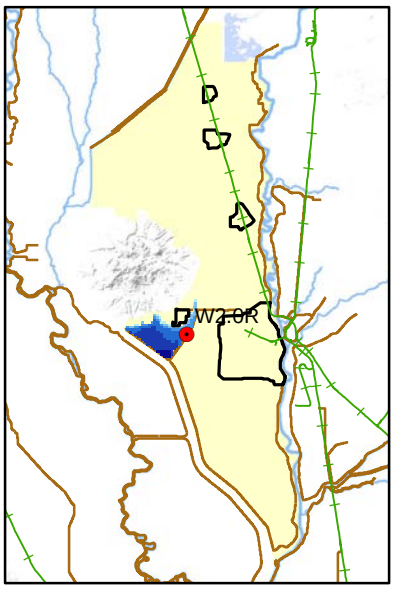
4% (1/25) ACE



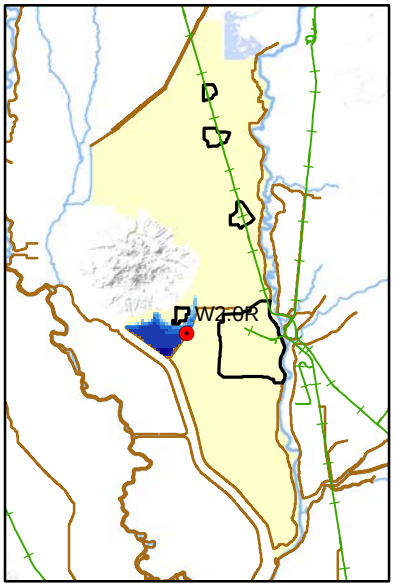
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

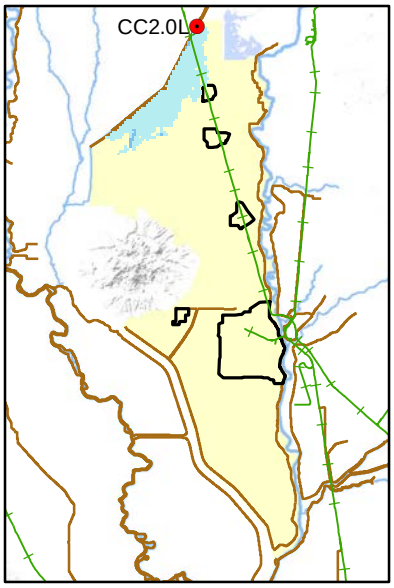
BREACH SIMULATION ALTERNATIVE SB-1 WADSWORTH CANAL NORTH LEVEE LOCATION W2.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

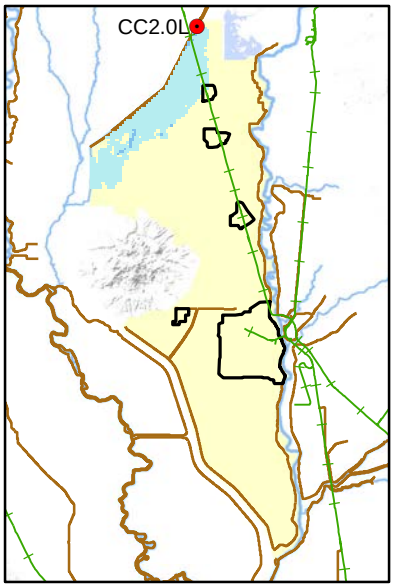
Prepared by T. Hatch

FEB 2013

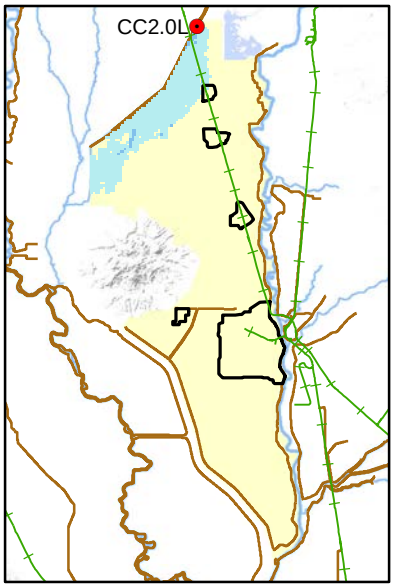
PLATE 43



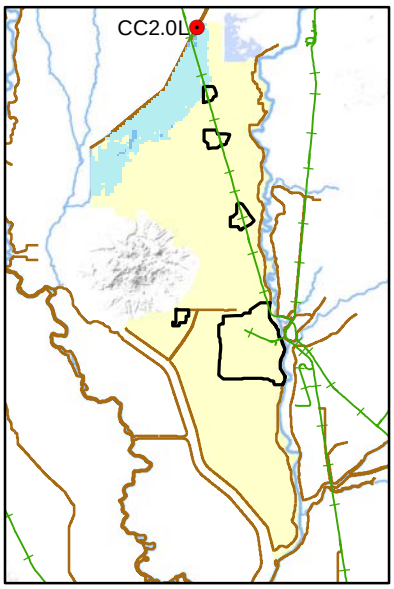
50% (1/2) ACE



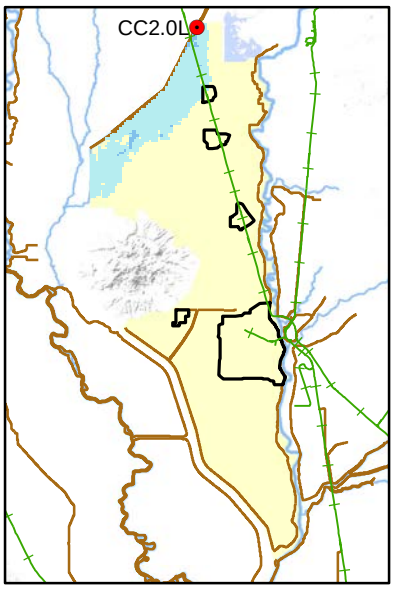
10% (1/10) ACE



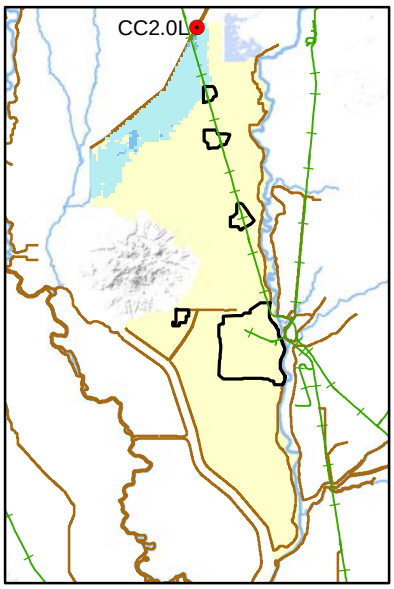
4% (1/25) ACE



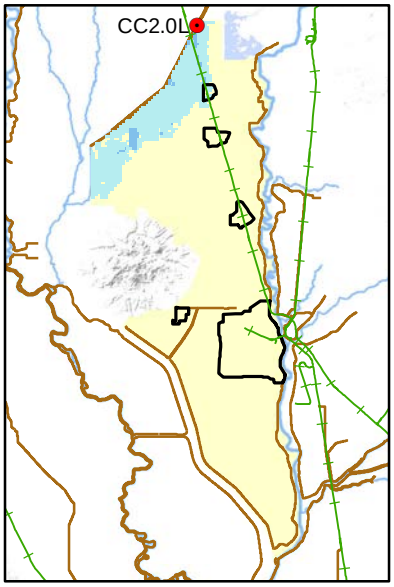
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

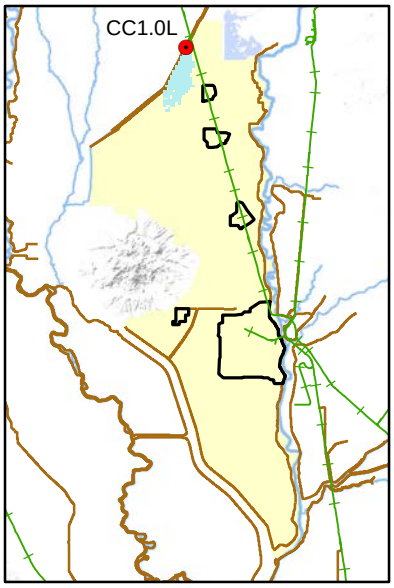
BREACH SIMULATION ALTERNATIVE SB-1 CHEROKEE CANAL SOUTH LEVEE LOCATION CC2.0L

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

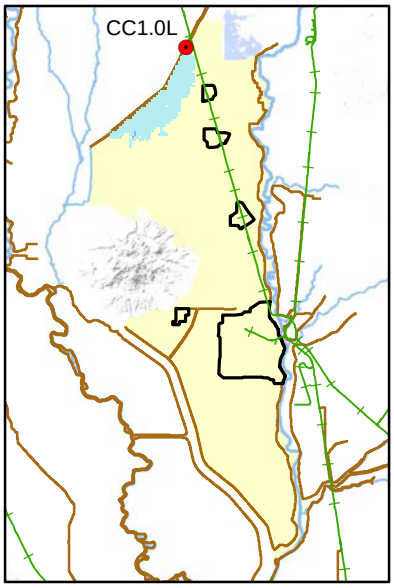
Prepared by T. Hatch

FEB 2013

PLATE 44



50% (1/2) ACE



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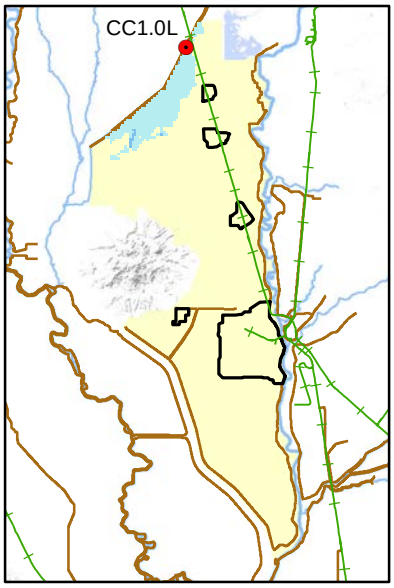

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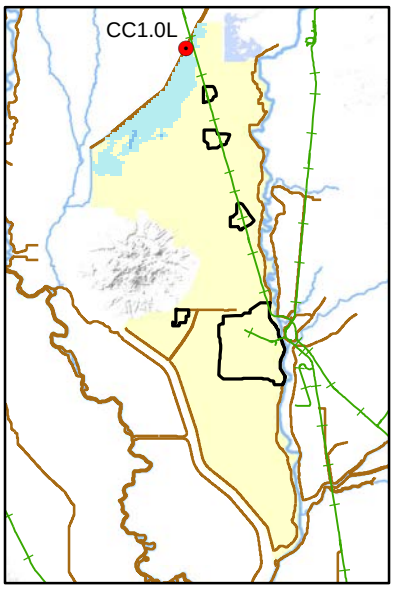

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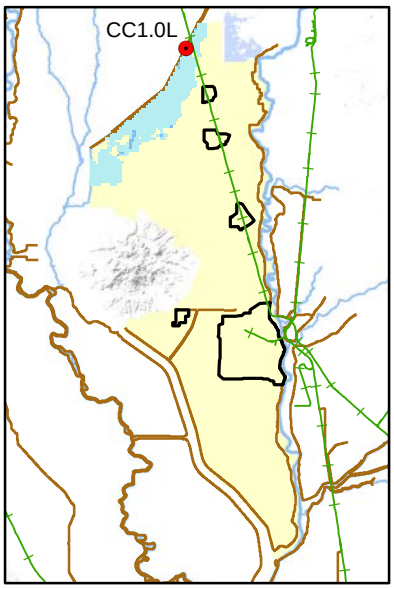
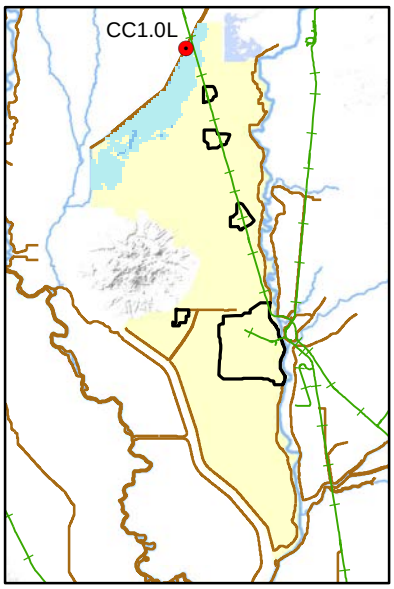
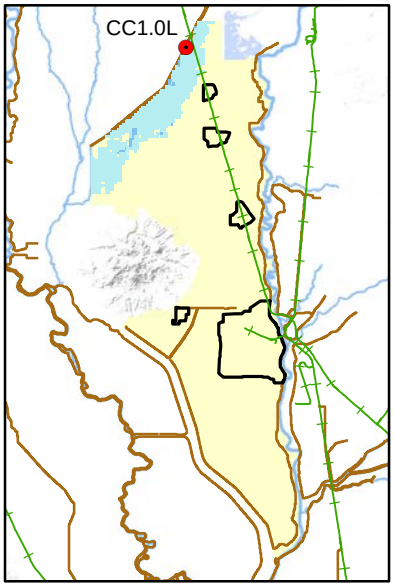


1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 CHEROKEE CANAL SOUTH LEVEE LOCATION CC1.0L

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

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NOT MODELED

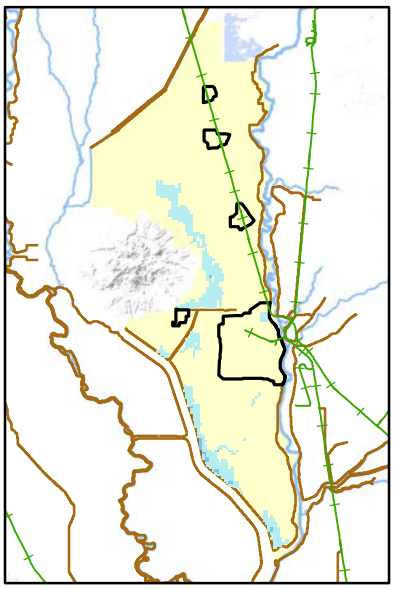
50% (1/2) ACE

NOT MODELED

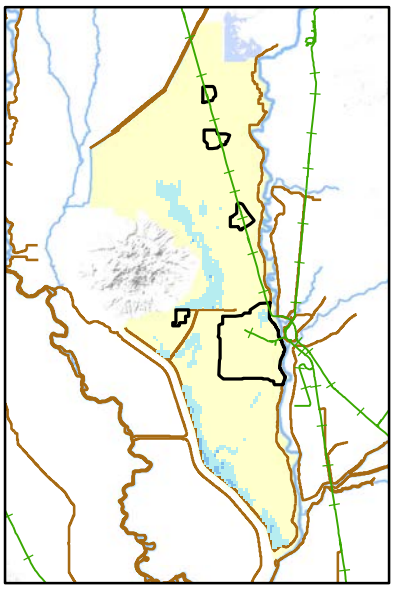
10% (1/10) ACE

NOT MODELED

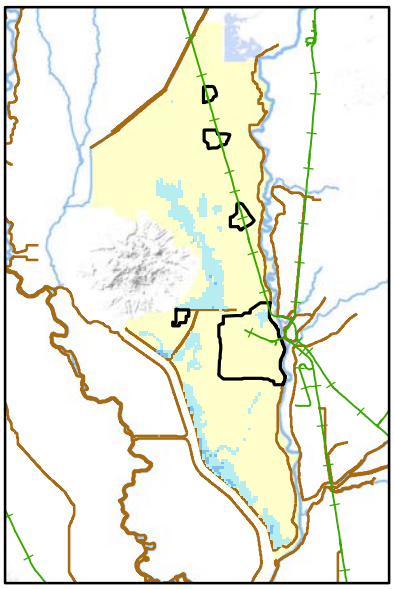
4% (1/25) ACE



2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE

NOT MODELED

0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

0 10 20 Miles

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

INTERIOR DRAINAGE ALTERNATIVE SB-1

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

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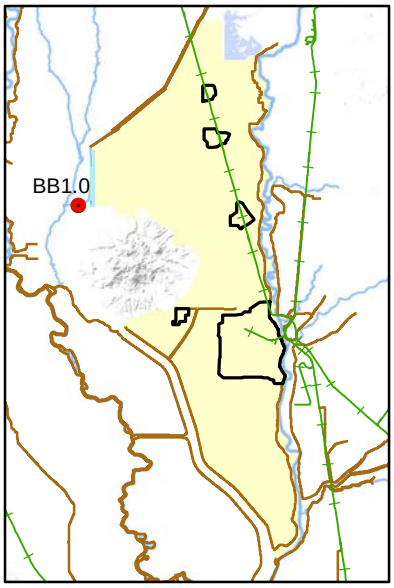
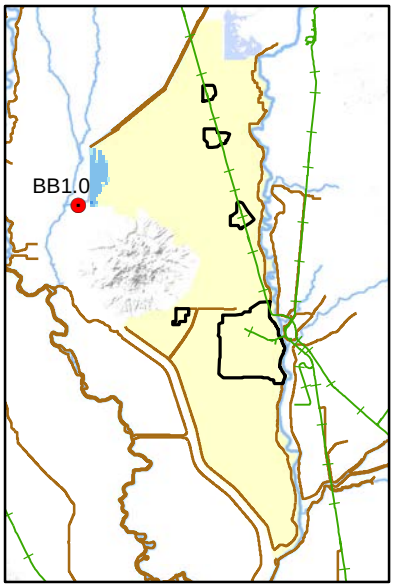
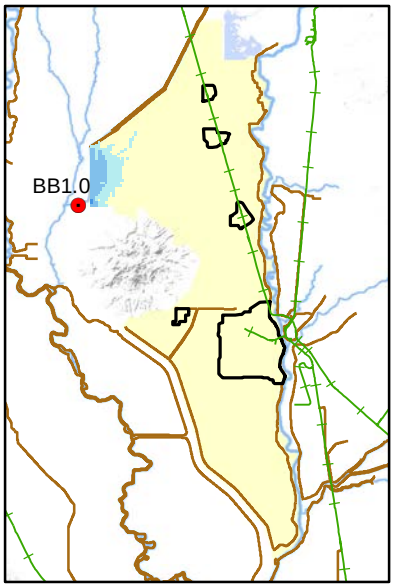
PLATE 46



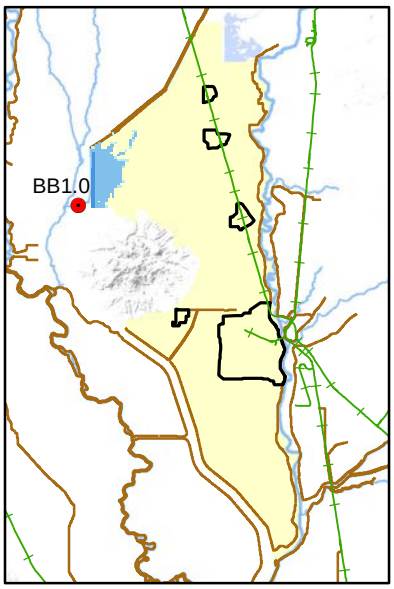
50% (1/2) ACE



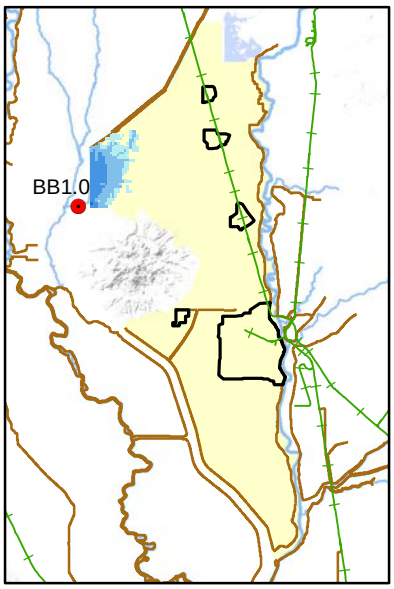
10% (1/10) ACE



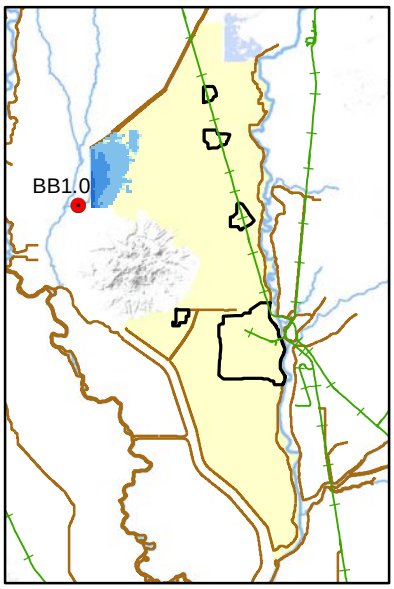
4% (1/25) ACE



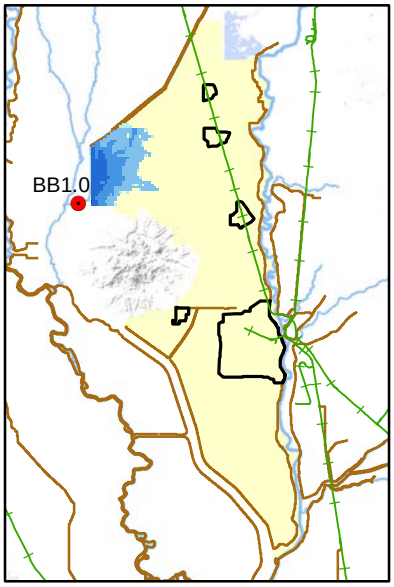
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

ALTERNATIVE SB-1
BUTTE BASIN
LOCATION BB1.0

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

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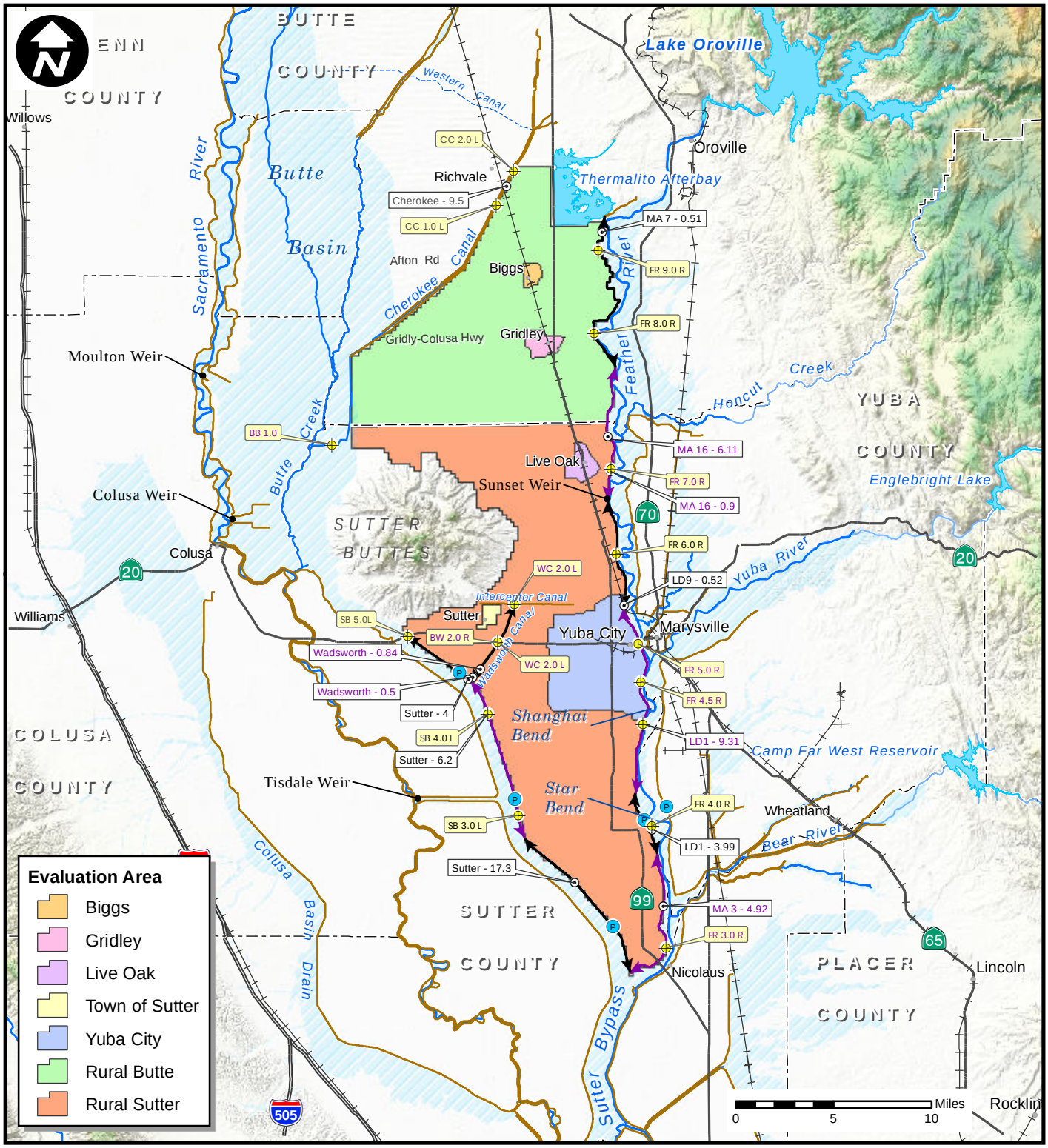


Legend

- Geotechnical Levee Reach
- Federal Levee
- Breach Simulation Site
- Geotechnical Index Point
- Pump Station
- City or Town
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

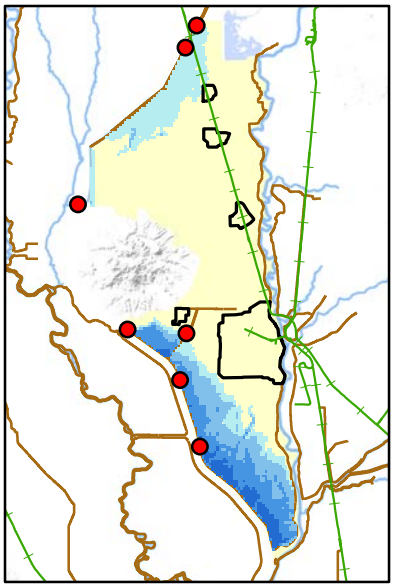
INDEX POINTS AND ECONOMIC IMPACT AREAS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

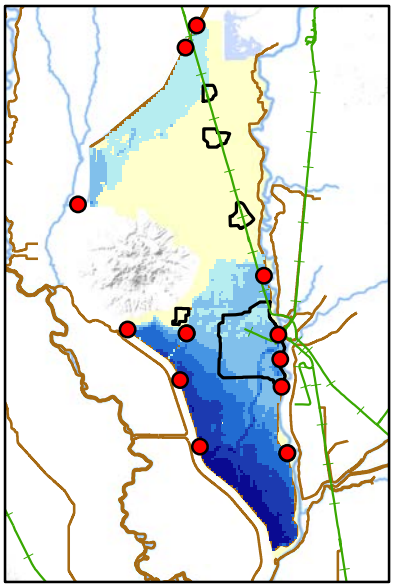
Prepared by Jim Mars

FEB 2013

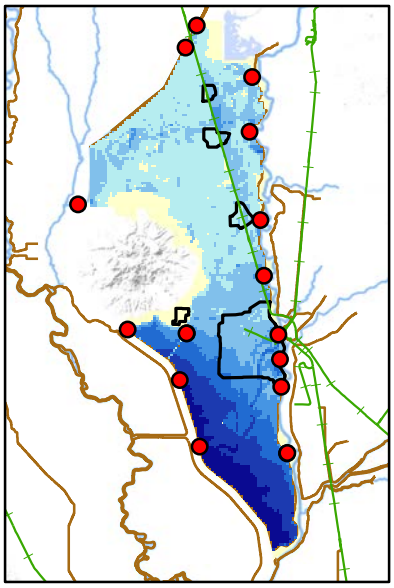
PLATE 48



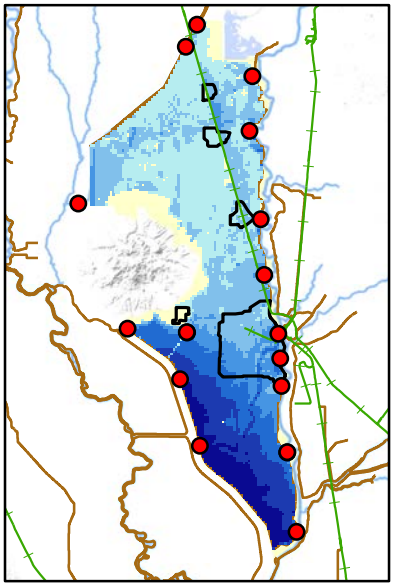
50% (1/2) ACE



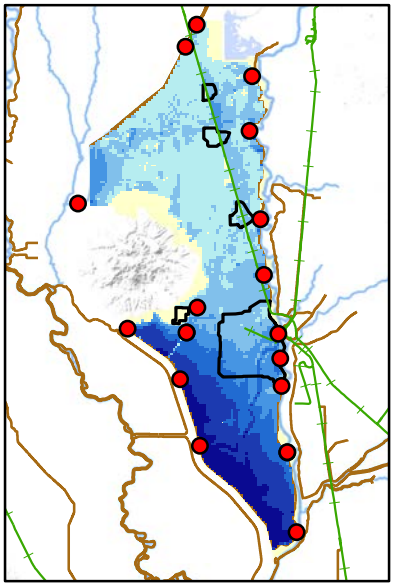
10% (1/10) ACE



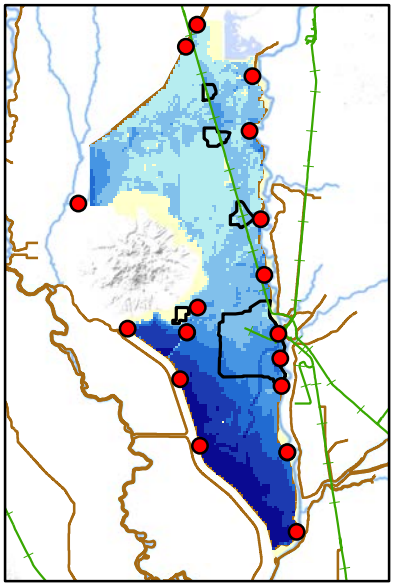
4% (1/25) ACE



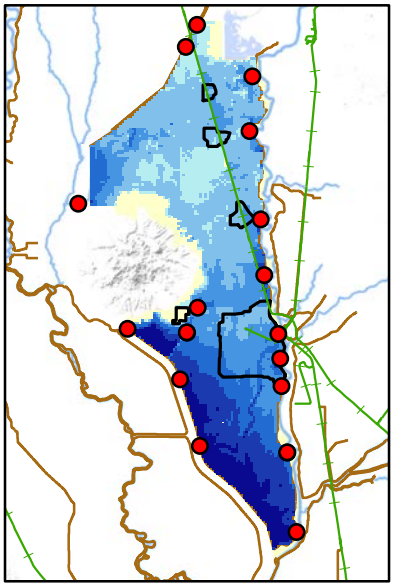
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20
- Railroad
- Levee Fails R&U Criteria

NOTE: Breach simulation shown if levee does not pass assurance criteria.1) Assurance less than 90% the levee does not pass criteria 2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

0 10 20 Miles

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

COMPOSITE FLOODPLAINS ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

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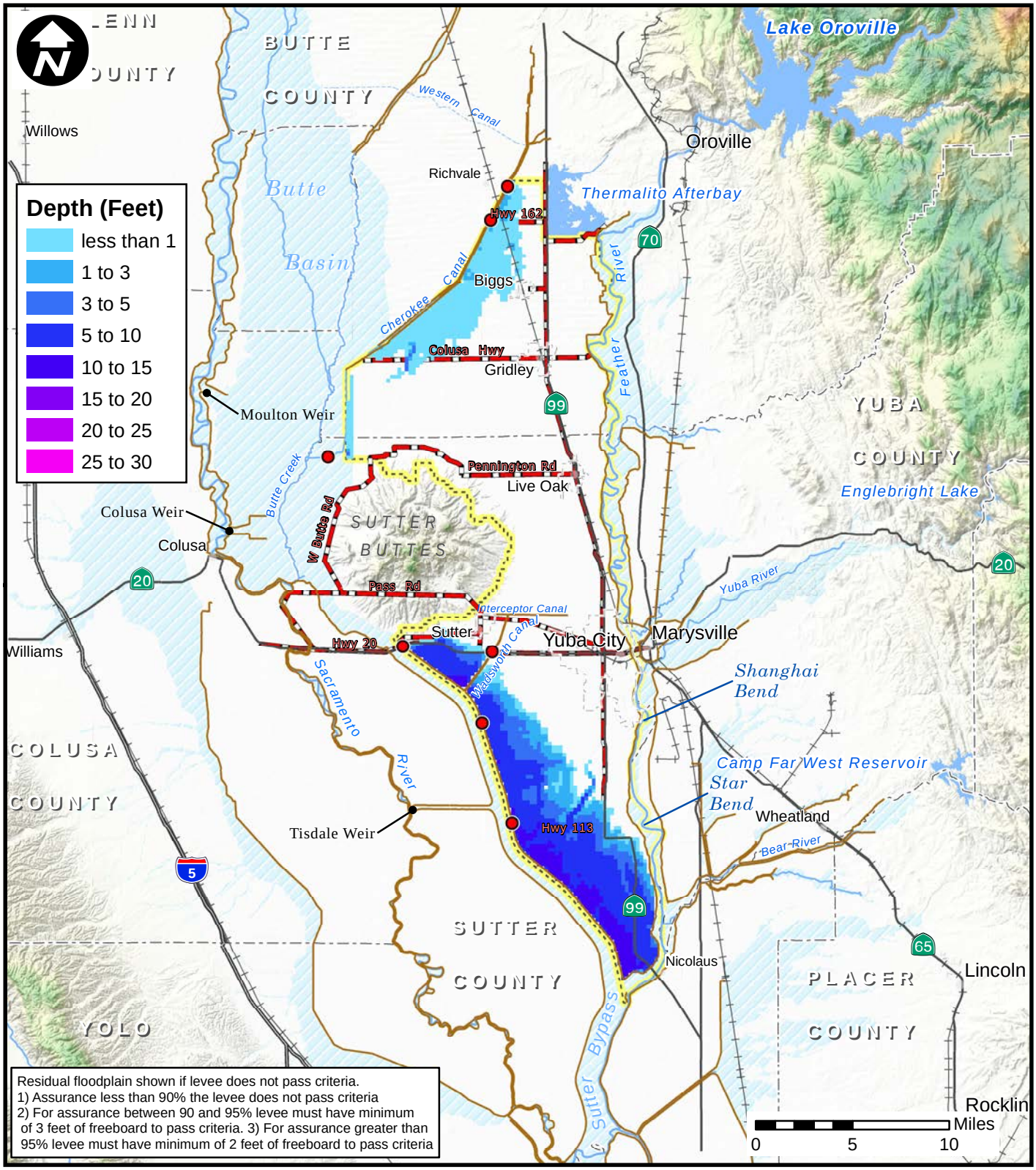

Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

50% (1/2) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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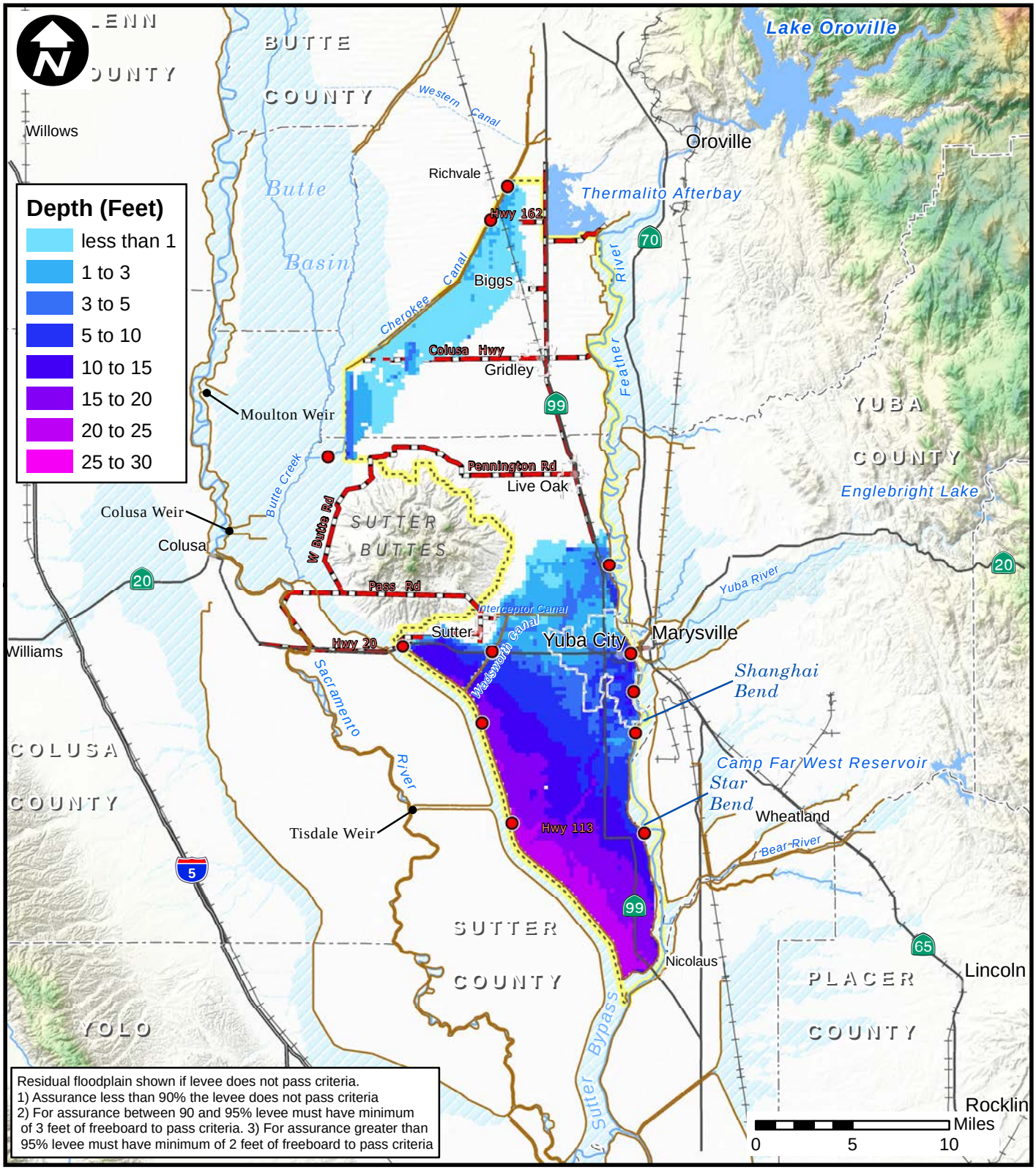
PLATE 50



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

10% (1/10) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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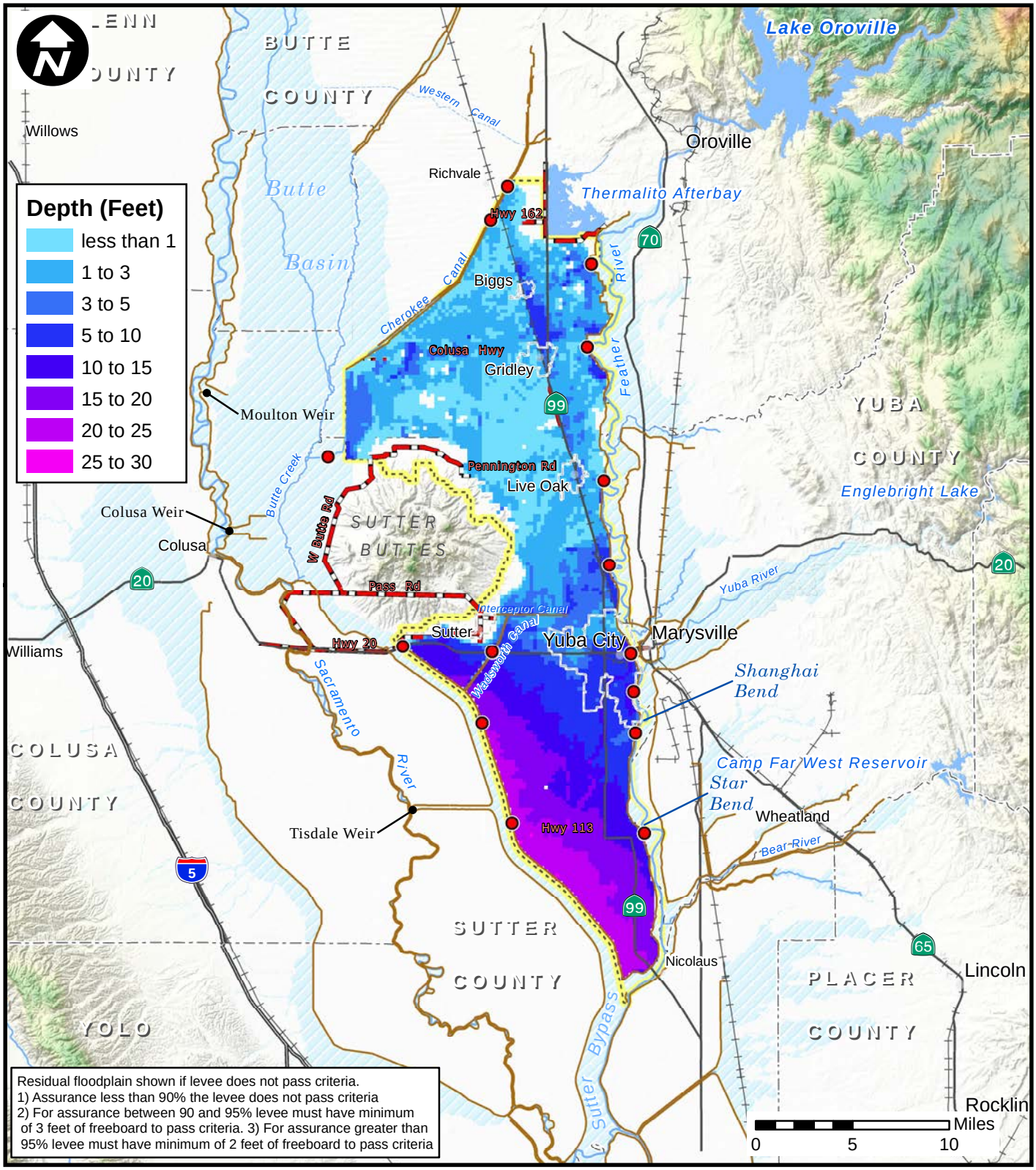
PLATE 51



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

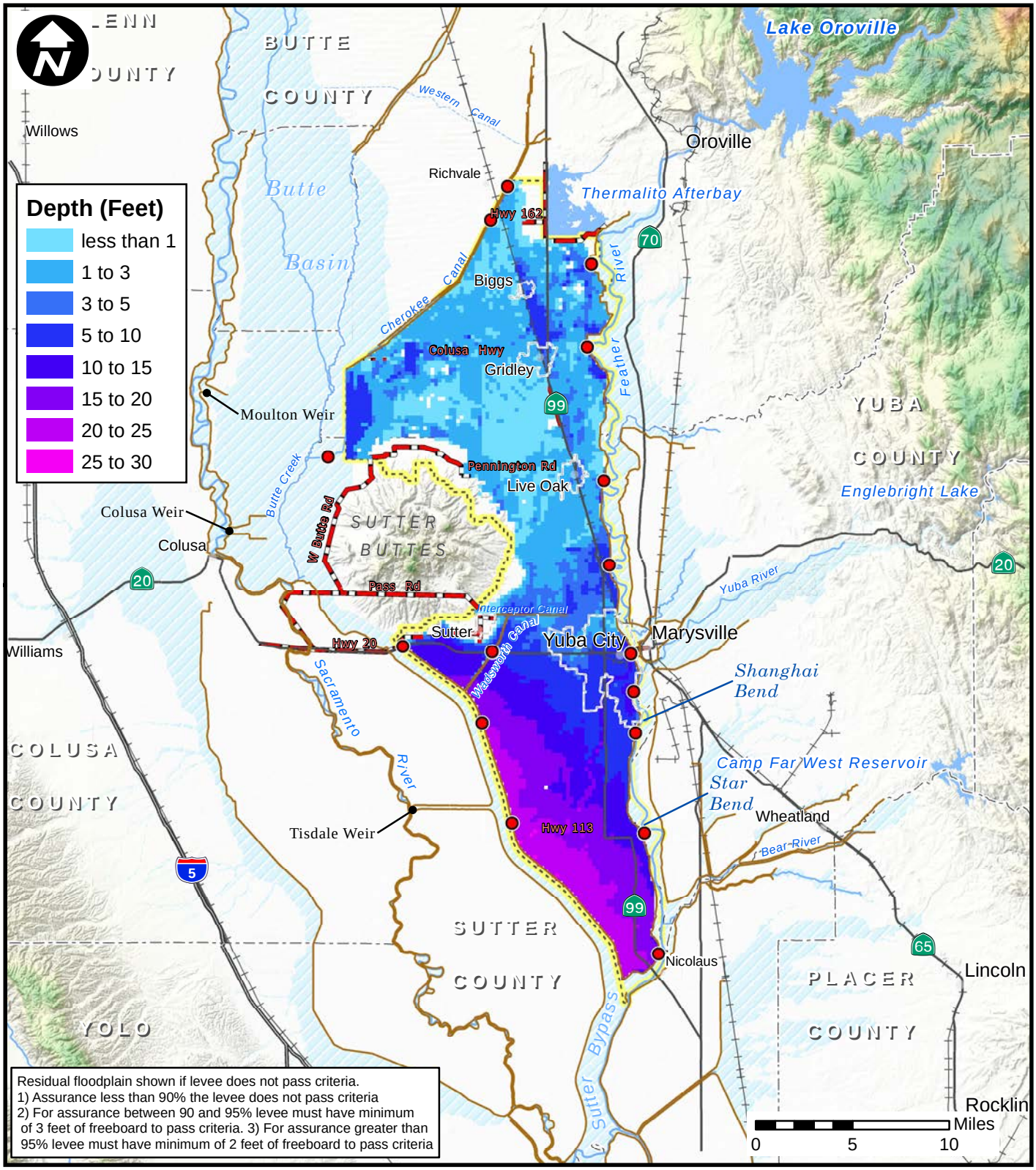
4% (1/25) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 52



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

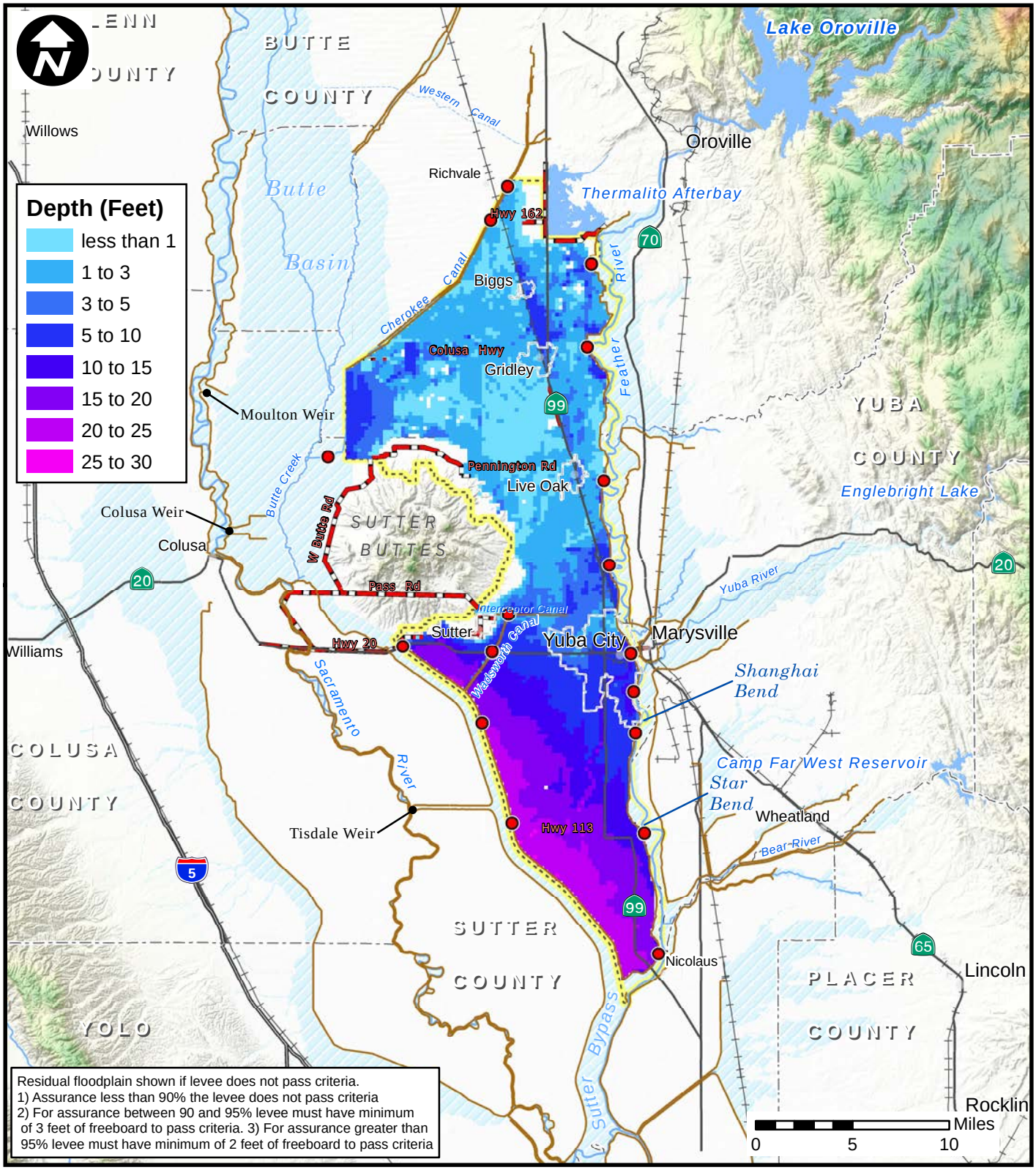
2% (1/50) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 53



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

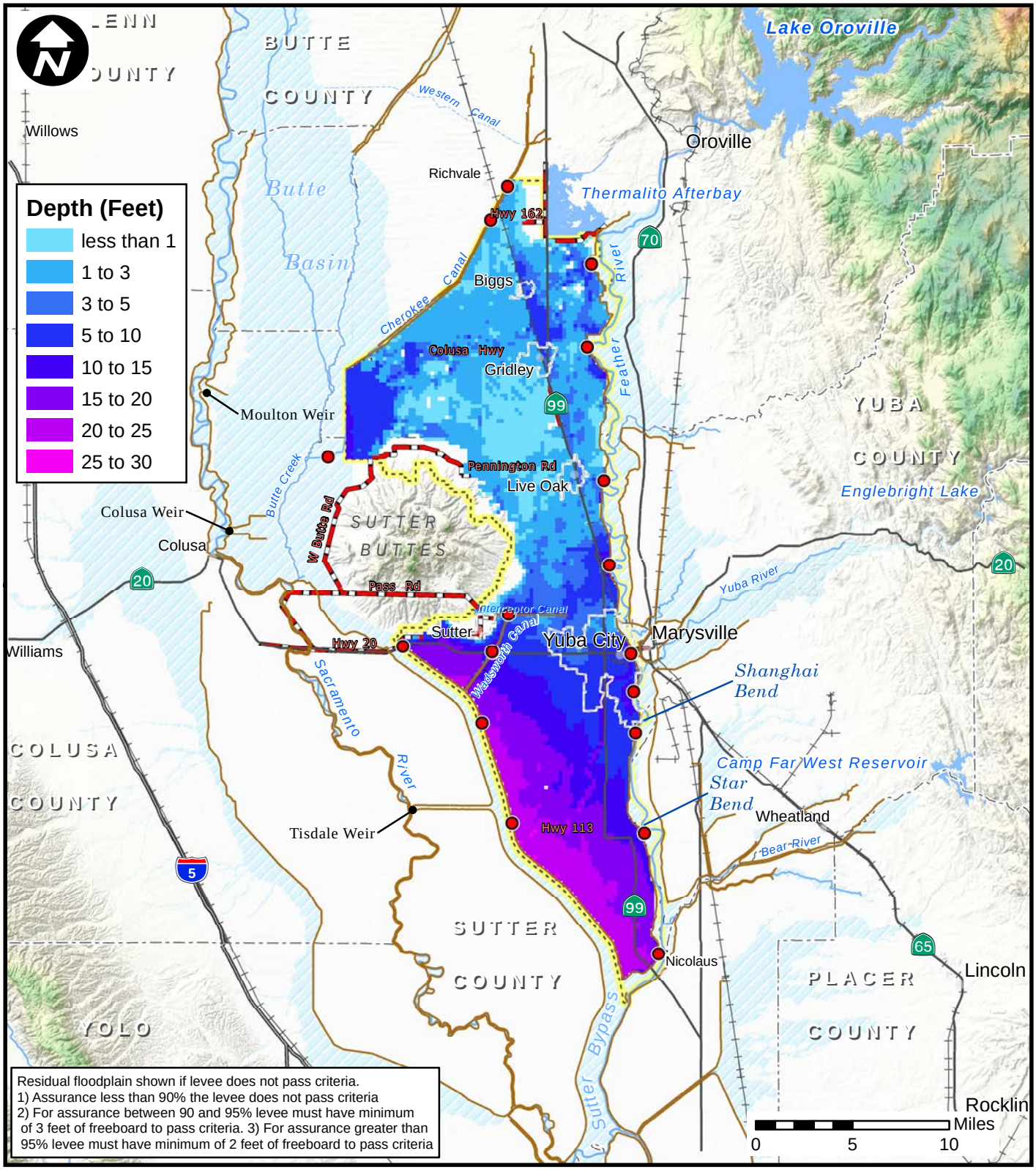
1% (1/100) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 54



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

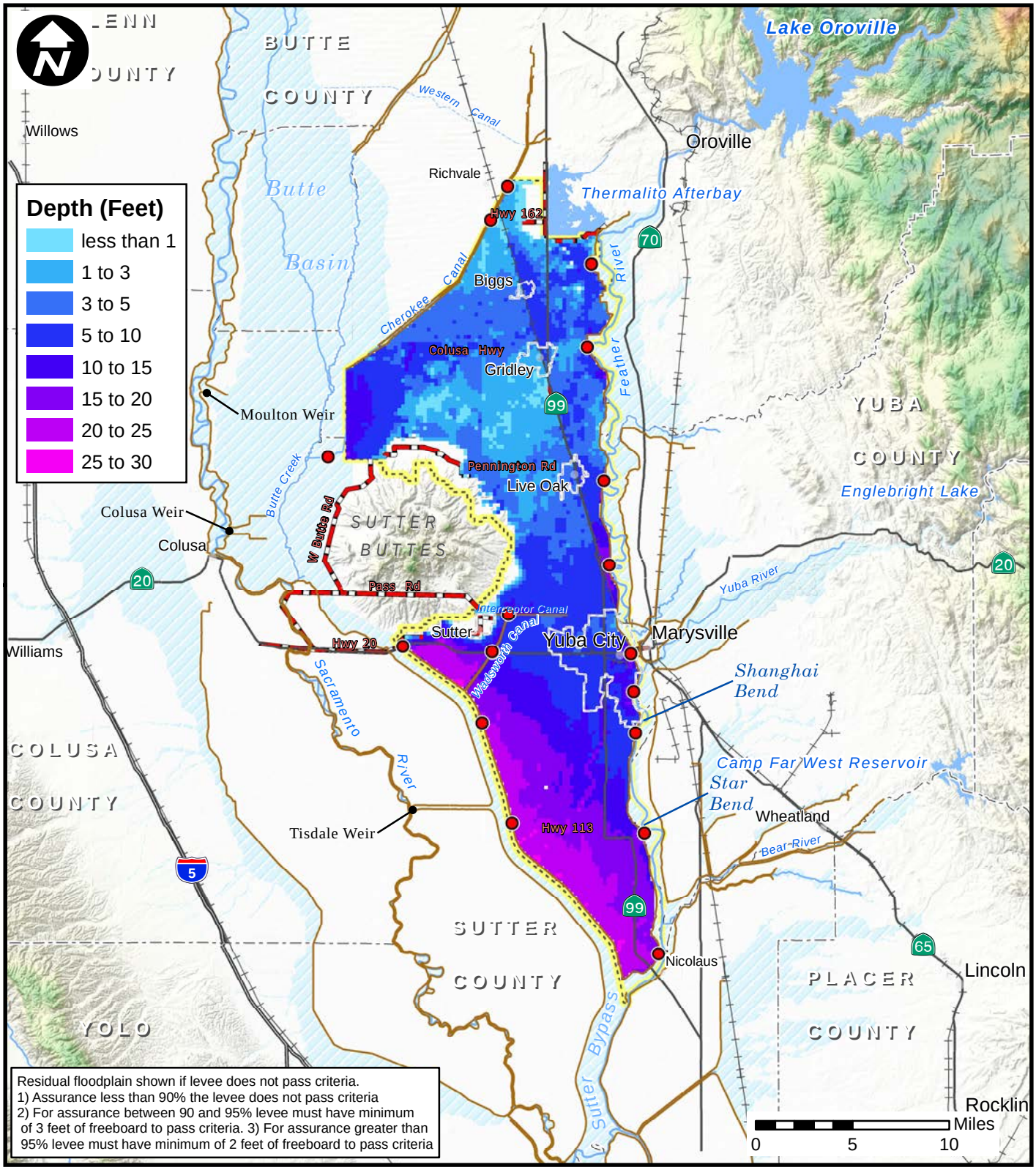
0.5% (1/200) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 55



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

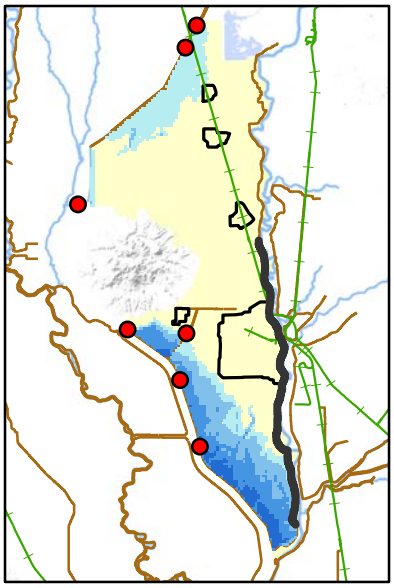
0.2% (1/500) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

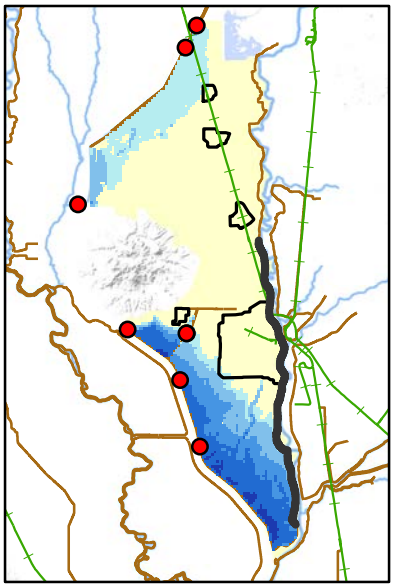
Prepared by Jim Mars

FEB 2013

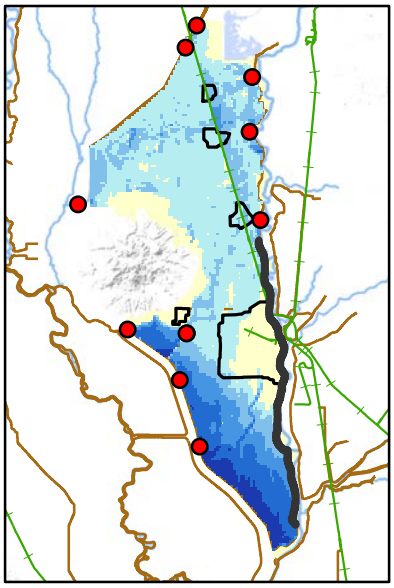
PLATE 56



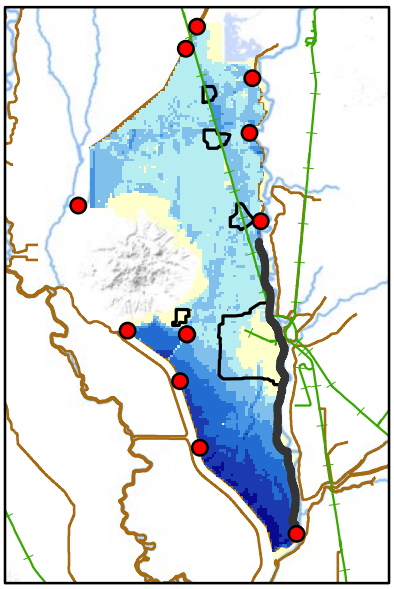
50% (1/2) ACE



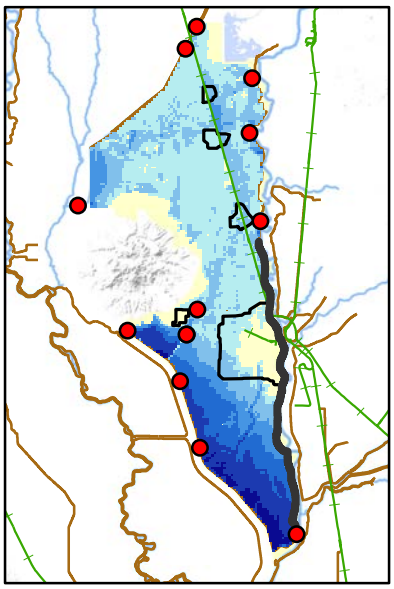
10% (1/10) ACE



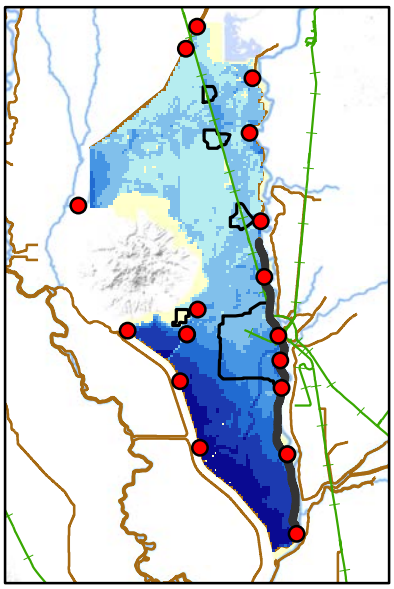
4% (1/25) ACE



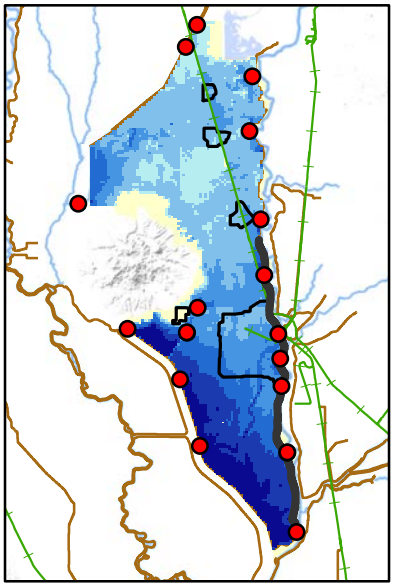
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

Alternative

Levee Fails R&U Criteria

NOTE: Breach simulation shown if levee does not pass assurance criteria.1) Assurance less than 90% the levee does not pass criteria 2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

0 10 20 Miles

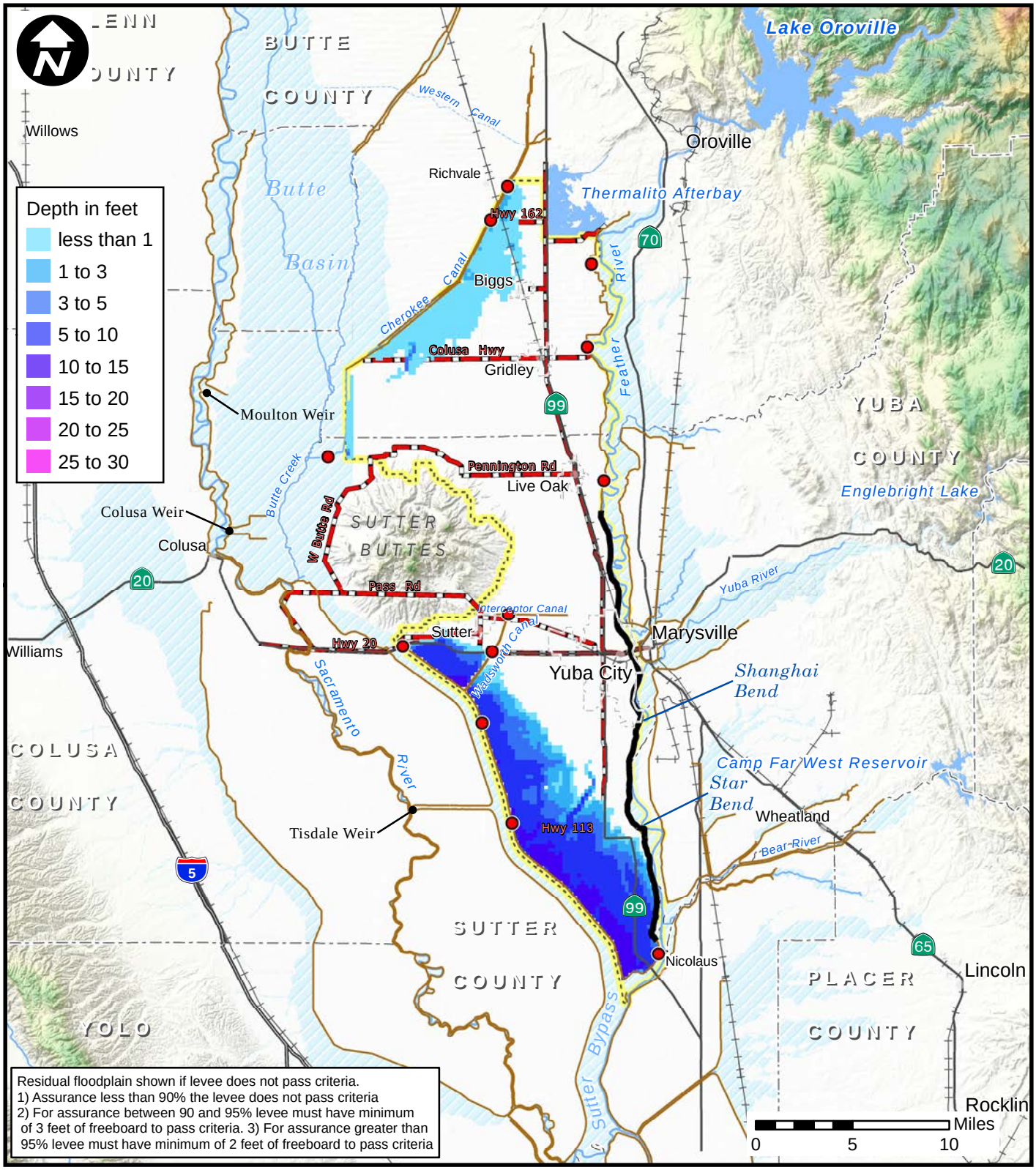
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

R&U ASSURANCE FLOODPLAINS ALTERNATIVE SB-7 FIX-IN-PLACE SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013



Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

50% (1/2) ACE FLOODPLAIN ALTERNATIVE SB-7 FIX IN PLACE FEATHER RIVER, SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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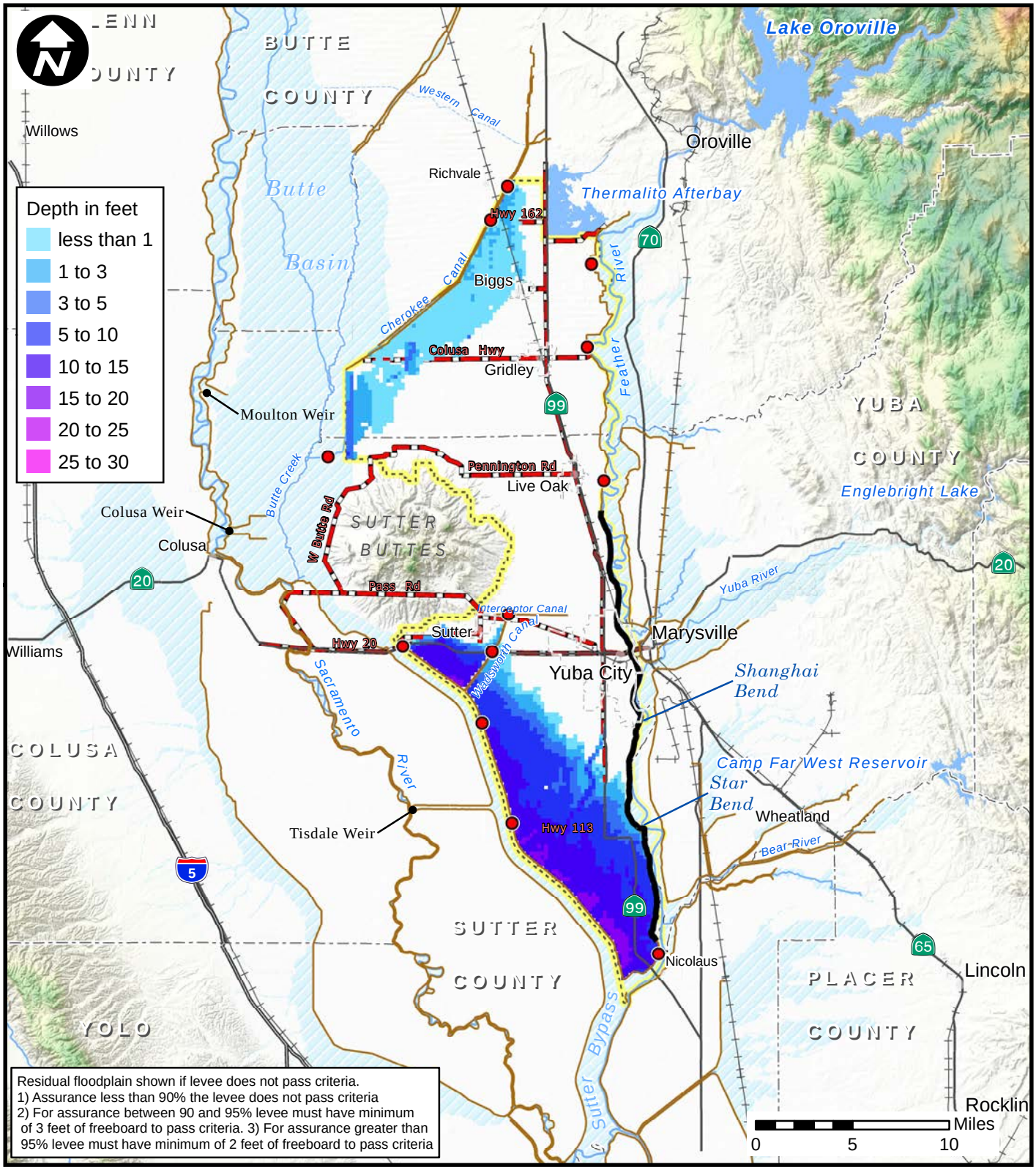
PLATE 58



Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

10% (1/10) ACE FLOODPLAIN ALTERNATIVE SB-7 FIX IN PLACE FEATHER RIVER, SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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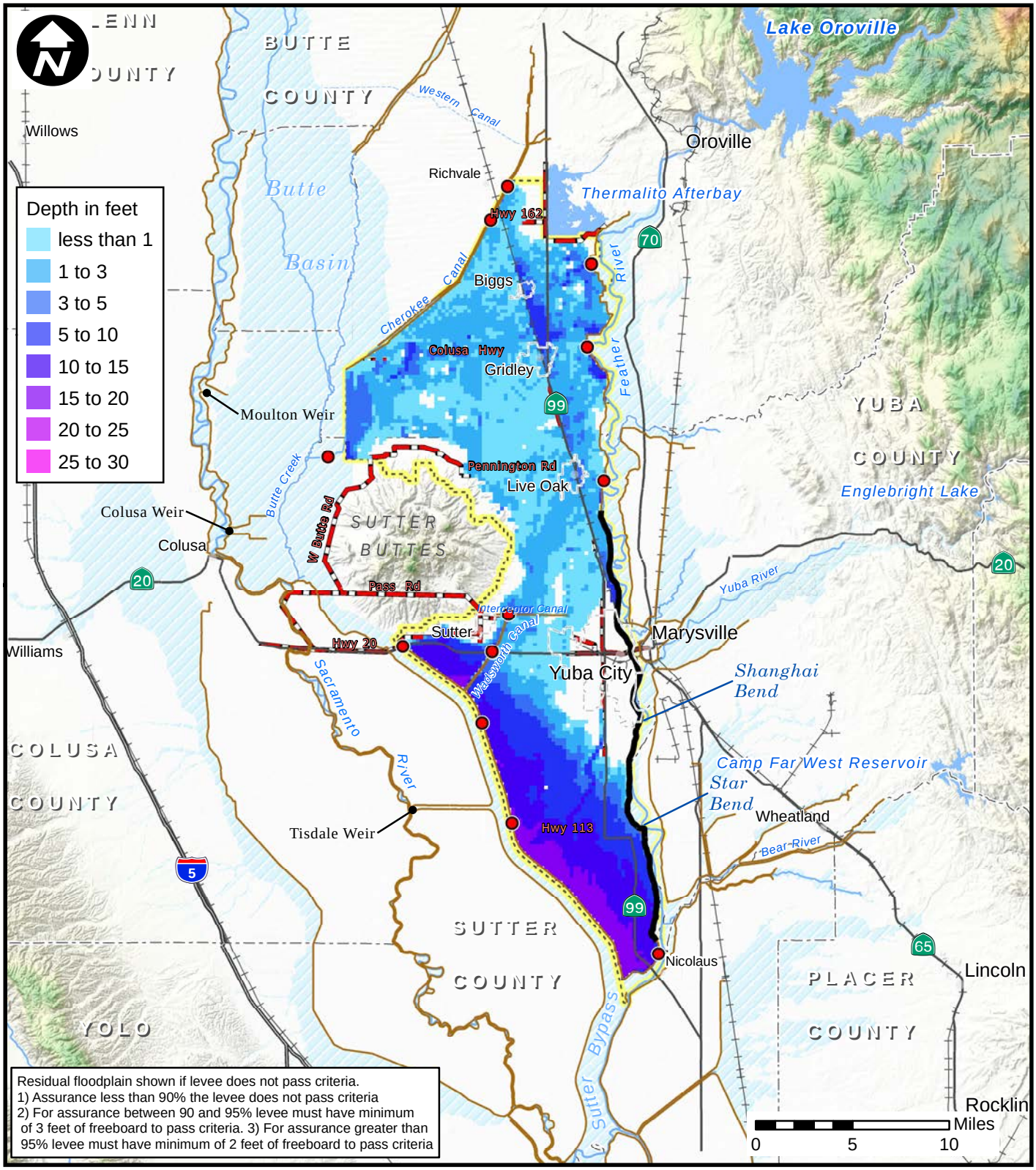
PLATE 59



Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

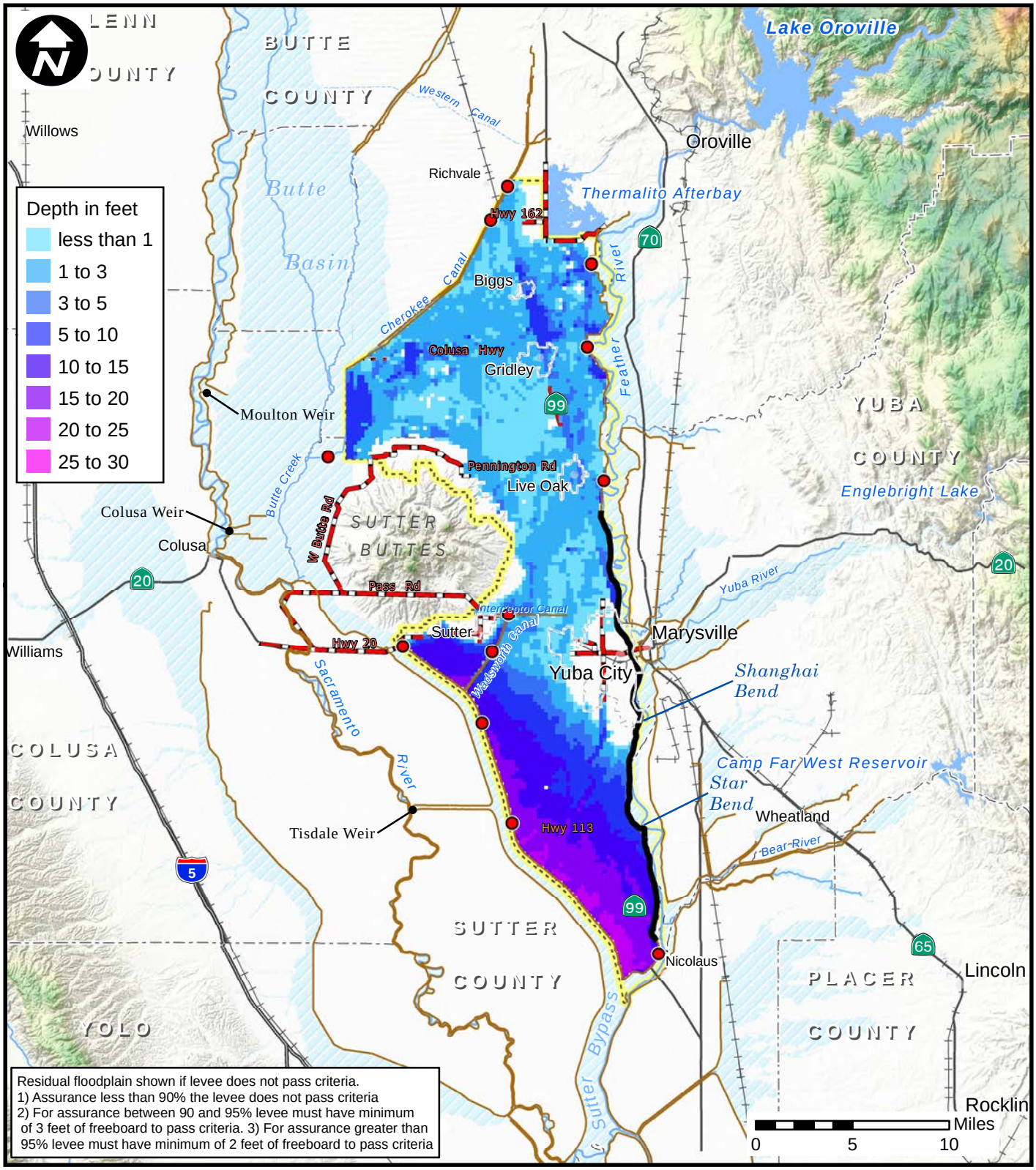
4% (1/25) ACE FLOODPLAIN ALTERNATIVE SB-7 FIX IN PLACE FEATHER RIVER, SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 60



Residual floodplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

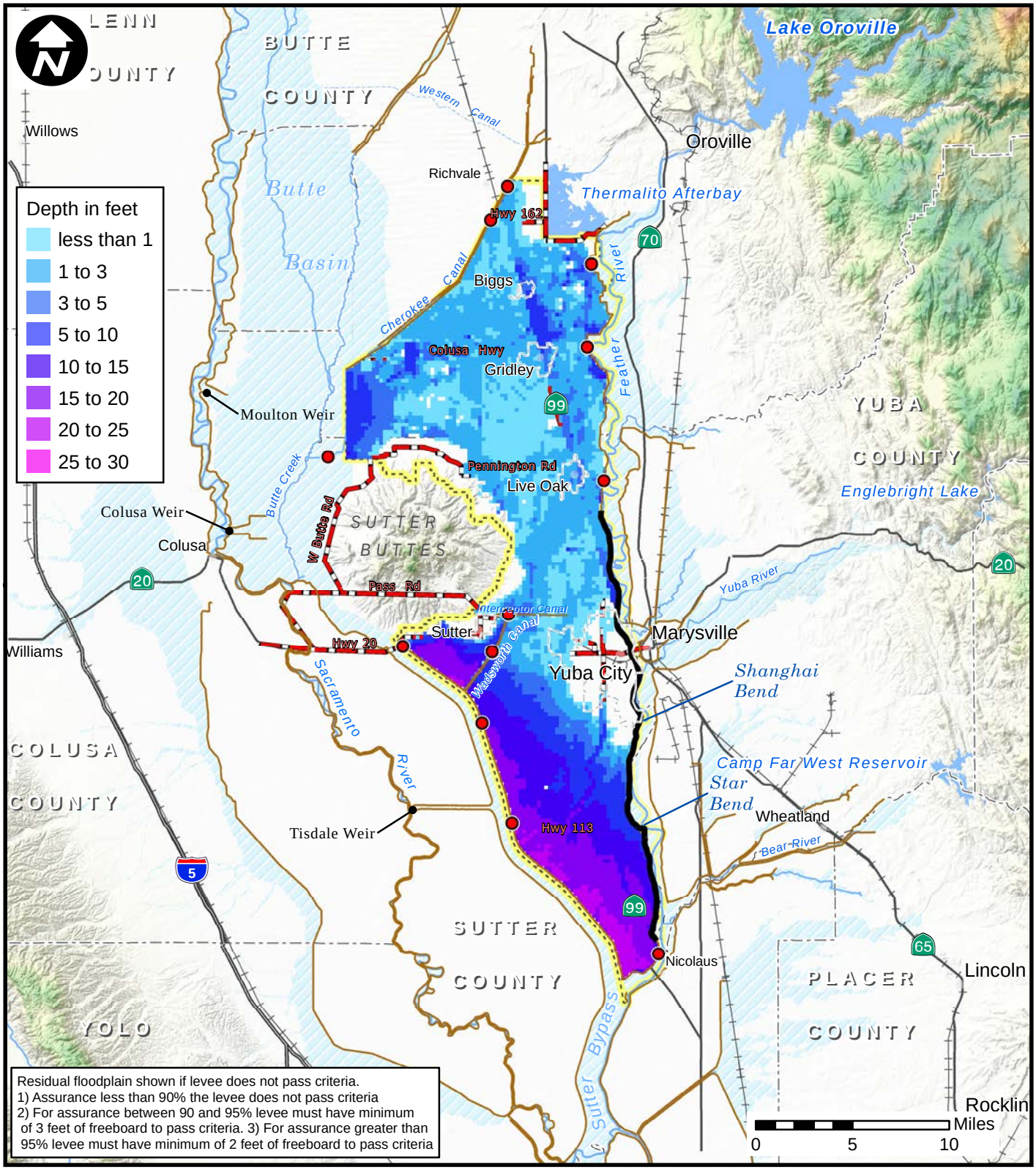
2% (1/50) ACE FLOODPLAIN ALTERNATIVE SB-7 FIX IN PLACE FEATHER RIVER, SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 61



Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

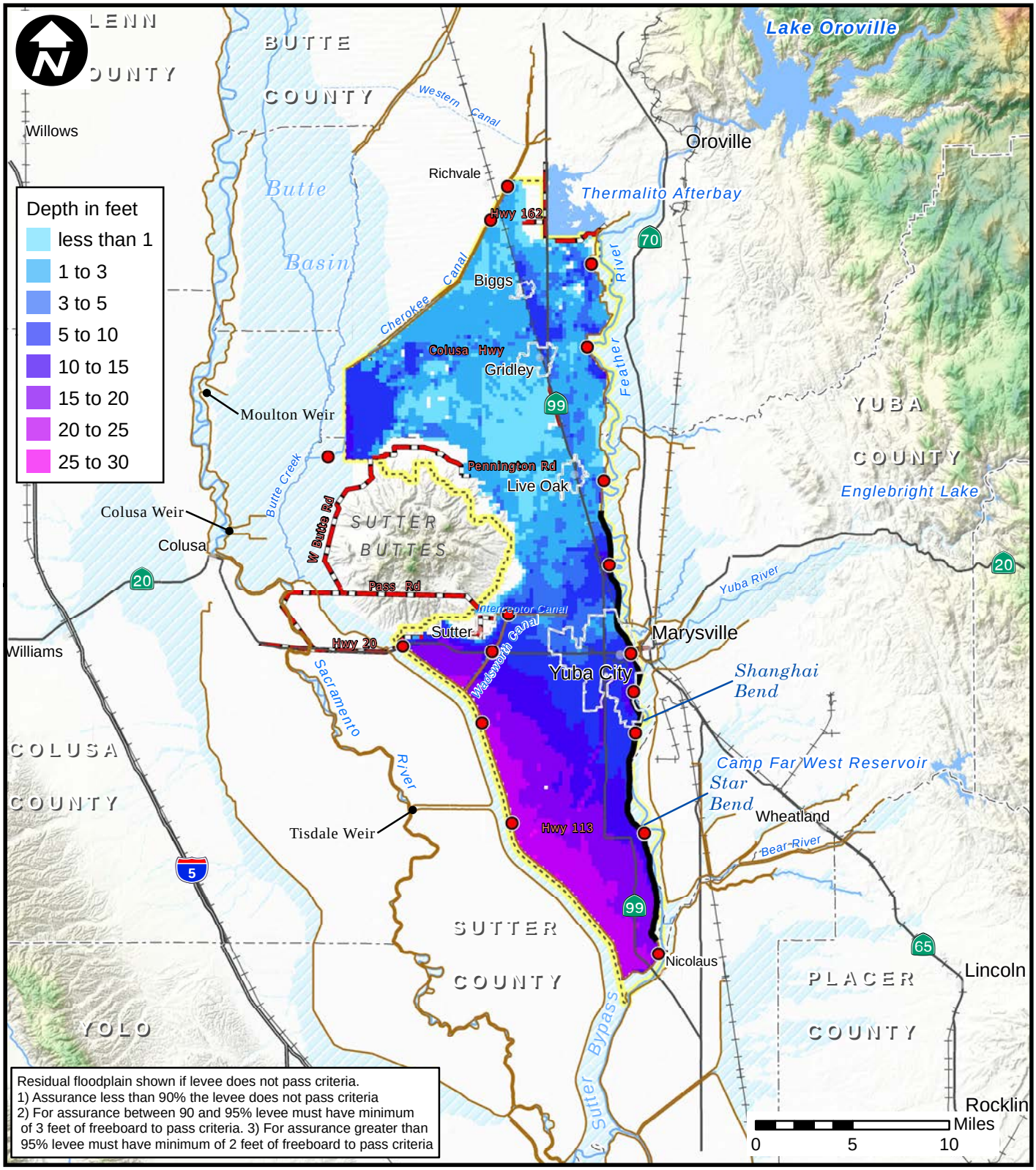
1% (1/100) ACE FLOODPLAIN ALTERNATIVE SB-7 FIX IN PLACE FEATHER RIVER, SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 62



Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

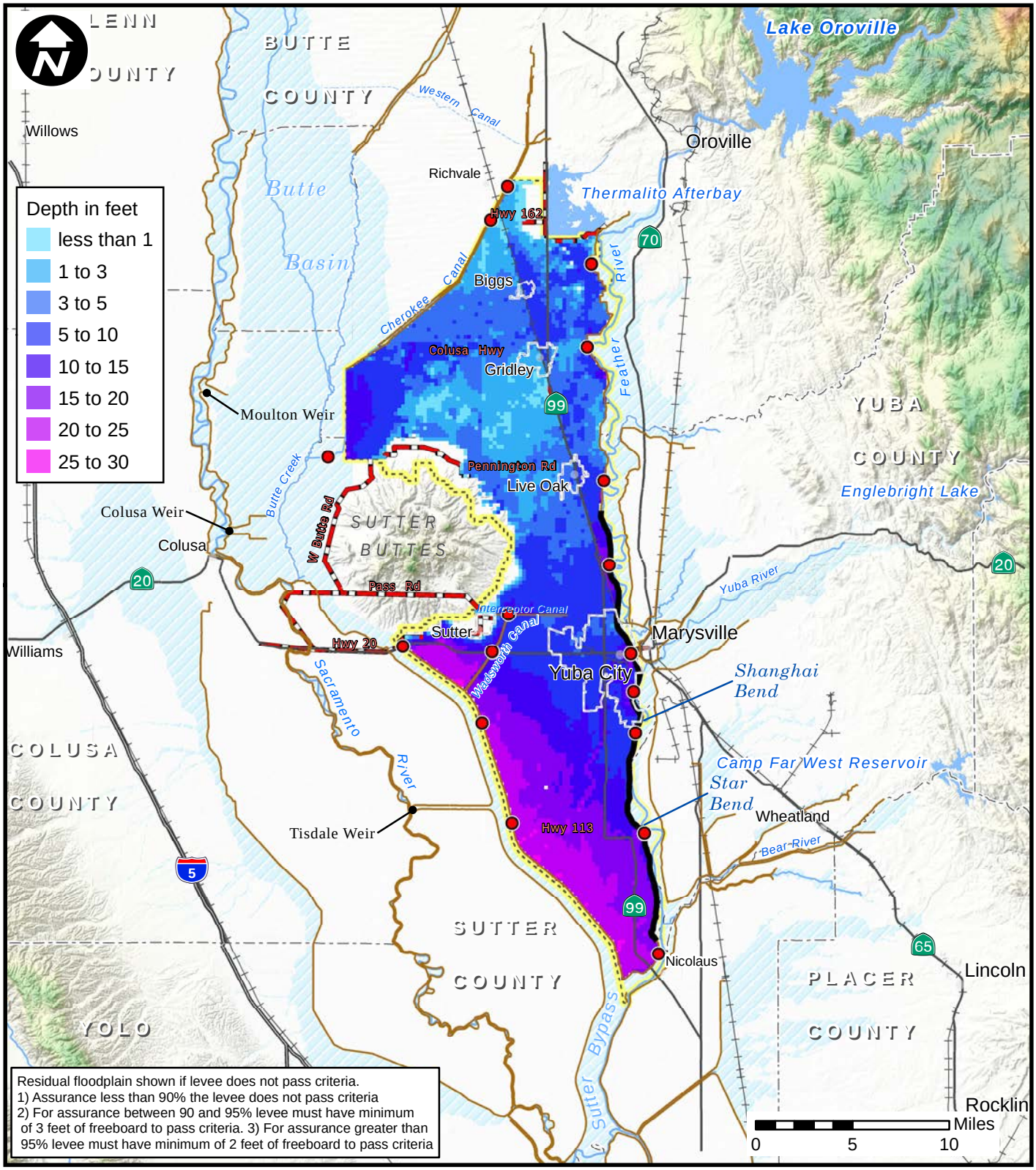
0.5% (1/200) ACE FLOODPLAIN ALTERNATIVE SB-7 FIX IN PLACE FEATHER RIVER, SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 63



Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

0.2% (1/500) ACE FLOODPLAIN ALTERNATIVE SB-7 FIX IN PLACE FEATHER RIVER, SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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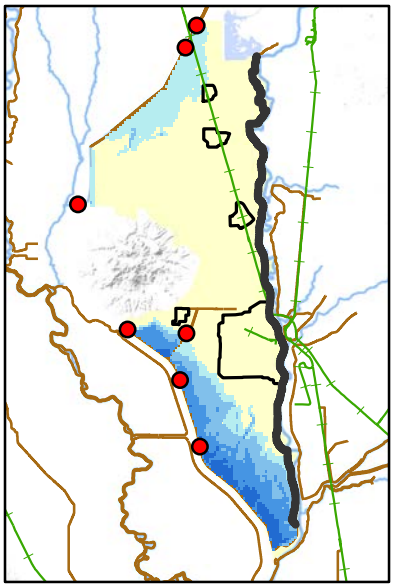
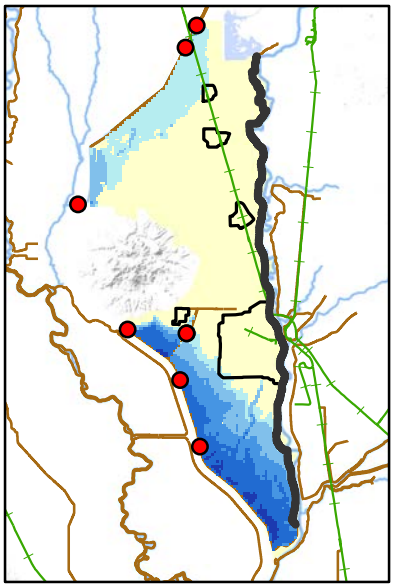
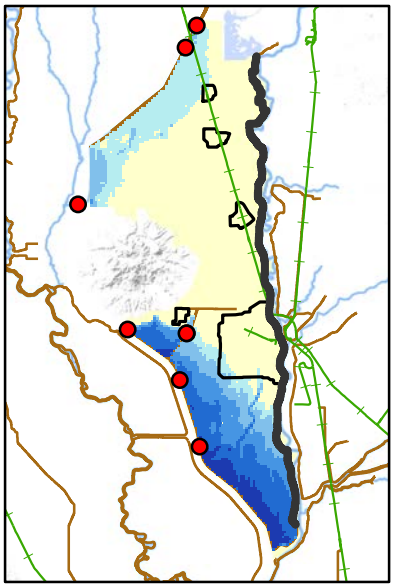
PLATE 64



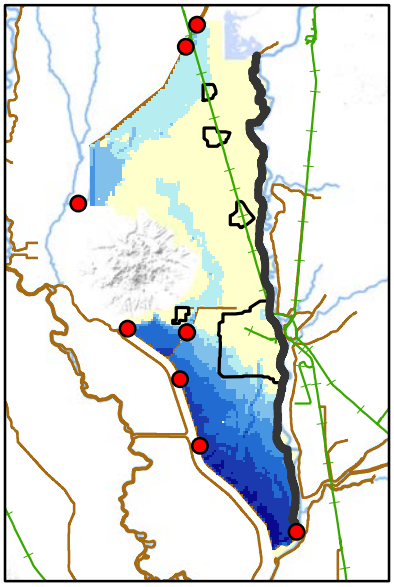
50% (1/2) ACE



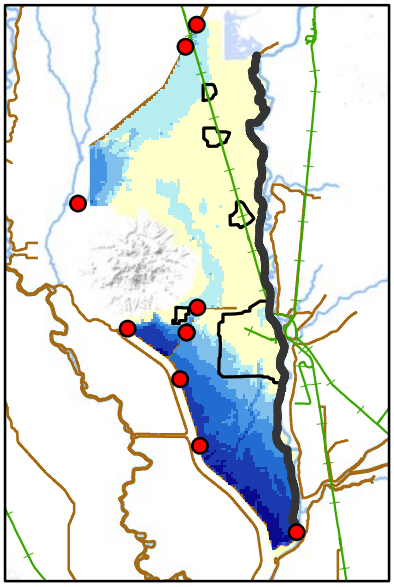
10% (1/10) ACE



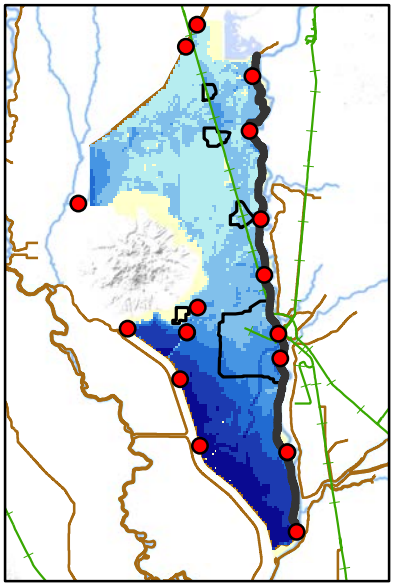
4% (1/25) ACE



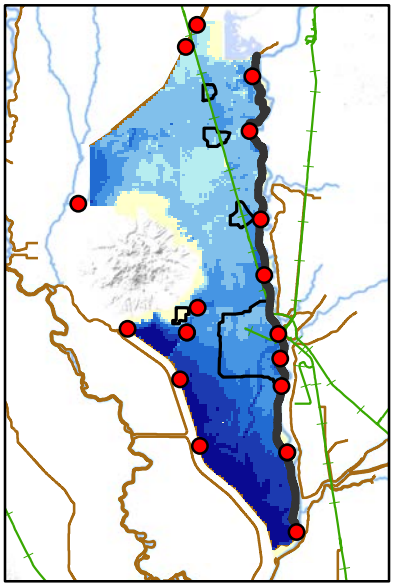
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

Alternative

Levee Fails R&U Criteria

NOTE: Breach simulation shown if levee does not pass assurance criteria.1) Assurance less than 90% the levee does not pass criteria 2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

0 10 20 Miles

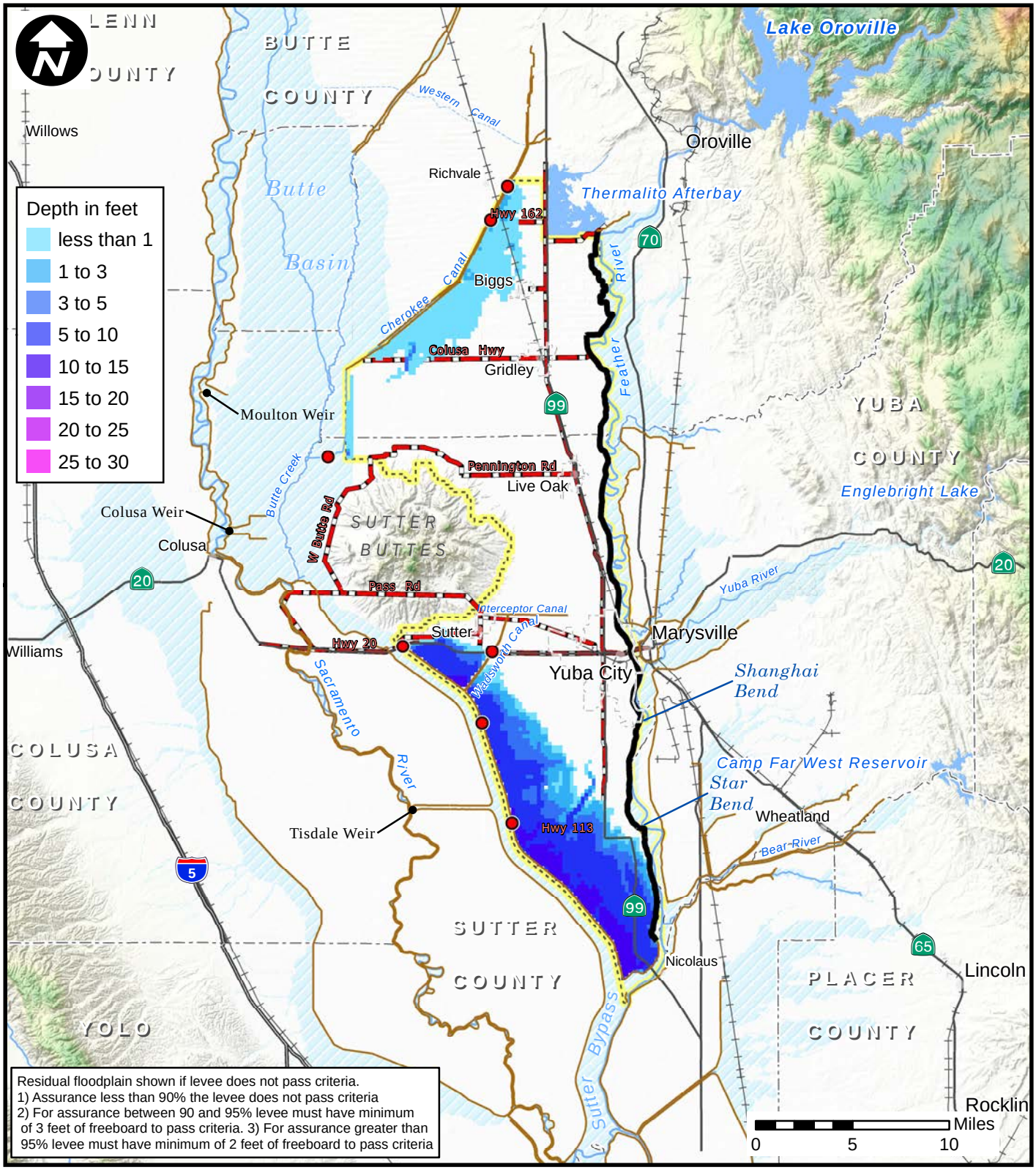
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

R&U ASSURANCE FLOODPLAINS ALTERNATIVE SB-8 FIX-IN-PLACE THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

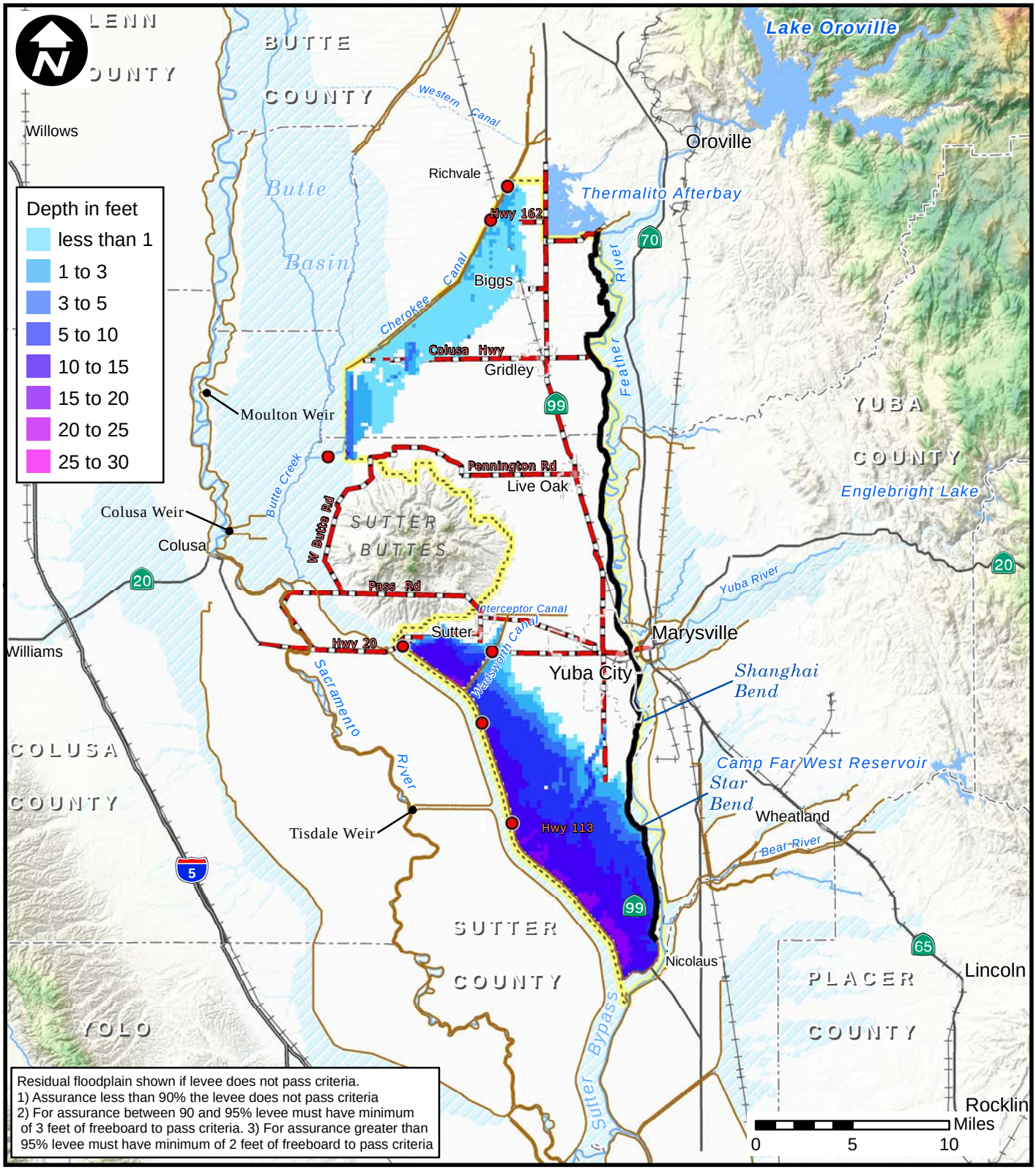
50% (1/2) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 66



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

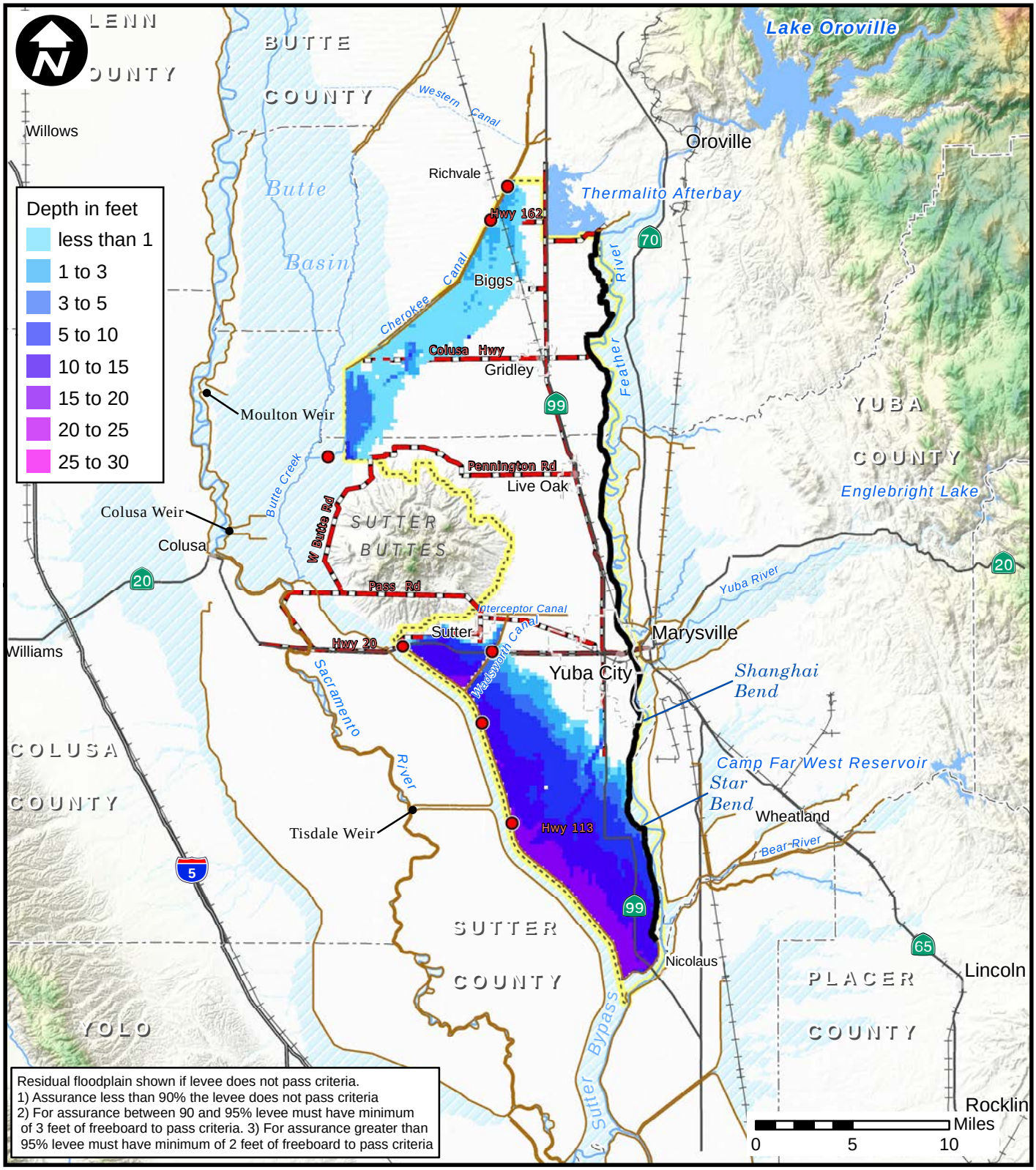
10% (1/10) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 67



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

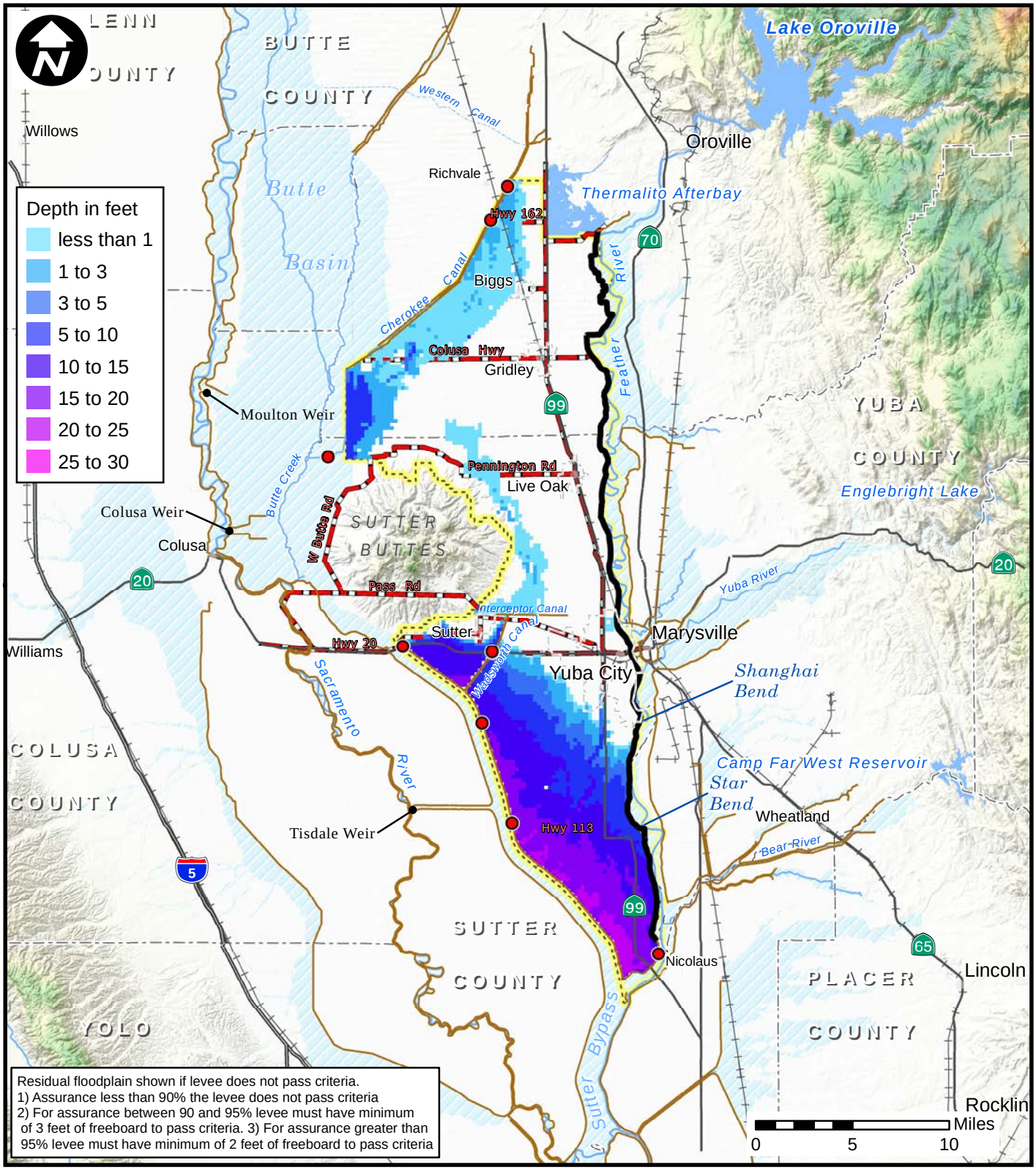
4% (1/25) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 68



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

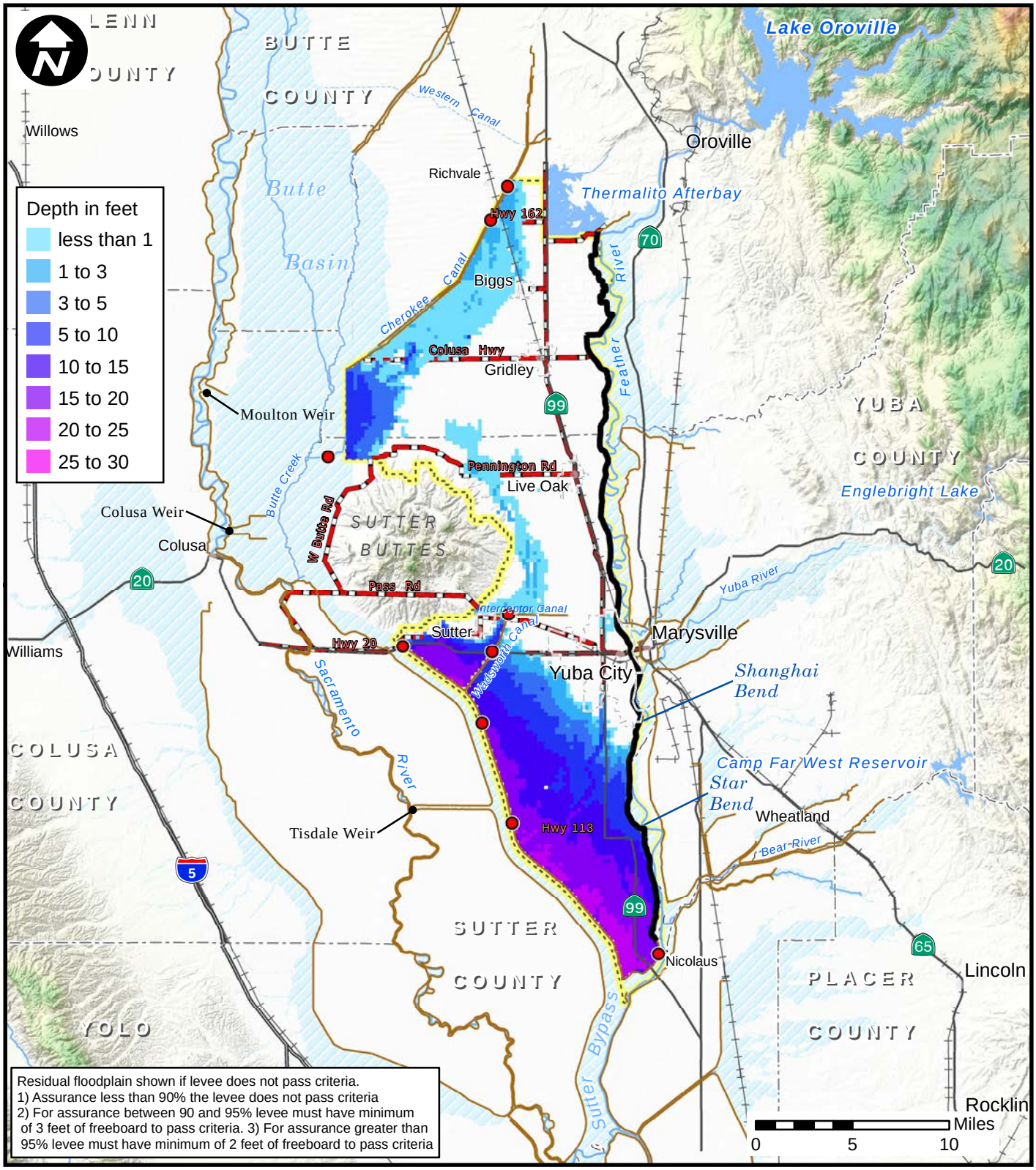
2% (1/50) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 69



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

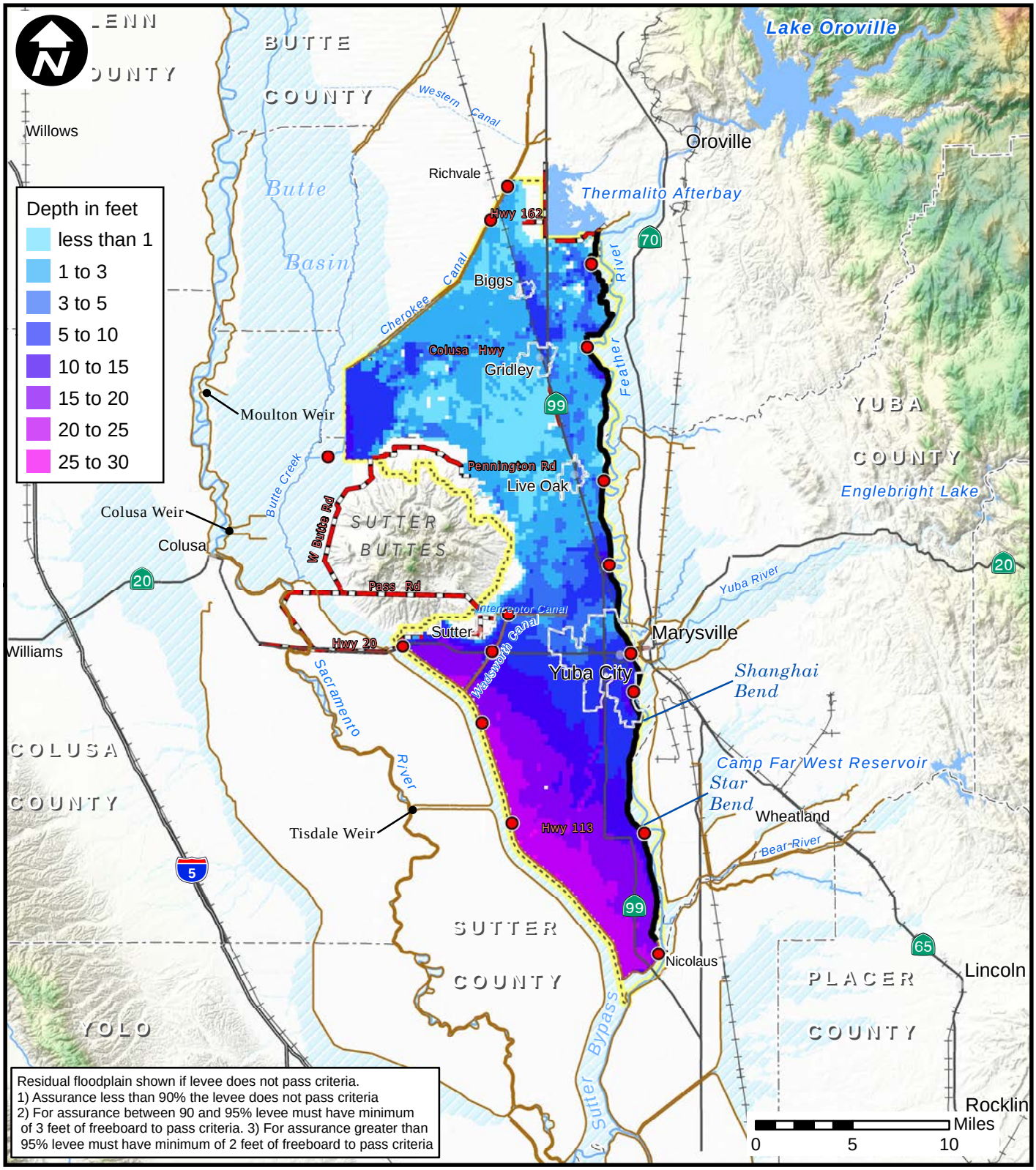
1% (1/100) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 70



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

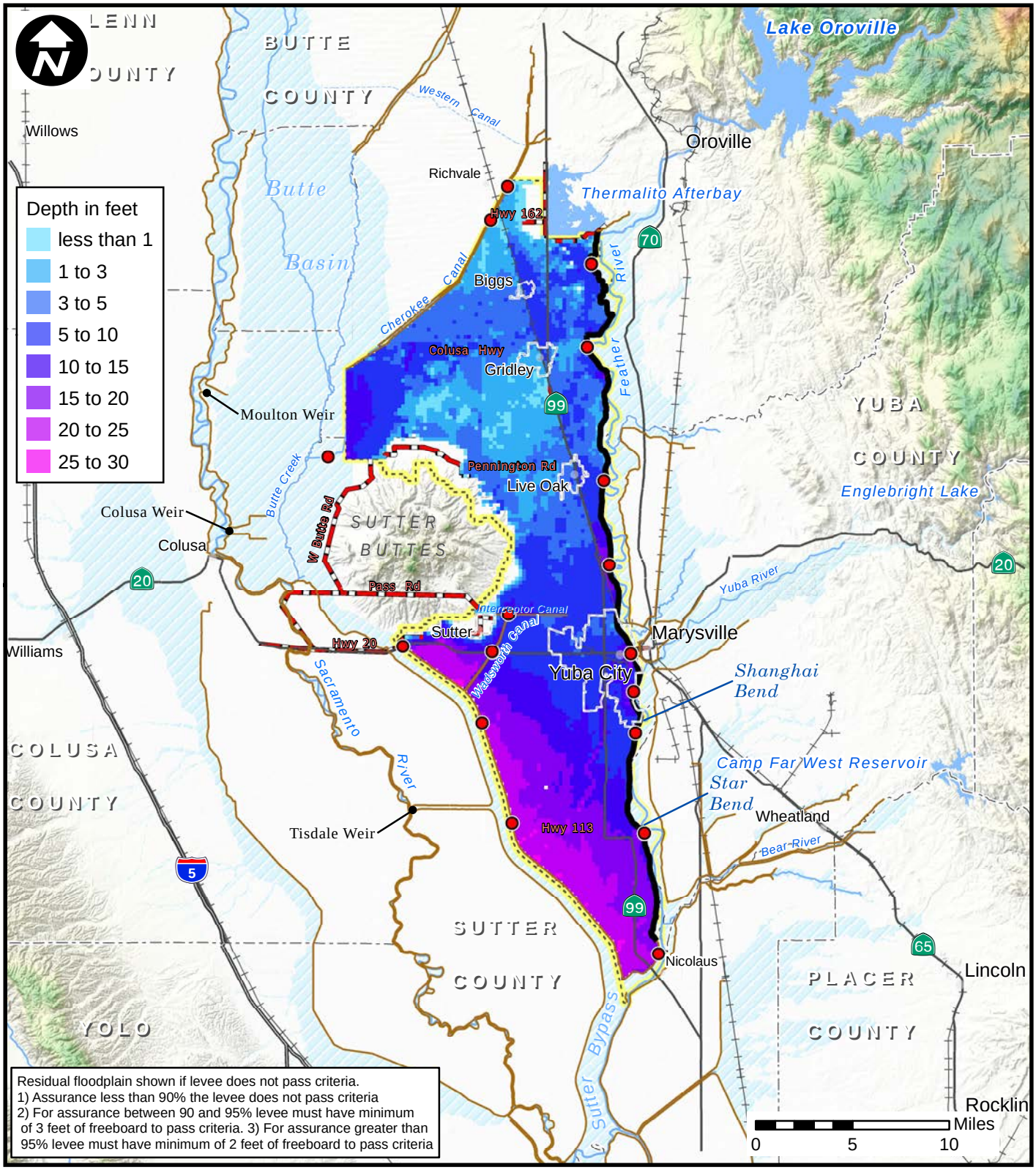
0.5% (1/200) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 71



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

0.2% (1/500) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 72

ATTACHMENT B

Final Geotechnical Fragility Curves

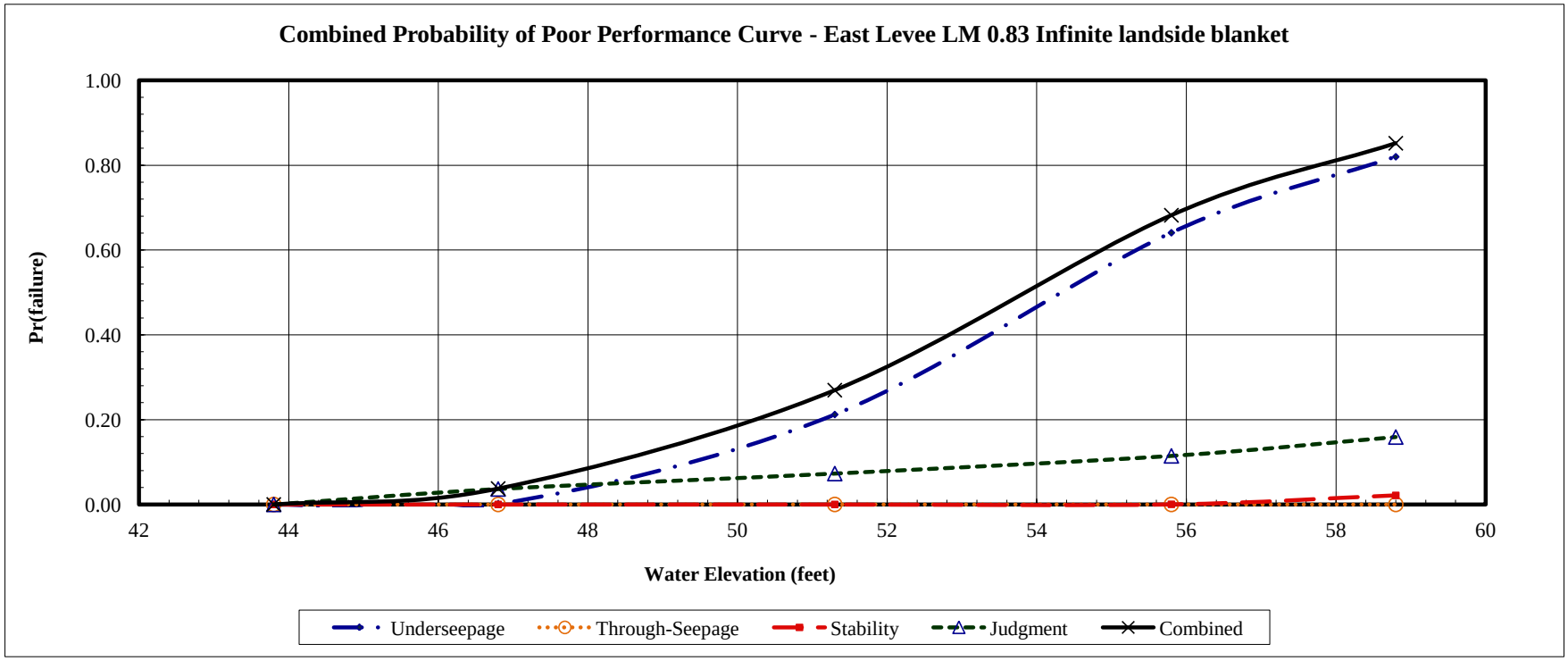
February 2013.

DRAFT

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	Sutter Feasibility Study	**Levee Mile:**	0.83	**Crest Elev.:**	58.80	**Analysis By:**	T. Huynh
Study Area:	Wadsworth Canal	**River Mile:**	2170954.86 N; (	**L/S Toe Elev.:**	43.80	**Checked By:**	E.W. James/J.M.
River Section:	East Levee	**Analysis Case:**	Infinite landside blanket	**W/S Toe Elev.:**	41.80	**Date:**	Updated 9/13/20

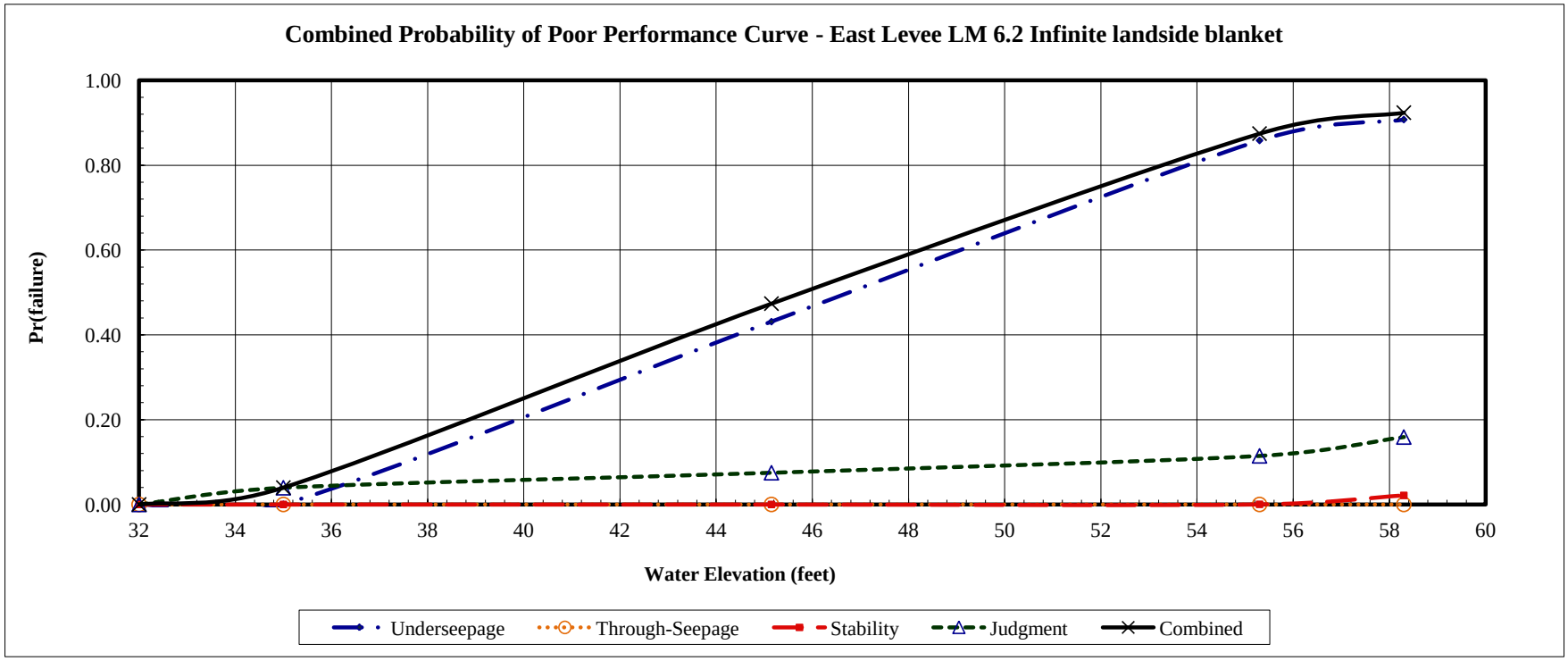
Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.80	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
46.80	0.0011	0.9989	0.0000	1.0000	0.0000	1.0000	0.0365	0.9635	0.0375	0.9625
51.30	0.2121	0.7879	0.0000	1.0000	0.0000	1.0000	0.0729	0.9271	0.2695	0.7305
55.80	0.6407	0.3593	0.0000	1.0000	0.0003	0.9997	0.1145	0.8855	0.6820	0.3180
58.80	0.8199	0.1801	0.0000	1.0000	0.0213	0.9787	0.1590	0.8410	0.8518	0.1482



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	Sutter Feasibility Study	**Levee Mile:**	6.20	**Crest Elev.:**	58.30	**Analysis By:**	T. Huynh
Study Area:	Sutter Bypass	**River Mile:**	2158855 N; 663	**L/S Toe Elev.:**	32.00	**Checked By:**	E.W. James/J.M.
River Section:	East Levee	**Analysis Case:**	Infinite landside blanket	**W/S Toe Elev.:**	32.00	**Date:**	9/13/2012

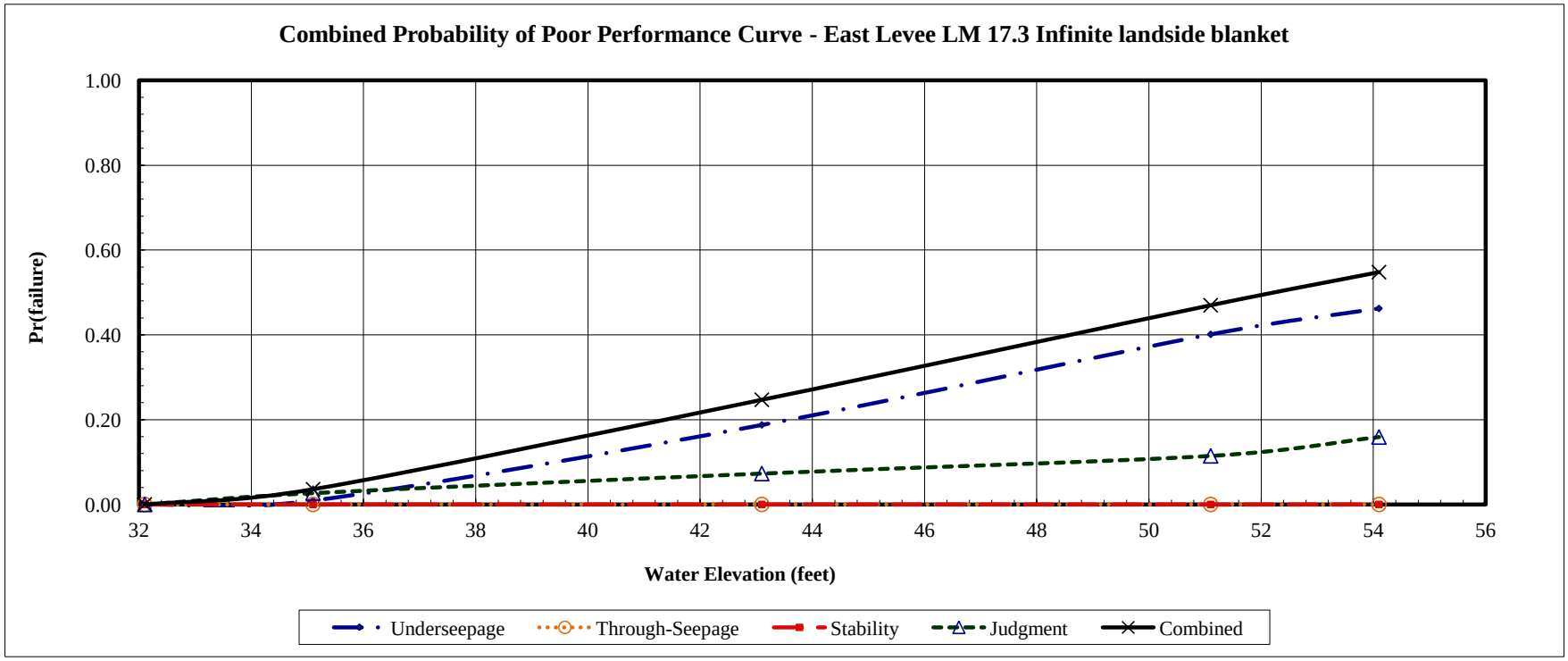
Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.00	0.0004	0.9996	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0398	0.9602
45.15	0.4311	0.5689	0.0000	1.0000	0.0000	1.0000	0.0747	0.9253	0.4736	0.5264
55.30	0.8583	0.1417	0.0000	1.0000	0.0003	0.9997	0.1145	0.8855	0.8746	0.1254
58.30	0.9076	0.0924	0.0000	1.0000	0.0213	0.9787	0.1590	0.8410	0.9239	0.0761



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	Sutter Feasibility Study	**Levee Mile:**	17.30	**Crest Elev.:**	54.10	**Analysis By:**	T. Huynh
Study Area:	Sutter Bypass	**River Mile:**	2113476.9763 N	**L/S Toe Elev.:**	32.10	**Checked By:**	E.W. James/J.M.
River Section:	East Levee	**Analysis Case:**	Infinite landside blanket	**W/S Toe Elev.:**	37.78	**Date:**	Updated 13 Augu

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.10	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.10	0.0094	0.9906	0.0000	1.0000	0.0000	1.0000	0.0267	0.9733	0.0359	0.9641
43.10	0.1876	0.8124	0.0000	1.0000	0.0000	1.0000	0.0729	0.9271	0.2468	0.7532
51.10	0.4011	0.5989	0.0000	1.0000	0.0000	1.0000	0.1145	0.8855	0.4697	0.5303
54.10	0.4623	0.5377	0.0000	1.0000	0.0001	0.9999	0.1590	0.8410	0.5478	0.4522



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

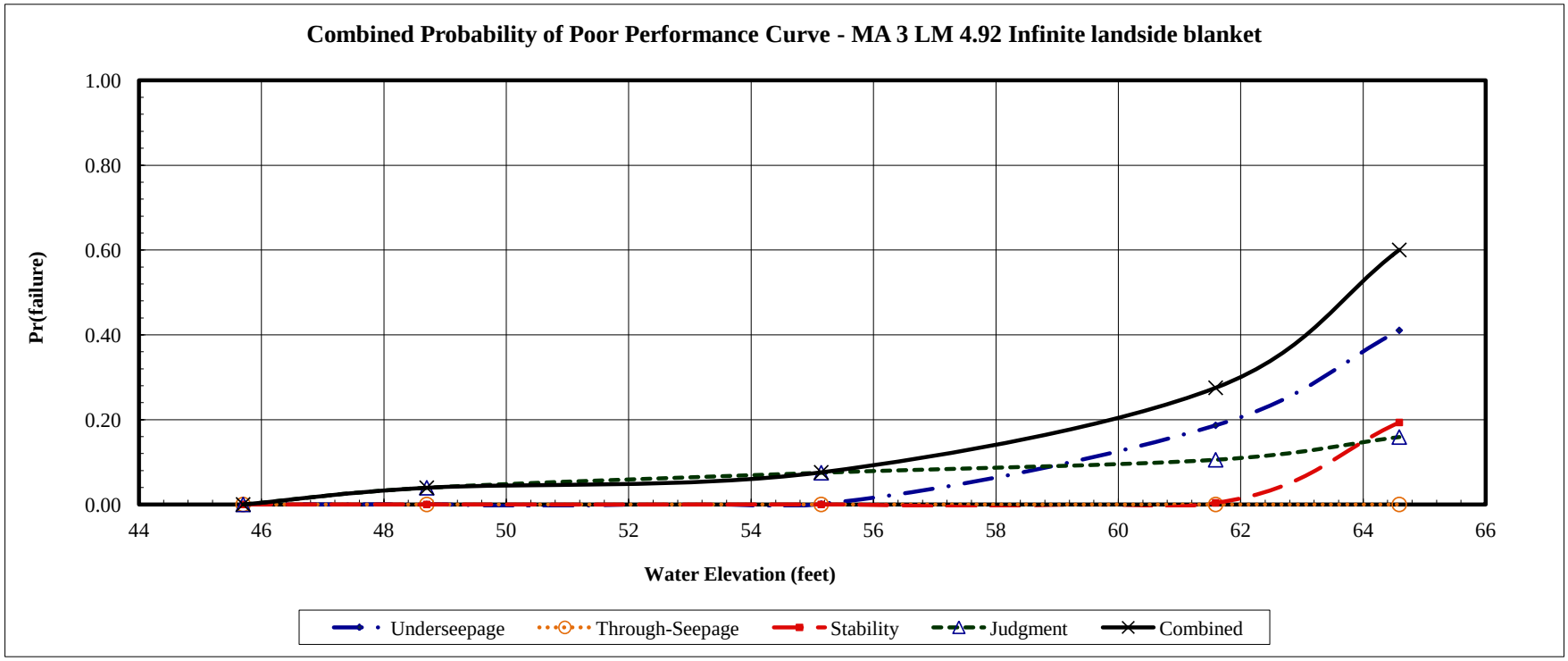
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: MA 3

Levee Mile: 4.92
River Mile: 2106963.58 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 64.59
L/S Toe Elev.: 45.70
W/S Toe Elev.: 45.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 09/12/2(

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
45.70	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
48.70	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0394	0.9606
55.15	0.0011	0.9989	0.0000	1.0000	0.0000	1.0000	0.0747	0.9253	0.0758	0.9242
61.59	0.1867	0.8133	0.0000	1.0000	0.0038	0.9962	0.1054	0.8946	0.2751	0.7249
64.59	0.4106	0.5894	0.0000	1.0000	0.1934	0.8066	0.1590	0.8410	0.6002	0.3998



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

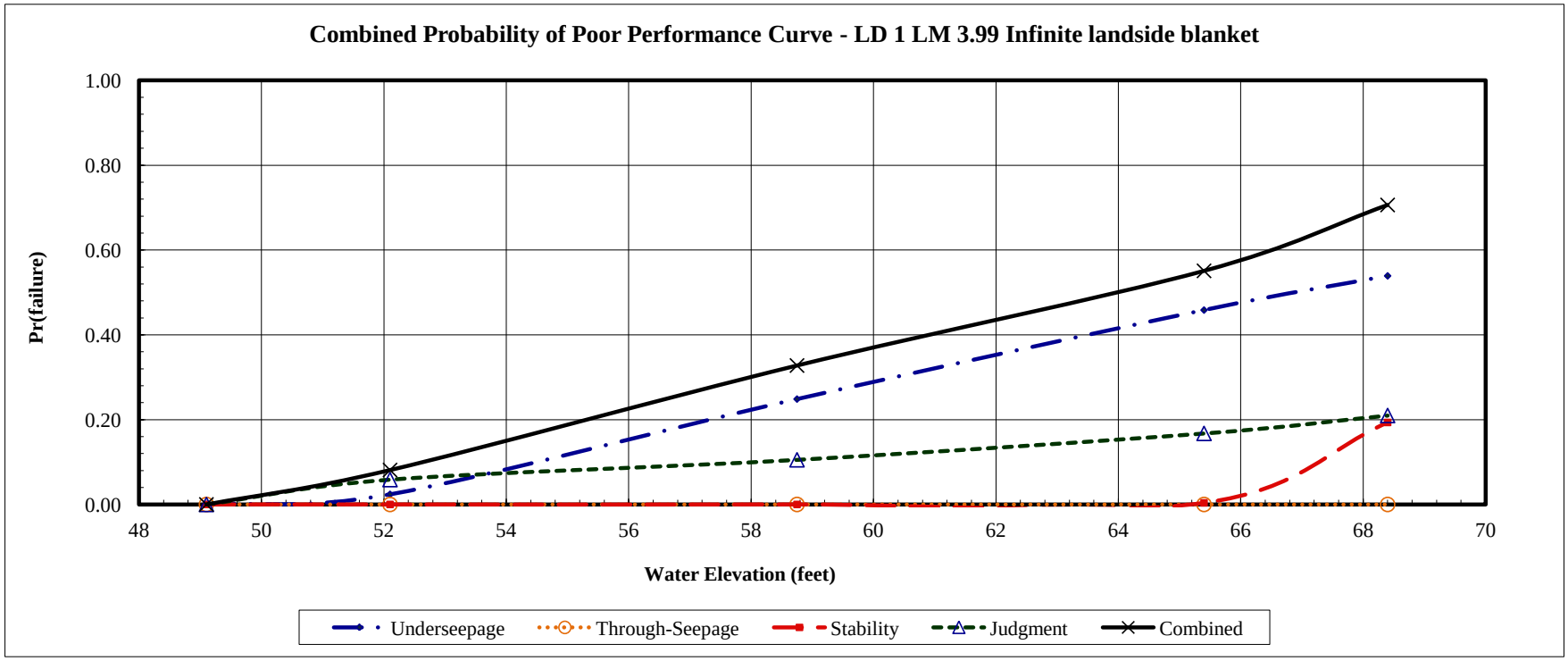
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

Levee Mile: 3.99
River Mile: 2127081.8143 N
Analysis Case: Infinite landside blanket

Crest Elev.: 68.40
L/S Toe Elev.: 49.10
W/S Toe Elev.: 40.00

Analysis By: T. Huynh
Checked By: E.W. James\J.M.
Date: Updated 09/26/2(

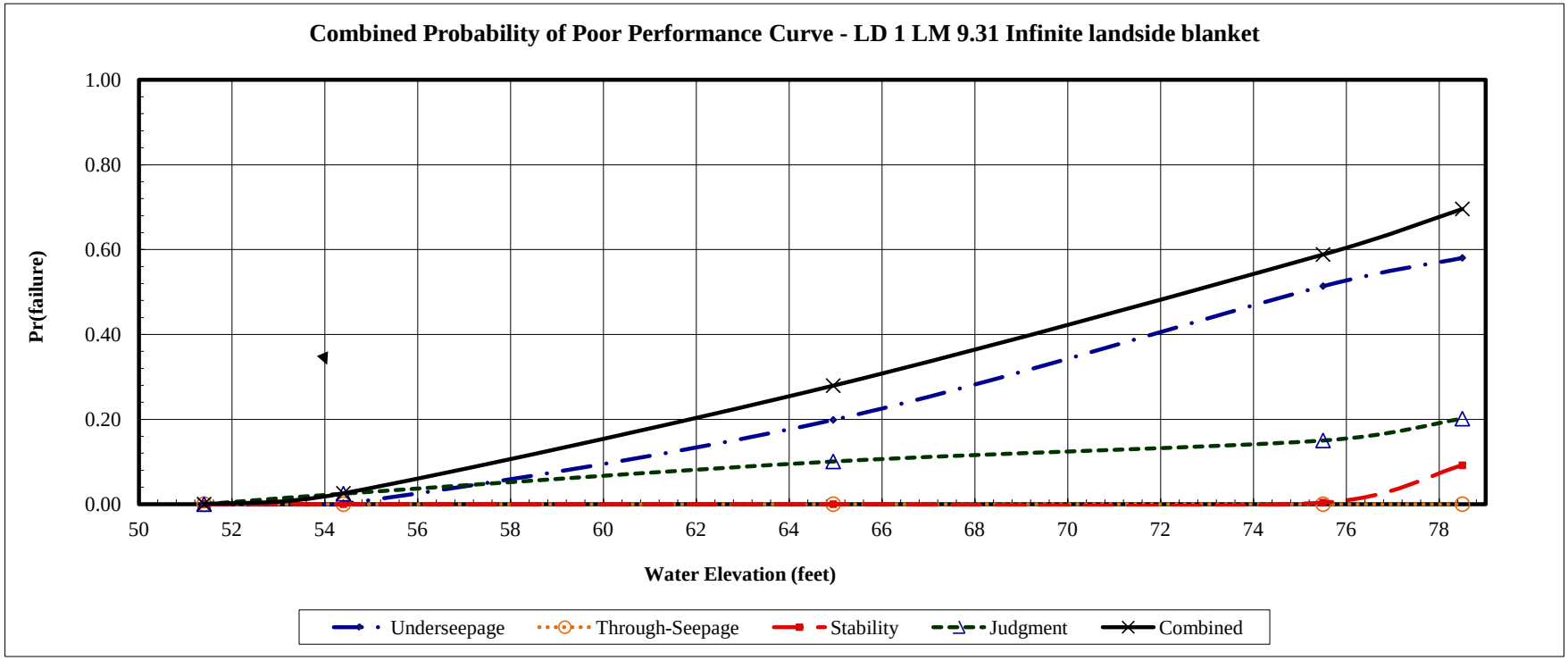
Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
49.10	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
52.10	0.0240	0.9760	0.0000	1.0000	0.0000	1.0000	0.0586	0.9414	0.0812	0.9188
58.75	0.2485	0.7515	0.0000	1.0000	0.0000	1.0000	0.1053	0.8947	0.3276	0.6724
65.40	0.4584	0.5416	0.0000	1.0000	0.0038	0.9962	0.1676	0.8324	0.5509	0.4491
68.40	0.5390	0.4610	0.0000	1.0000	0.1934	0.8066	0.2098	0.7902	0.7062	0.2938



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	Sutter Feasibility Study	**Levee Mile:**	9.31	**Crest Elev.:**	78.50	**Analysis By:**	T. Huynh
Study Area:	Feather River South	**River Mile:**	2156078.18 N; (	**L/S Toe Elev.:**	51.40	**Checked By:**	E.W. James/J.M.
River Section:	LD 1	**Analysis Case:**	Infinite landside blanket	**W/S Toe Elev.:**	53.70	**Date:**	Updated 2/21/20

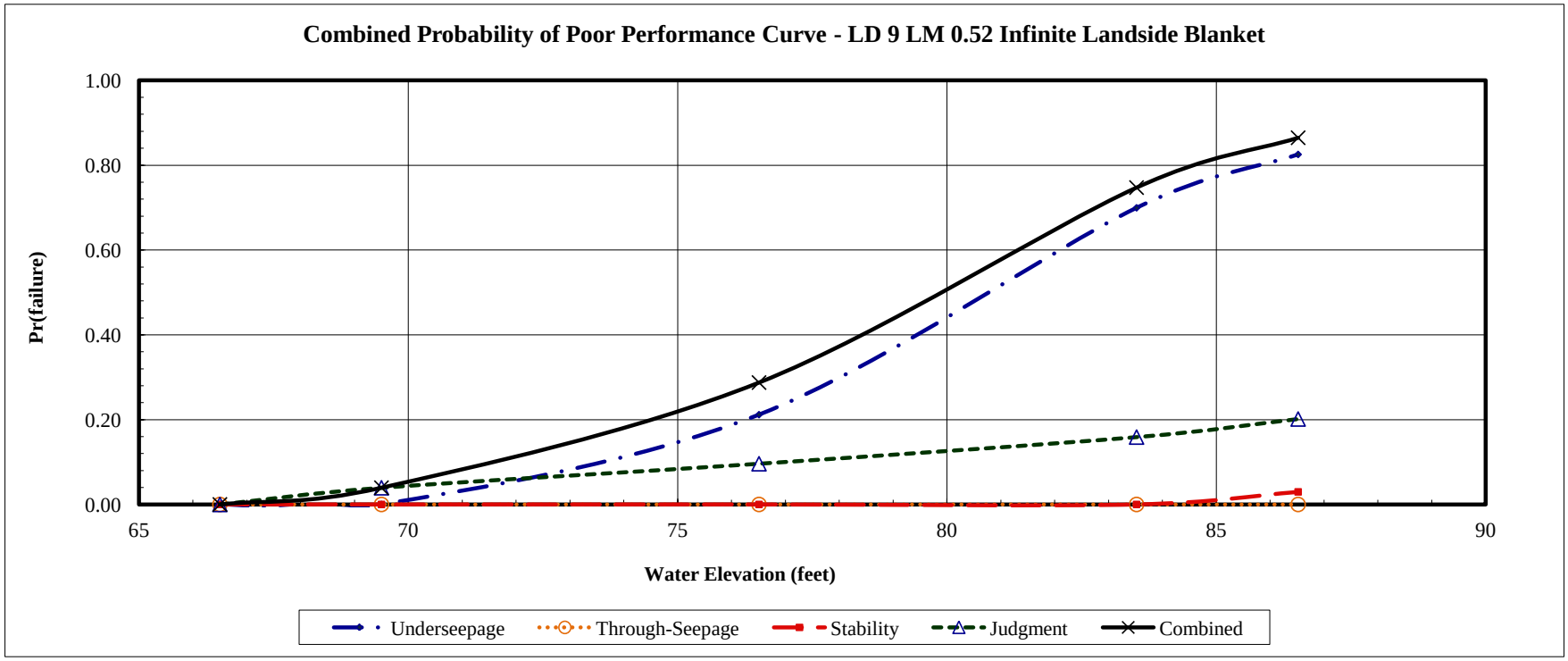
Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
51.40	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
54.40	0.0008	0.9992	0.0000	1.0000	0.0000	1.0000	0.0248	0.9752	0.0255	0.9745
64.95	0.1986	0.8014	0.0000	1.0000	0.0000	1.0000	0.1007	0.8993	0.2793	0.7207
75.50	0.5140	0.4860	0.0000	1.0000	0.0038	0.9962	0.1501	0.8499	0.5885	0.4115
78.50	0.5805	0.4195	0.0000	1.0000	0.0917	0.9083	0.2015	0.7985	0.6958	0.3042



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	Sutter Feasibility Study	**Levee Mile:**	0.52	**Crest Elev.:**	86.52	**Analysis By:**	T. Huynh
Study Area:	Feather River South	**River Mile:**	2188213.88 N; (	**L/S Toe Elev.:**	66.50	**Checked By:**	E.W. James/J.M.
River Section:	LD 9	**Analysis Case:**	Infinite landside blanket	**W/S Toe Elev.:**	58.90	**Date:**	Updated 9/12/20

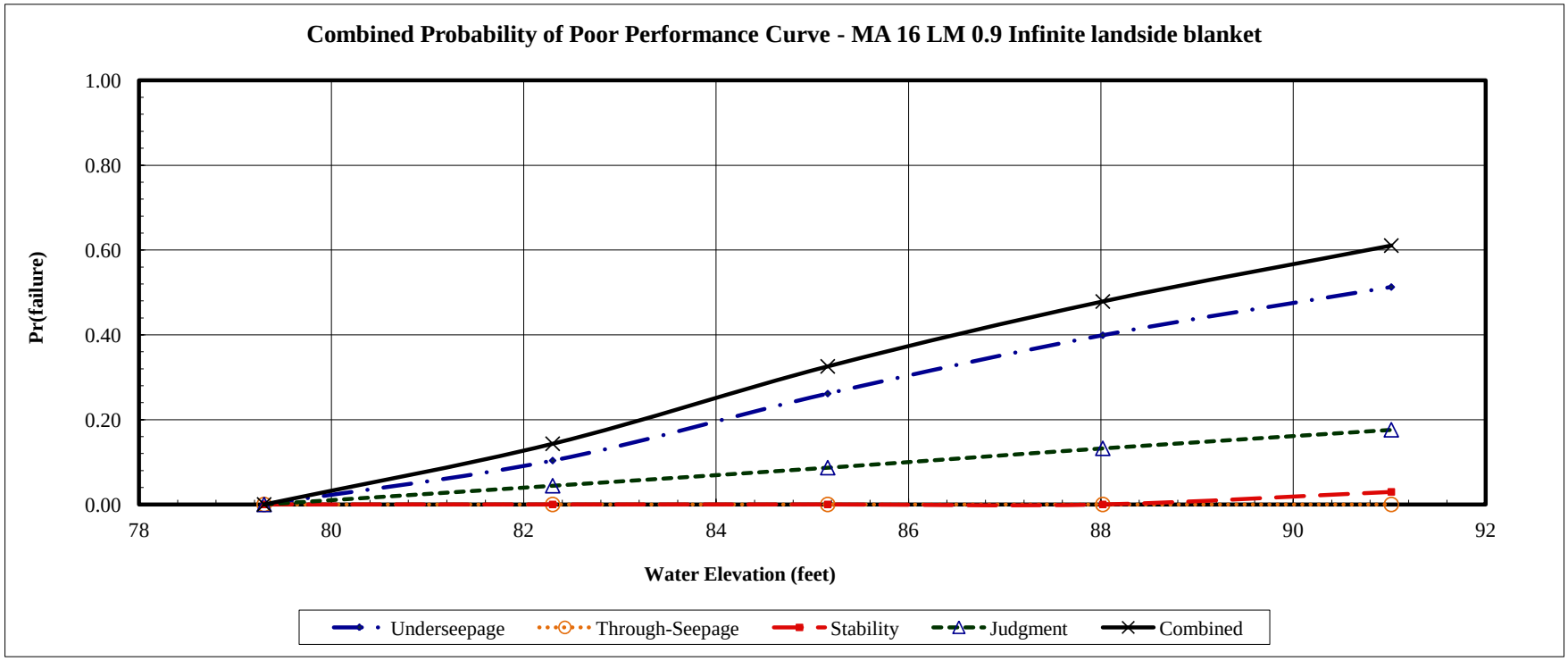
Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
66.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
69.50	0.0001	0.9999	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0394	0.9606
76.51	0.2117	0.7883	0.0000	1.0000	0.0000	1.0000	0.0961	0.9039	0.2875	0.7125
83.52	0.6995	0.3005	0.0000	1.0000	0.0000	1.0000	0.1589	0.8411	0.7473	0.2527
86.52	0.8254	0.1746	0.0000	1.0000	0.0297	0.9703	0.2015	0.7985	0.8647	0.1353



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	Sutter Feasibility Study	**Levee Mile:**	0.90	**Crest Elev.:**	91.02	**Analysis By:**	T. Huynh
Study Area:	Feather River North	**River Mile:**	2224154.37 N; (	**L/S Toe Elev.:**	79.30	**Checked By:**	E.W. James/J.M.
River Section:	MA 16	**Analysis Case:**	Infinite landside blanket	**W/S Toe Elev.:**	77.30	**Date:**	Updated 9/12/20

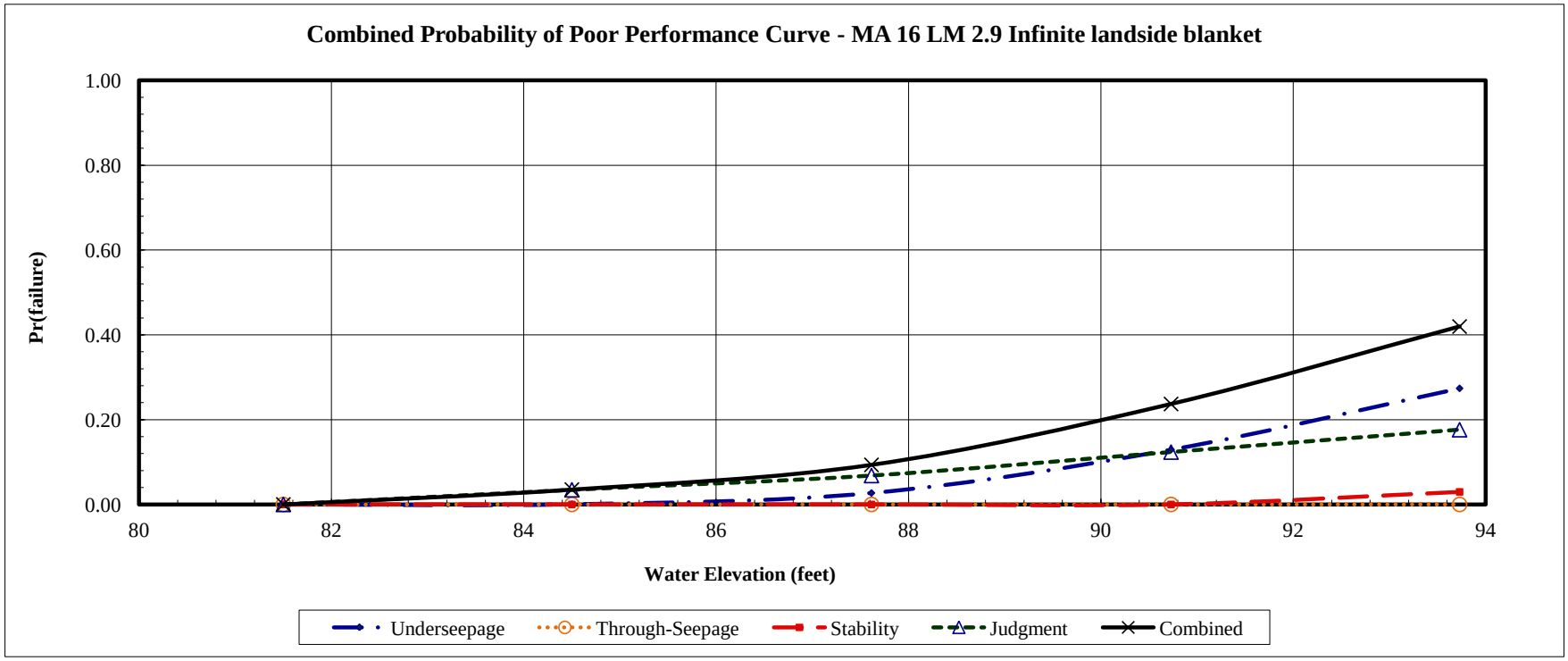
Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
79.30	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
82.30	0.1036	0.8964	0.0000	1.0000	0.0000	1.0000	0.0442	0.9558	0.1432	0.8568
85.16	0.2614	0.7386	0.0000	1.0000	0.0000	1.0000	0.0869	0.9131	0.3256	0.6744
88.02	0.3990	0.6010	0.0000	1.0000	0.0000	1.0000	0.1324	0.8676	0.4786	0.5214
91.02	0.5127	0.4873	0.0000	1.0000	0.0297	0.9703	0.1761	0.8239	0.6105	0.3895



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	Sutter Feasibility Study	**Levee Mile:**	2.90	**Crest Elev.:**	93.73	**Analysis By:**	T. Huynh
Study Area:	Feather River North	**River Mile:**	2233626.25 N; (	**L/S Toe Elev.:**	81.50	**Checked By:**	E.W. James/J.M.
River Section:	MA 16	**Analysis Case:**	Infinite landside blanket	**W/S Toe Elev.:**	79.40	**Date:**	Updated 9/12/20

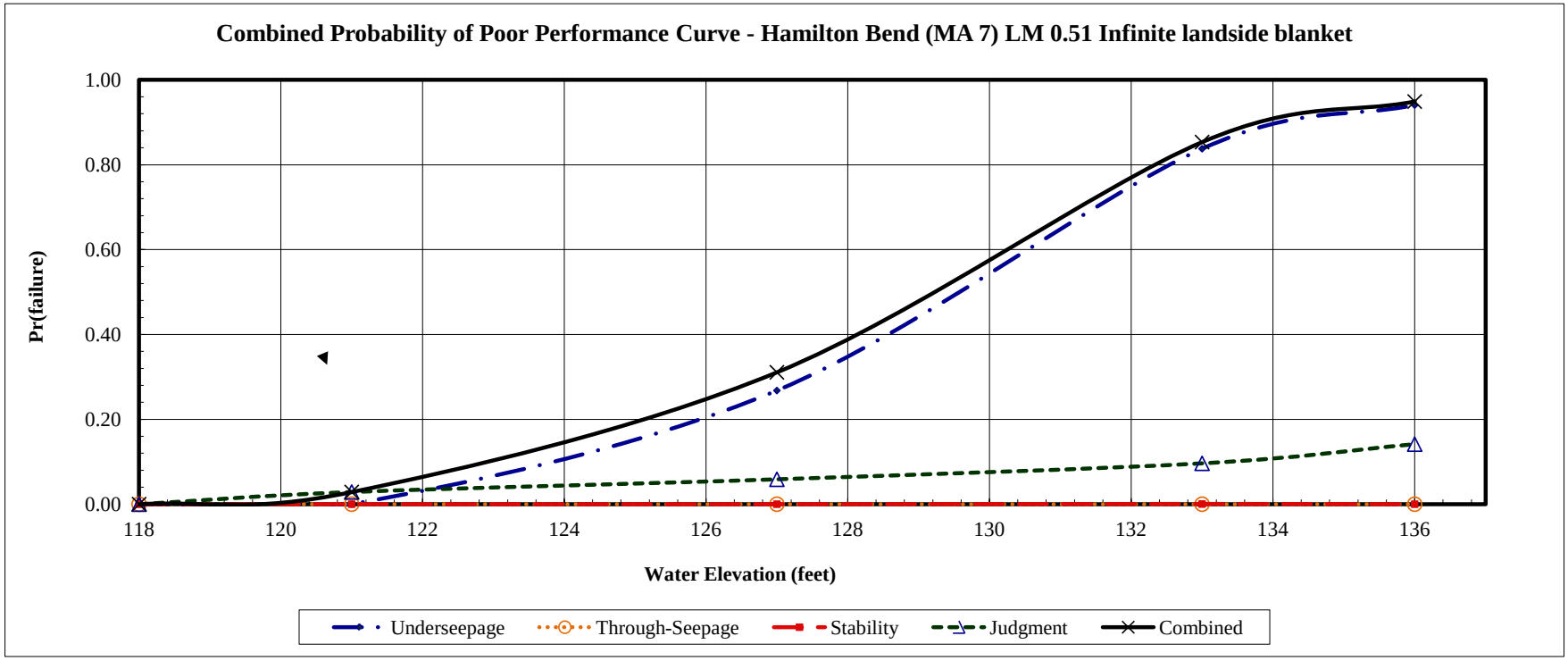
Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
81.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
84.50	0.0005	0.9995	0.0000	1.0000	0.0000	1.0000	0.0345	0.9655	0.0350	0.9650
87.62	0.0271	0.9729	0.0000	1.0000	0.0000	1.0000	0.0681	0.9319	0.0934	0.9066
90.73	0.1294	0.8706	0.0000	1.0000	0.0000	1.0000	0.1235	0.8765	0.2369	0.7631
93.73	0.2738	0.7262	0.0000	1.0000	0.0297	0.9703	0.1762	0.8238	0.4195	0.5805



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	Sutter Feasibility Study	**Levee Mile:**	0.51	**Crest Elev.:**	136.00	**Analysis By:**	T. Huynh
Study Area:	Feather River North	**River Mile:**	2288660.96 N; (	**L/S Toe Elev.:**	118.00	**Checked By:**	E.W. James/J.M.
River Section:	Hamilton Bend (MA 7)	**Analysis Case:**	Infinite landside blanket	**W/S Toe Elev.:**	118.00	**Date:**	Updated 2/21/20

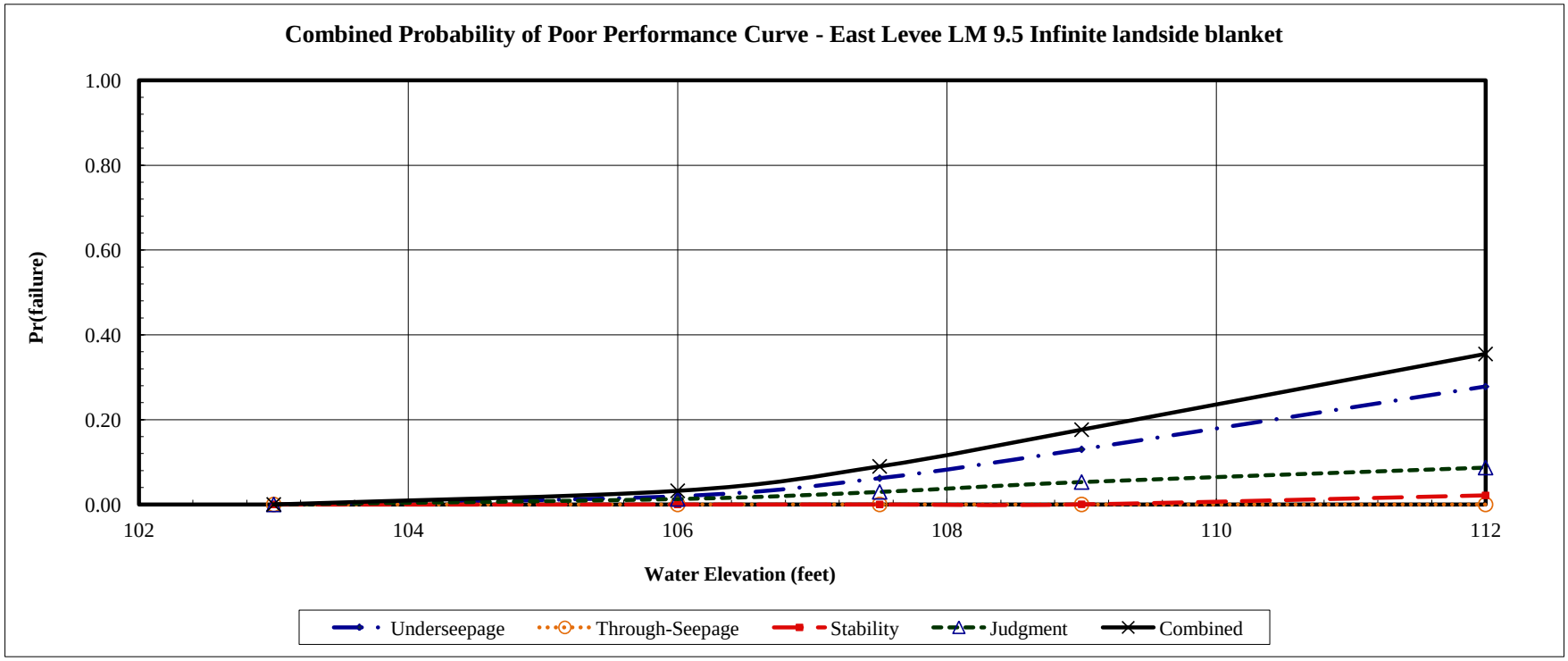
Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
118.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
121.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0287	0.9713	0.0287	0.9713
127.00	0.2678	0.7322	0.0000	1.0000	0.0000	1.0000	0.0587	0.9413	0.3108	0.6892
133.00	0.8376	0.1624	0.0000	1.0000	0.0003	0.9997	0.0963	0.9037	0.8533	0.1467
136.00	0.9405	0.0595	0.0000	1.0000	0.0000	1.0000	0.1414	0.8586	0.9489	0.0511



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	Sutter Feasibility Study	**Levee Mile:**	9.50	**Crest Elev.:**	112.00	**Analysis By:**	T. Huynh
Study Area:	Cherokee Canal	**River Mile:**	2301045.948 N:	**L/S Toe Elev.:**	103.00	**Checked By:**	E.W. James/J.M.
River Section:	East Levee	**Analysis Case:**	Infinite landside blanket	**W/S Toe Elev.:**	104.00	**Date:**	Updated 9/13/12

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
103.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
106.00	0.0195	0.9805	0.0000	1.0000	0.0000	1.0000	0.0129	0.9871	0.0322	0.9678
107.50	0.0620	0.9380	0.0000	1.0000	0.0000	1.0000	0.0297	0.9703	0.0898	0.9102
109.00	0.1300	0.8700	0.0000	1.0000	0.0003	0.9997	0.0529	0.9471	0.1763	0.8237
112.00	0.2780	0.7220	0.0000	1.0000	0.0213	0.9787	0.0870	0.9130	0.3548	0.6452



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

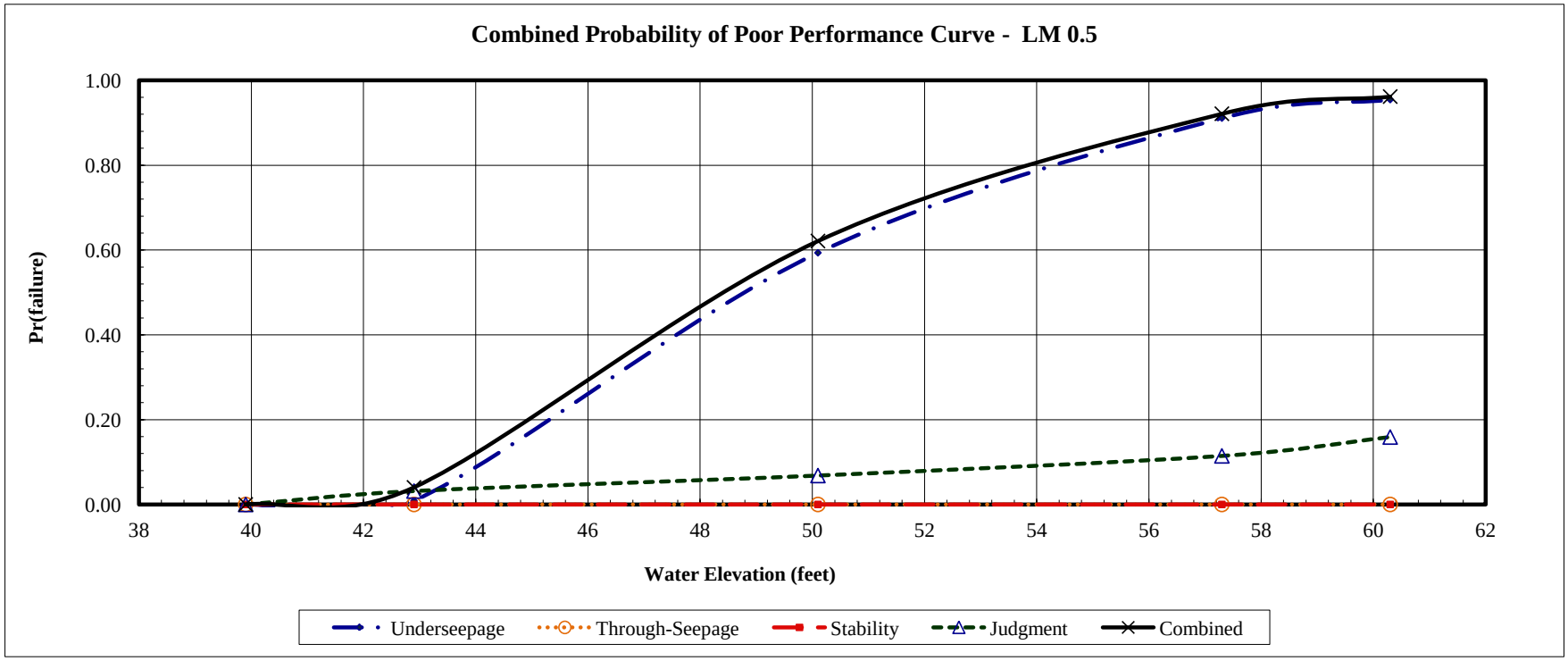
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal - Right Bank
River Section:

Levee Mile: 0.50
River Mile: 2168750 N; 662
Analysis Case:

Crest Elev.: 60.30
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: E.W. James
Checked By: J.M. Bolton
Date: Updated 09/14/

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
39.90	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
42.90	0.0088	0.9912	0.0000	1.0000	0.0000	1.0000	0.0316	0.9684	0.0402	0.9598
50.10	0.5935	0.4065	0.0000	1.0000	0.0000	1.0000	0.0682	0.9318	0.6212	0.3788
57.30	0.9112	0.0888	0.0000	1.0000	0.0000	1.0000	0.1145	0.8855	0.9213	0.0787
60.30	0.9547	0.0453	0.0000	1.0000	0.0000	1.0000	0.1590	0.8410	0.9619	0.0381



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

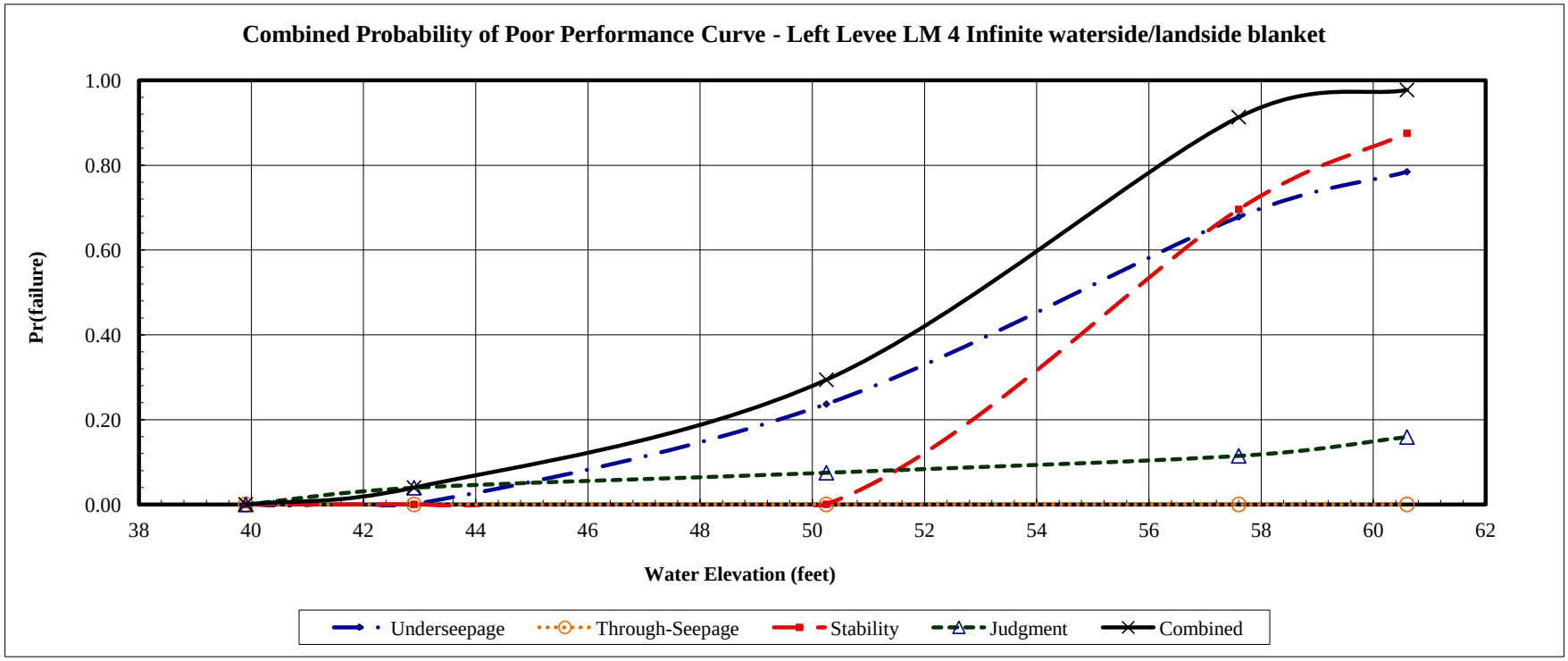
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: Left Levee

Levee Mile: 4.00
River Mile: 2168110 N; 662
Analysis Case: Infinite waterside/landside blanket

Crest Elev.: 60.60
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/14/20

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
39.90	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
42.90	0.0004	0.9996	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0398	0.9602
50.25	0.2366	0.7634	0.0000	1.0000	0.0005	0.9995	0.0747	0.9253	0.2940	0.7060
57.60	0.6780	0.3220	0.0000	1.0000	0.6959	0.3041	0.1145	0.8855	0.9133	0.0867
60.60	0.7846	0.2154	0.0000	1.0000	0.8754	0.1246	0.1590	0.8410	0.9774	0.0226



C1c. Geotechnical Design

SUTTER BASIN PILOT FEASIBILITY DRAFT REPORT-DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT/ENVIRONMENTAL IMPACT REPORT

SUTTER AND BUTTE COUNTIES, CALIFORNIA

GEOTECHNICAL APPENDIX

DRAFT FOR ATR REVIEW

Prepared by: U.S. Army Corps of Engineers

Sacramento District, Geotechnical Branch, Levee Safety Section

8 April 2013

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1 INTRODUCTION

This report presents the results of the geotechnical engineering evaluation of the levees associated with the Sutter Basin Feasibility Study (SBFS). The purpose of this report is to document the geotechnical existing condition of the levees within the study area and to provide geotechnical information in support of the final array of alternatives in the Feasibility Study.

The SBFS is a Pilot Study for the Corps of Engineers to further develop Planning concepts, methodologies, and processes. This report relies heavily on the massive volume of data gathered by the California Department of Water Resources (DWR) Urban Levee Evaluation (ULE) study described in Section 1.3.2, and (for the Feather River levees) supplemented by the Sutter-Butte Flood Control Agencies (SBFCA) Feather River West Levee (FRWL) Improvement Project described in Section 1.3.3. The reports prepared for the ULE and FRWL Improvement Project are included as Enclosure M of this report, but are provided as separate files for ease of use by reviewers.

1.1 Project Description

The Sutter Basin system consists of a mainline levee system (hereafter referred to as the Sutter Basin Levee System or SBLS) surrounding the communities of Yuba City, Live Oak, Gridley, Biggs and other smaller towns in Sutter and Butte Counties, California. There are several Local Maintenance Authority (LMA) entities: Levee District (LD) 1 of Sutter County, LD 9 of Sutter County, and California Department of Water Resources (DWR) Maintenance Areas (MA) (3, 7, 13, 16, Wadsworth Canal, and Sutter Bypass). These entities maintain all levees within the study area. Other than the high ground at the Sutter Buttes and where the upstream end of the Feather River ties into the southern dike of the Thermalito Afterbay Dam, these levees completely surround and protect the interior area. Plate 1 shows the SBLS and the nearby surrounding area. The levee segments in the study area are shown on Plate 1 and are listed below:

- **Wadsworth Canal Left Levee:** Left levee (on the south bank) of the Wadsworth Canal from Project Levee Mile (PLM) 0.00 at the confluence with the Sutter Bypass upstream to PLM 4.66 at the East Interceptor Canal

- **Sutter Bypass:** Left levee (on the east bank) of the Sutter Bypass from the confluence with the Wadsworth Canal at PLM 4.40 downstream to PLM 22.11 at the confluence with the Feather River

- **Feather River – MA 3:** Right levee (on the west bank) of the Feather River from PLM 0.00 at the Sutter Bypass confluence upstream to PLM 5.19 at the downstream boundary of the LD 1 segment

- **Feather River – LD 1:** Right levee (on the west bank) of the Feather River from PLM 0.00 at the boundary of MA 3 upstream to PLM 16.65 at the downstream boundary of the LD 9 segment

- **Feather River – LD 9:** Right levee (on the west bank) of the Feather River from PLM 0.00 at the LD 1 boundary upstream to PLM 6.24 at the downstream boundary of the MA16 segment

- **Feather River – MA 16:** Right levee (on the west bank) of the Feather River from PLM 0.00 at the LD 9 boundary upstream to PLM 4.09 at the downstream boundary of the MA 7 segment

- **Feather River – MA 7**: Right levee (on the west bank) of the Feather River from PLM 0.00 at the MA 16 boundary upstream to PLM 12.07 at the downstream boundary of the Hamilton Bend segment

- **Feather River – Hamilton Bend Area**: Right levee (on the west bank) of the Feather River from PLM 0.00 at the MA 7 boundary upstream to PLM 1.20 at the Thermalito Afterbay outlet channel.

- **Cherokee Canal – MA 13:** Left levee (on the south bank) of the Cherokee Canal from PLM 9.90 at the Southern Pacific Railroad bridge upstream to PLM 6.10 at the Western Canal crossing (this partial segment is not part of the ULE program)

At the request of the local sponsor, a second levee system was added to the project. The area within this levee system is referred to as "the Sutter triangle" because the protected area is roughly triangular-shaped between two levee segments and the high ground of the Sutter Buttes and it includes the small town of Sutter. This system is also shown on Plate 1. This levee system is not part of the ULE program. The levee segments of this system are:

- **Wadsworth Canal Right Levee:** Right levee (on the north bank) of the Wadsworth Canal from PLM 0.00 at the Sutter Bypass confluence upstream to PLM 4.66 at the West Interceptor Canal

- **Sutter BypassUpstream of Wadsworth Canal:** Left levee (on the east bank) of the Sutter Bypass from the high ground at the Sutter Buttes at PLM 0.00 downstream to the confluence of the Wadsworth Canal at PLM 4.31

Photos of the levee segments covered under the ULE program are in Enclosure A of this Geotechnical Appendix.

1.2 General Levee Descriptions

This section provides a general description of the geometry, soil conditions, performance history, and modifications/improvements of each levee segment. This section is a summary of the more detailed descriptions found in chapter 2 of the ULE Phase 1 Preliminary Geotechnical Evaluation Report (P1GER) for levee segments covered under the ULE program, Appendix C of the DWR Non-Urban Levee (NULE) Geotechnical Assessment Report (GAR) for the Cherokee Canal, and Appendix E of the NULE GAR report for the Sutter triangle levees. Explorations conducted for the ULE program are presented in detail in the ULE Phase 1 Geotechnical Data Report (P1GDR) and Supplemental Geotechnical Data Report (SGDR). Explorations conducted for the Feather River West Levee (FRWL) Improvement project are presented in detail in the Geotechnical Data Report (GDR). Tables summarizing the performance history and modifications/improvements of the SBLS from Periodic Inspection Report No. 1 (2010) are in Enclosure B of this Geotechnical Appendix.

1.2.1 Wadsworth Canal Left Levee

1.2.1.1 General Description

The Wadsworth Canal and its associated levees were constructed by the State of California in 1924. The levees were constructed primarily with soil excavated from the canal. The canal was deepened and the levees were enlarged by the Corps of Engineers in 1942. The left levee of the Wadsworth Canal extends from PLM 0.00 at the confluence with the Sutter Bypass to the northeast (upstream) to PLM 4.66 at the East Interceptor Canal. The levee crest elevation varies between 60 feet NAVD at the downstream end to 65 feet NAVD at the upstream end. The levee height varies between 6 feet at the upstream end and 26 feet at the downstream end. The crest width varies between 12 feet at the upstream end and 27 feet at the downstream end. The waterside slope varies between 3H:1V and 3.5H:1V. The landside slope varies between 2H:1V and 2.5H:1V. There is a relatively flat bench 10 to 35 feet wide between the waterside levee toe and the excavated canal sideslopes. There are a few houses and outbuildings near the landside levee toe over the downstream half-mile of the levee segment.

1.2.1.2 Soil Conditions

The levee soils consist of interbedded lean clay, fat clay, sand, and silty sand. Sand and silty sand are the dominant soils over the downstream 1.4 miles of the levee segment. Clay soils dominate in the upstream 3.3 miles of the levee. The levee is founded on Basin deposits, generally 4 to 9 feet thick, consisting mostly of lean and fat clay with occasional lenses of silt and sand. The Modesto Formation underlies the Basin deposits. The upper contact of the Modesto Formation is characterized by very stiff to hard clays, called “hardpan” locally. Below the hardpan, the Modesto Formation consists of silt, lean clay, and fat clay, with 1 to 9 foot thick layers of sand and silty sand.

1.2.1.3 Performance History and Levee Improvements

Excessive through-levee seepage, underseepage, and boils occurred between PLM 0.00 and 1.25 during the 1986 and 1997 flood events. The Corps constructed a soil-cement-bentonite cutoff wall between PLM 0.00 and 0.57 in 2008. The depth of the cutoff wall varied between 42 and 63 feet.

1.2.2 Sutter Bypass Left Levee (downstream of Wadsworth Canal)

1.2.2.1 General Description

The Sutter Bypass was constructed in 1924 by the State of California to convey flood water diverted from the Sacramento River. This levee was constructed primarily with soil excavated from the bypass channel. This segment was raised and enlarged by the Corps in 1941-1942. The levee extends from the confluence with the Wadsworth Canal left bank levee at PLM 4.4 to the south (downstream) along the left bank of the Sutter Bypass to the confluence with the Feather River right bank levee at PLM 22.12. The levee crest elevation varies from 52 feet NAVD at the downstream end to 60 feet NAVD at the upstream end. The levee height varies between 14 and 22 feet with an average height of 19 feet. The crest width varies between 17 and 30 feet. The waterside slope varies between 3H:1V and 4H:1V and the landside slope varies between 2.7H:1V and 4H:1V. There is a 1-foot high, 50-foot wide berm at the landside levee toe, with a drainage ditch located at the toe of the berm over most of this segment. There are a few houses and outbuildings located near the landside levee toe. There is a small bench with an access road between the waterside levee toe and the sideslope of the excavated channel.

1.2.2.2 Soil Conditions

The levee soils consist mostly of lean and fat clays with occasional lenses of silt, sand, and silty sand up to 4 feet thick. Subsurface soil conditions are variable over the Bypass alignment, due to the geomorphology of the levee alignment cutting across numerous historic small drainage channels at approximately 90 degree angles. The foundation consists of a clay blanket 10-60 feet thick, with the layer thickness generally lower towards the downstream end of the segment. A portion of the clay blanket is cemented at some locations, locally called “hardpan”. There are pockets of sand and silty sand within the clay blanket, varying between 4 and 20 feet thick. The top of some of these pockets is 6 feet below the top of the impervious blanket layer. A widespread sand, silty sand, and gravel layer is underneath the clay blanket.

1.2.2.3 Performance History and Levee Improvements

The landside toe area of this levee segment was under water during the 1955 flood due to the break in the Feather River levee near Shanghai Bend. Performance history and levee improvements during subsequent floods are detailed below.

- During the 1958 flood numerous types of levee distress were observed between PLM 5.4 and 13 (McClatchy Road to Gilsizer Slough). Ground heaving with mud flowing from the center of the mounds, accompanied by longitudinal cracking and movement towards the drainage ditch was observed along the landside toe berm and sand boils were observed in the drainage ditch. Longitudinal cracking along the landside levee slope about 4 feet below the crest was observed at the downstream portion of this reach. During the flood, sandbag rings were constructed at the five worst locations. After the flood, the Corps of Engineers constructed a 2-foot wide, 15-foot deep toe drain trench.
- During the 1986 flood, wavewash and county maintenance equipment induced erosion at the waterside toe and halfway up the waterside slope between PLM 20 and 22.37. This erosion was repaired by the Corps of Engineers under a PL84-99 action.
- During the 1986 flood, seepage and boils in the landside drainage ditch occurred between PLM 12.7 and 14.6 (Gilsizer Slough to Everglade Road). The Corps of Engineers constructed a pervious toe drain and overlying stability berm at this site under Sacramento River Flood Control Project Phase II Levee Reconstruction, Site 12.
- Heavy seepage and soil heaving was observed between PLM 4.4 and 5.4 (Wadsworth Canal to McClatchy Road) during the 1997 flood. After the flood the Corps of Engineers constructed a toe drain trench and berm at this location under a PL84-99 rehabilitation action.
- Seepage occurred at PLM 17.6 during the 1997 flood. The Corps of Engineers constructed a 2-foot wide, 5-foot deep pervious toe trench with an overlying stability berm at this site in 2001 under a PL 84-99 rehabilitation action.
- During the 1997 flood seepage, boils, and a sinkhole were observed in a “berm” (an abandoned railroad embankment) on the landside of the levee between PLM 21.88 and 22.07 (Feather River confluence to 1,000 feet upstream). The Corps of Engineers constructed a pervious vertical drain in the berm in 2001 under a PL84-99 rehabilitation action.

1.2.3 Feather River – MA 3

1.2.3.1 General Description

The Feather River is a meandering river that flows from the Sierra Nevada Mountains down to the confluence with the Sacramento River. The MA 3 levee segment goes along the right bank of the Feather River from PLM 0.00 at the Sutter Bypass left bank levee to the north (upstream) to PLM 5.19. This levee segment was originally constructed by local residents, date unknown. The Corps enlarged the portion of the segment downstream of the Highway 99 bridge in 1942. The Corps of Engineers also relocated a landside drainage ditch 20 to 50 feet away from the toe over the upstream (northern) half of the segment in 1962. The ditch is 5 feet wide at the bottom and 6 feet deep, with 1.5H:2V sideslopes. The levee crest elevation varies between 52 feet NAVD at the downstream end to 66 feet about half a mile downstream of the upstream end of the segment. The levee height varies between 18 and 26 feet, with an average height of 22 feet. The crest width varies between 20 and 30 feet. The waterside slope varies between 1.6H:1V and

2.5H:1V. The landside slope varies between 1.5H:1V and 3H:1V. There are a few outbuildings near the landside levee toe. The waterside bench between the levee toe and the riverbank varies between 300 and 3,700 feet wide. There are waterside borrow pits near the levee toe at some locations.

1.2.3.2 Soil Conditions

The levee soils consist mostly of alternating layers of silty sand and silt, with lesser amounts of lean clay and sandy clay. The foundation consists of a sandy clay/clay/sandy silt blanket 1 to 50 feet thick. In general, the blanket layer thickness decreases moving upstream along the segment. There is no hardpan within the blanket layer. The underlying pervious layer consists of sand, silty sand, and gravel.

1.2.3.3 Performance History and Levee Improvements

The performance history and levee improvements on this segment are listed below.

- A breach was reported between approximate PLM 3.64 and 3.70, date unknown (pre-1955).
- The levee was deliberately cut and reconstructed between PLM 0.72 and 0.82 to drain floodwater from the levee breach near Shanghai Bend after the 1955 flood.
- After the 1986 flood, a “sinkhole” was discovered at the waterside levee toe at PLM 1.2. The sinkhole was 30 feet long, 10 feet wide, and 10 feet deep. No distress was observed on the landside during the flood at this location. The sinkhole was filled with gravel.
- Heavy seepage, mostly running clear, was observed over much of the segment during the 1986 and 1997 floods. Boils were observed in a few isolated locations, primarily in the bottom of the drainage ditch along the upstream half of the segment. After the 1997 flood, pervious toe drains with overlying stability berms were constructed by the Corps of Engineers between PLM 2.28 and 2.43 (Sacramento River Flood Control Project Phase II Levee Reconstruction, Site 11) and between PLM 3.46 and 3.83(PL84-99 rehabilitation).
- During the 1997 flood heavy seepage into the drainage ditch caused sloughing of soil into the ditch between PLM 3.76 and 4.45. During the flood, the ditch was filled with sandbags placed on plastic sheeting. After the flood the ditch was converted to a pervious toe drain.
- Erosion of the waterside levee slope occurred at two locations during the 1997 flood and one location during the 2006 flood. These locations were repaired after the floods.

1.2.4 Feather River – LD 1

1.2.4.1 General Description

The LD 1 segment of the Feather River goes along the right bank of the Feather River from PLM 0.00 at the upstream end of the MA 3 segment to the north (upstream) to PLM16.65 at the

downstream end of the LD 9 segment. The city of Yuba City is adjacent to the upstream 6 miles of this segment. This levee segment was originally constructed by local residents, date unknown. The Corps raised and enlarged the segment in the late 1930's. The crest elevation varies between 62 feet NAVD at the downstream end and 88 feet NAVD about 200 feet downstream of the upstream end of the segment. The levee height varies between 19 and 25 feet, with an average height of 22 feet. The crest width varies between 15 and 22 feet. The waterside slope varies between 2H:1V and 3.5H:1V. The landside slope varies between 1.8H:1V and 3.1H:1V. There are waterside borrow pits near the levee in some locations. Within Yuba City buildings, swimming pools, and retaining walls have been built at and near the landside levee toe and, in some cases, cutting into the landside levee slope. The waterside bench between the levee toe and the riverbank varies from about 30 to 4,500 feet wide.

1.2.4.2 Soil Conditions

The levee soils consist of sandy silt, sandy clay, and clay with occasional zones of silty sand downstream of Star Bend (PLM 0.00 to 5.7) and sand, silty sand, and clayey sand with some zones of sandy silt and sandy clay upstream of Star Bend. The foundation soils are highly variable and consist of a clay, sandy clay and sandy silt blanket between 2 and 62 feet in thickness. Occasional, discontinuous zones of the blanket are cemented into hardpan. The blanket layer overlies a sand and gravel pervious layer that is up to 45 feet thick.

1.2.4.3 Performance History and Levee Improvements

The performance history and levee improvements within this segment are listed below.

- The levee breached just upstream of Shanghai Bend in the southern part of Yuba City (approximate PLM 11.0 to 12.4) in 1909, 1911, and 1955. The 1955 breach resulted in 38 fatalities. The Corps reconstructed the levee to the landside of its original alignment and installed relief wells in 1955-1957. Boils in this area required sandbagging during the 1986 flood. The City of Yuba City installed additional relief wells between the old relief wells in the southern portion of the relief well area in 1991 to reduce seepage into a new housing development. Floodfighting was required for boils in the northern portion of the relief well area during the 1997 flood. The Corps of Engineers installed new relief wells between the original relief wells in the northern portion of the relief well area in 2000.
- Seepage and boils occurred at Shanghai Bend during the 1986 and 1997 floods. The levee alignment had a horseshoe bend at this location. The Corps of Engineers constructed a setback levee with a 25-foot deep cutoff wall through the foundation after the 1997 flood under a PL84-99 action. The setback levee cut off the horseshoe bend.
- During the 1986 flood the landside levee slope became saturated and bulged within downtown Yuba City (approximate PLM 14.00 to 15.5) , and water flowed through cracks in pavement and floor slabs near the levee toe. Yuba City constructed an emergency berm during the flood. A permanent stability berm was constructed after the flood by LD 1. After the 1997 flood the Corps constructed a cutoff wall 40 to 55 feet

deep between PLM 12.76 and 14.54. The southern portion of the wall was constructed under the Marysville/Yuba City Levee Reconstruction Project. The northern portion of the wall was constructed under a PL84-99 rehabilitation action.

- Waterside levee erosion occurred near the Fifth Street Bridge in Yuba City during the 1986 and 1997 floods (PLM 14.27 to 14.57). The erosion was repaired with riprap.
- Floodfighting was required for seepage and boils just north of Star Bend during the 1986 and 1997 floods (PLM 4.56 to 5.42). The Corps of Engineers installed relief wells after the 1997 flood. Light seepage was noted between the upstream 3 relief wells during the 2006 flood.
- LD 1 constructed a setback levee with a 40 to 65-foot deep soil-bentonite cutoff wall through the foundation in 2008 at Star Bend (PLM 3.76 to 4.58). The setback cut off a 90-degree bend in the levee alignment.
- During the 1997 flood the waterside levee slope became unstable between PLM 5.55 to 5.66. The instability was believed to be due to a rapid drawdown situation after the levee on the opposite bank of the Feather River breached. The Corps repaired the slope after the flood under a PL 84-99 rehabilitation action.
- At PLM 1.5, a crack in the levee occurred during the 1986 flood and boils occurred during the 1997 flood. The Corps constructed a stability berm after the 1997 flood under a PL84-99 rehabilitation action after the 1997 flood.

1.2.5 Feather River – LD 9

1.2.5.1 General Description

The LD 9 segment goes along the right bank of the Feather River from PLM 0.00 at the upstream end of the LD 1 segment to the north (upstream) to PLM 6.24 at the downstream end of the MA 16 segment. An active railroad embankment crosses the levee alignment at the LD1/LD 9 boundary. The railroad embankment is about 4 feet lower than the levee; this opening is sandbagged during flood events. This levee segment was originally constructed by local residents, date unknown. Portions of this segment were raised and enlarged by the Corps in 1933 and 1944. The levee crest elevation varies between 83 feet NAVD at the downstream end and 91 feet NAVD near the upstream end of the segment. The levee height varies between 11 and 21 feet, with an average height of 19 feet. The crest width varies between 16 and 25 feet. The waterside slope varies between 1.9H:1V and 3H:1V. The landside slope varies between 1.4H:1V and 2.6H:1V. An irrigation canal (Sutter Butte Canal) is adjacent to the landside levee toe over a portion of this segment. The Sutter Butte Canal is about 30 feet wide at the bottom and varies between 5 and 8 feet deep. Smaller, localized drainage ditches are at the landside levee toe in some areas where the Sutter Butte Canal is not adjacent to the toe. There are also a few houses and outbuildings near the landside levee toe. Width of the waterside bench between the levee toe and the riverbank varies between 5 and 3,800 feet.

1.2.5.2 Soil Conditions

The levee soils consist of silt, sandy silt, sandy lean clay with occasional silty sand. The clay soils predominate at the downstream end of the segment and the silty and sandy soils predominate towards the upstream end of the segment. The foundation soils consist of a sandy clay/sandy silt blanket of variable thickness (average thickness 12 feet), sometimes cemented into a hardpan, overlying a sand/silty sand pervious layer. The pervious layer has some gravel lenses in the downstream half of the segment.

1.2.5.3 Performance History and Levee Improvements

The performance history and levee improvements on this segment are listed below.

- Boils were observed at PLM 2.12 and 3.60 during the 1955 flood. The landside levee slope at those locations was rebuilt with a gravel filter.
- Boils were observed between PLM 4.63 and 4.91 in 1957.
- Several waterside "sinkholes" appeared near the levee toe between PLM 0.1 and 0.46 in 1966. The sinkholes were attributed to improper removal of tree stumps and they were filled in.
- A "sinkhole" was observed at PLM 0.81 in 1986; documentation does not show the location (waterside or landside).
- Seepage and boils were observed in an irrigation ditch at PLMs 3.75 and 5.13 during the 1986 flood.
- Trench drains were placed at the landside levee toe between PLM 3.0 and 3.83 and between PLM 4.33 and 4.9 by LD 9 in 1992. The trenches were 4-5 feet deep and 2 feet wide and consisted of a geotextile lining around drain rock, with a perforated PVC pipe near the bottom of the trench.
- Seepage and boils were observed at several locations during the 1997 flood. At most of these locations, LD 9 personnel report that seepage quantities were "significantly higher" than during previous flood events. These locations included PLM 0.0 and 1.3; PLM 2.80 and 3.07; and PLM 4.50 and 5.30. There is no evidence of post-flood repairs at those locations. Boils also occurred between PLM 2.43 and 2.59; the Corps of Engineers constructed a toe drain with a concrete V-ditch collector at this location in 1998.
- Heavy seepage into the Sutter Butte Canal caused landside levee toe sloughing into the canal and a longitudinal crack in the levee slope between PLM 5.44 and 5.65 during the 1997 flood. The canal was filled with gravel during the flood. The canal was relocated into a pipeline away from the levee toe after the flood.

1.2.6 Feather River – MA 16

1.2.6.1 General Description

The MA 16 segment goes along the right bank of the Feather River from PLM 0.00 at the upstream end of the LD 9 segment to the north (upstream) to PLM 4.09 at the downstream end of the MA 7 segment. This levee was originally constructed by local residents, date unknown. Portions of this segment were raised by the Corps in 1933 and 1944. The levee crest elevation

varies between 91 feet NAVD at the downstream end to 96 feet NAVD at the upstream end. The levee height varies between 7 and 14 feet, with an average height of 10 feet. The crest width varies between 15 and 25 feet. The waterside slope varies between 1.9H:1V and 3.2H:1V. The landside slope varies between 1.3H:1V and 3H:1V. The Sutter Butte Canal is adjacent to the landside levee toe over a portion of this segment. The Canal is about 30 feet wide at the bottom and the depth varies between 5 and 8 feet. There are a few houses and outbuildings near the landside levee toe. The waterside bench between the levee toe and the riverbank varies between 30 and 3,100 feet wide.

1.2.6.2 Soil Conditions

The levee soils consist mostly of sandy silt, with some zones of sandy clay. The foundation consists of a clay/sandy silt blanket, at some locations cemented into hardpan, between 0 and 50 feet thick (average thickness about 20 feet) overlying a pervious sand layer. The pervious layer contains gravel in the upstream half of the segment.

1.2.6.3 Performance History and Levee Improvements

There is no documented history of performance problems and subsequent levee modifications to this segment.

1.2.7 Feather River – MA 7

1.2.7.1 General Description

The MA 7 segment goes along the right bank of the Feather River from PLM 0.00 at the upstream end of the MA 16 segment to the north (upstream) to PLM 12.07 at the downstream end of the Hamilton Bend segment. This levee was originally constructed by local residents, date unknown. The Corps reconstructed this levee in 1954. The levee crest elevation varies between 96 feet NAVD at the downstream end and 135 feet NAVD at the upstream end. The levee height varies between 5 and 22 feet, with an average height of 15 feet. The crest width varies between 15 and 25 feet. The waterside slope varies between 1.9H:1V and 3.2H:1V. The landside slope varies between 1.3H:1V and 3H:1V. The Sutter Butte Canal is adjacent to the landside levee toe over a portion of this segment. The Canal has a bottom width of about 30 feet and is between 5 and 8 feet deep. There are a few houses and outbuildings near the landside levee toe. The waterside bench between the levee toe and the riverbank varies between 5 and 4,800 feet wide. Dredge tailings, consisting primarily of cobbles and gravel, have been placed on the waterside bench over the upstream 4 miles of the segment.

1.2.7.2 Soil Conditions

The levee soils consist mostly of sandy silt, with some zones of sandy clay and occasional lenses of sand. The foundation consists of a blanket of clay/sandy in the southern portion of the

segment and silt/silty sand in the northern portion of the segment. Thickness of the blanket varies between 0 and greater than 80 feet; the average thickness is about 15 feet, and in general the thickness decreases moving upstream along the segment. The pervious layer consists of sand and gravel. The pervious layer is almost entirely gravel upstream of PLM 3.2.

1.2.7.3 Performance History and Levee Improvements

The performance history and levee improvements/modifications to this segment are listed below.

- During the 1955 flood, waterside slope erosion caused the west span of the Gridley bridge across the Feather River to collapse, although the levee did not breach due to floodfighting efforts. The levee and the bridge were rebuilt by local residents after the flood. The bridge was replaced by a new bridge about 450 feet downstream of the old bridge in the mid-1960's.
- Boils were observed between PLM 0.1 and 0.9 during the 1955 flood event.
- During the 1986 flood, seepage and boils were observed between PLM 2.68 and 2.82. The Corps constructed a 50-foot deep cutoff wall at this location (plans not found).
- Seepage and boils were also observed between PLM 9.7 and 9.8 during the 1986 flood.
- The Corps raised the levee about 2 feet and reworked the landside slope between PLM 9.9 and 10.4 in 1998 under the Sacramento River Flood Protection Project Phase II System Evaluation.
- During the summer dry season, when the Feather River is low and the Sutter Butte Canal is full, seepage flows from the canal and exits on the waterside of the levee between PLM 0.0 and 1.0.

1.2.8 Feather River – Hamilton Bend

1.2.8.1 General Description

The Hamilton Bend segment goes along the right bank of the Feather River from PLM 0.00 at the upstream end of the MA 7 segment to the north (upstream) to PLM 1.20 at the Thermalito Afterbay outlet channel. This levee was originally constructed by the Corps of Engineers in 1947. The Corps raised the levee in the mid-1950's and widened the downstream mile of the levee in 1963. The Sutter Butte Canal crosses the levee alignment at PLM 1.05-1.06. A concrete headgate structure was built across the canal alignment. The headgate structure is 36 feet tall, 50 feet long, and 13.5 feet wide. The headgate structure was abandoned after construction of the upstream Oroville Dam in 1968. The levee crest elevation varies between 134 feet NAVD at the downstream end and 139 feet NAVD at the upstream end. The levee height varies between 3 and 24 feet, with an average height of 14 feet. The crest width is 15-20 feet upstream of the headgate structure and 60-70 feet downstream of the headgate structure. The waterside slope varies between 2H:1V and 2.5H:1V. The landside slope varies between 1.5H:1V and 3H:1V. There is one small outbuilding near the landside levee toe. The waterside bench between the levee toe and the riverbank varies between 50 and 1,100 feet wide. The downstream 0.8 miles of the segment was built through dredge tailings piles. The dredge tailings

consist of silty sand, gravel, and cobbles and are higher than the levee crest elevation at some locations.

1.2.8.2 Soil Conditions

The levee is constructed of clay upstream of the headgate structure and silty sand, gravel, and cobbles (dredge tailings) downstream of the headgate structure. There is a thin clay blanket underlying less than half of this levee segment. The pervious layer consists of silty sand, gravel, and cobbles (dredge tailings) about 80 feet thick.

1.2.8.3 Performance History and Levee Improvements

This segment experienced seepage and boils downstream of the headgate structure during the 1955 flood, which was floodfought by local residents. This portion of the levee was widened by the Corps of Engineers in 1963. The Sutter Butte Canal Headgate Structure was also floodfought for overtopping during the 1955 flood; the crest elevation of the structure is lower than the crest elevation of the adjacent levee, and water was reportedly 16 inches below the crest of the structure.

1.2.9 Cherokee Canal (MA 13)

1.2.9.1 General Description

The Cherokee Canal and its associated levees were constructed by the Corps of Engineers in the late 1950's. The Cherokee Canal is located in the northwest portion of the project area. The Canal discharges water into the Butte Sink, a low-lying area between the Sacramento River and the Sutter Buttes. The entire canal is 23.1 miles long; this Feasibility Study only includes the left bank levee from PLM 9.90 at the Southern Pacific Railroad bridge to the northeast (upstream) to PLM 6.10 at the Western Canal confluence. This portion of the levee would flood the town of Biggs if it breached or overtopped. The levee height is 6-10 feet and the crest width is 10-20 feet. The waterside slope varies between 3H:1V and 3.5H:1V and the landside slope varies between 2.5H:1V and 3H:1V. An irrigation ditch is present at the landside toe.

1.2.9.2 Soil Conditions

The levee is constructed of lean and fat clay, silt, and elastic silt. The foundation soils consist of a silt and sandy silt blanket between 3 and 19 feet thick, overlying a pervious layer of silty sand, clayey sand, and clean sand. Where the pervious layer consists of clean sand, it generally contains silt lenses that are 2-4 feet thick.

1.2.9.3 Performance History and Levee Improvements

This section of levee overtopped during the 1986 flood due to debris buildup at the railroad bridge. There is no documentation of any other performance problems during floods or improvements/modifications to this portion of the segment.

1.2.10 Wadsworth Canal Right Levee

1.2.10.1 General Description

This levee segment extends from PLM 0.00 at the confluence with the right bank levee of the Sutter Bypass to the northeast (upstream) along the right bank of the Wadsworth Canal to PLM 4.66 at the West Interceptor Canal. The levee height varies between 20 feet at the downstream end to 5 feet at the upstream end. The crest width is 10-20 feet. The waterside slope varies between 3H:1V and 3.5H:1V. The landside slope varies between 2H:1V and 2.5H:1V. A small drainage canal is located at the landside levee toe over most of this segment. The DWR Sutter Maintenance Yard is located at the landside of the levee immediately south of Highway 20.

1.2.10.2 Soil Conditions

There are no known explorations in this levee segment. Since the canal is fairly small (about 300 feet from levee crest centerline to levee crest centerline), it is anticipated that soil conditions would be similar to the left bank levee of the Wadsworth Canal, discussed in section 1.2.1.2 of this report.

1.2.10.3 Performance History and Levee Improvements

This segment has experienced seepage and boils between PLM 0.00 and 2.4 during floods, and waterside bank erosion encroaching into the levee toe has been reported at PLM 3.2. No modifications or improvements have been constructed on this segment.

1.2.11 Sutter Bypass Upstream of Wadsworth Canal

1.2.11.1 General Description

This levee segment extends along the right bank of the Sutter Bypass from PLM 0.00 at high ground at the Sutter Buttes to the southeast (downstream) to the confluence of the right bank levee of the Wadsworth Canal at PLM 4.31. The levee height varies between 15 feet at the upstream end and 23 feet at the downstream end. The crest width is 20 feet. The waterside slope varies between 3.5H:1V and 4H:1V and the landside slope varies between 2.5H:1V to 3H:1V. A project pump plant at PLM 2.7 pumps interior drainage water over the levee into the Bypass. There are some outbuildings near the landside toe of the levee. There is also a drainage canal on the landside of the levee. The canal is located 15 to 50 feet from the landside toe and is about 5 feet deep and 12 feet wide at the bottom.

1.2.11.2 Soil Conditions

There are no existing explorations on this levee segment.

1.2.11.3 Performance History and Levee Improvements

Moderate seepage, not carrying material, was reported at PLM 2.68 during the 1997 flood; no remedial action was undertaken. Also during the 1997 flood, heavy seepage and soil heaving occurred between PLM 3.7 to 4.3. A pervious toe drain and overlying stability berm were constructed by the Corps of Engineers under a PL84-99 rehabilitation action.

1.3 Previous Geotechnical Studies

Over the years, many geotechnical studies have been performed on the Sutter Basin, particularly on the Feather River levee in the vicinity of Yuba City. The major geotechnical engineering studies for the Sutter Basin area in recent years include:

- The original Sutter Basin Feasibility Study without project condition report (i.e. F3 report) completed in 2004.
- The State of California Department of Water Resources (DWR) Urban Levee Evaluation (ULE), ongoing.
- The Sutter-Butte Flood Control Agency (SBFCA) Feather River West Levee (FRWL) Improvement Project, ongoing.
- The State of California DWR Non-Urban Levee Evaluation (NULE), ongoing.

1.3.1 Initial Sutter Basin Report

The initial Sutter Basin report had a different study area, and included all levees within Sutter County, as identified in Sutter County, California Feasibility Study Feasibility Scoping Meeting (F3 Milestone) Report (2004). That study area did not include any complete levee systems; the levees studied stopped at the Sutter County boundaries. That assemblage of segments and partial segments did not fully protect any one area completely, and relied on levees that were not located within Sutter County. The initial study did not include any new explorations and it was done before the DWR ULE program began, so it relied on a limited amount of historical explorations and reports.

1.3.2 DWR Urban Levee Evaluation (ULE)

DWR initiated the ULE study in 2007. The ULE study, which is ongoing, is a major geotechnical evaluation of all the levee systems protecting urban areas within the Central Valley of California. The definition of the Urban Levees for the DWR project is a levee system protecting more than a population of 10,000. The Sutter Basin part of the ULE program includes most of the same levee segments as this project. The levees along the right bank of the

Cherokee Canal, the right bank of the Wadsworth Canal, and the left bank of the Sutter Bypass upstream of Wadsworth Canal were not included in the ULE program because they do not protect a large enough population. The DWR ULE study was partially funded by this project as in-kind services for geotechnical explorations and geotechnical deterministic evaluations.

1.3.3 SBFCA Feather River West Levee (FRWL) Improvement Project

SBFCA is a consortium of Sutter and Butte Counties, the Cities of Yuba City, Live Oak, Gridley, and Biggs, and Levee Districts 1 and 9 of Sutter County. The agency was formed in 2007 to finance and construct regional levee improvements. The FRWL Improvement Project's goal is to improve the 44 miles of the right bank levee of the Feather River from the Thermalito Afterbay outlet to the confluence with the Sutter Bypass under a Section 408 permit. The FRWL Improvement Project design team works closely with the DWR ULE team and much of the geotechnical design of the FRWL Improvement project is based on the geomorphic study and the explorations and laboratory testing done for the ULE project. The FRWL project did additional explorations and laboratory testing to fill in data gaps at specific locations and to have the information necessary for a design project. The additional data, including subsurface investigation and deterministic analyses provided by the study for the FRWL Improvement Project was also used for development of this Feasibility Study geotechnical evaluation. Currently the FRWL Improvement Project is at 90 % design for what has been designated the Contract C area (between Shanghai Bend and Live Oak, LD 1 PLM 11.1 to MA16 PLM 2.87). SBFCA plans to construct that contract in 2013. The areas designated as Contract A1 (Laurel Avenue to Star Bend, MA3 PLM 3.64 to LD 1 PLM 3.76), Contract B (Star Bend to Shanghai Bend, LD1 PLM 4.56 to LD 1 PLM 10.62), and Contract D (Live Oak to Thermalito Afterbay, MA 7 PLM 0.00 to Hamilton Bend PLM 1.20) are at the 65% design level.

1.3.4 DWR Non-Urban Levee Evaluation (NULE)

The NULE study, which is ongoing, is a major geotechnical evaluation of all the levee systems protecting non-urban areas within the Central Valley of California. The levees along the Cherokee Canal, the right bank levee of the Wadsworth Canal, and the left bank levee of the Sutter Bypass upstream of the Wadsworth Canal (between PLM 0.00 and 4.31) are included in the DWR NULE study. The DWR NULE study is just beginning; a Geotechnical Assessment Report (GAR), a collection of existing exploration, geomorphology, and levee performance information was prepared in April 2011, but no new explorations have currently taken place.

1.4 Use of DWR ULE/NULE and SBFCA FRWL Improvement Project Studies

This geotechnical report uses the ULE/NULE and SBFCA FRWL Improvement Project reports as the source for the majority of data upon which this geotechnical evaluation is based. The purpose of this report is not to duplicate the efforts of the ULE/SBFCA project reports, especially due to the massive volume of data gathered by those projects and the restraints of the Feasibility Pilot Study process. This report is an independent evaluation (analysis and conclusions); though in many cases the evaluations of the ULE/SBFCA projects were used to

facilitate this report. The geotechnical explorations, the geomorphic study, and the deterministic analyses developed in the ULE/SBFCA projects were used as the basis for the geotechnical risk-based analysis in this Feasibility Study. The design plans and cost estimate for the SBFCA project were used to prepare the design and cost estimates for the alternatives carried forward in this study.

2 PROJECT DATUM AND STATIONING

The project study used existing topographical data, which was previously developed for the Sacramento/San Joaquin Rivers Comprehensive Study (Comp Study). The Comp Study topography was surveyed using the National Geodetic Vertical Datum of 1929. Comp Study elevations which were not surveyed in NAVD88 were converted to NAVD88 as discussed in section 2.2 of this report.

2.1 Horizontal Control

Index point locations are referenced in relation to the Project Levee Mile (PLM) system as provided in paragraph 1.1 and with northing and easting coordinates. All northing and eastings provided herein are referenced to the NAD83 Horizontal datum. All horizontal coordinates are projected to the California State Plane Zone II coordinate system. PLMs have been established by the Project Sponsor and the LMAs and are shown in the existing Operations and Maintenance (O&M) Manuals. The SBFCA FRWL Improvement Project has set up a stationing system along the FRWL that is used in their plans and design reports. Table 2-1 shows a correlation between PLMs and the SBFCA stationing for each levee segment on the Feather River.

Table 2-1 PLM and SBFCA Stationing

LMA	PLM	SBFCA Station
MA 3	0.00	10+00
	5.11	280+60
LD 1	0.00	280+60
	16.65	1131+00
LD 9	0.00	1131+00
	6.24	1460+40

LMA	PLM	SBFCA Station
MA 16	0.00	1460+40
	4.09	1674+30
MA 7	0.00	1674+30
	12.07	2303+50
Hamilton Bend	0.00	2303+50
	1.20	2367+00

2.2 Topographical Base

As required by ER 1110-2-8160 all elevations provided herein are referenced to the NAVD88 vertical datum at an appropriate level of accuracy. The geotechnical deterministic and risk-based analysis done for this report used topography originally developed by the Sacramento/San Joaquin Rivers Comprehensive Study (Comp Study), with the exception of Cherokee Canal. The Comp Study topography was collected in the NGVD 29 vertical datum. The Comp Study topography was converted to the NAVD 88 vertical datum by HJW GeoSpatial, Inc. (2010) following the requirements in ER 1110-2-8160 and the uncertainty in the conversion has been recognized in the study results. The report on the datum conversion is in Enclosure C of this report. The conversion between NGVD29 and NAVD88 ranges from -2.3 to -2.4 feet over the study area. The levee crest elevations at the index point locations were verified with the levee crest elevations in the National Levee Database, which was surveyed in the NAVD 88 vertical datum. The Cherokee Canal channel and levee cross-sections use LiDAR data provided by DWR.

3 PAST FLOODS AND LEVEE PERFORMANCE

Significant high water events in recent years include the Floods of 1986 and 1997. Significant seepage and large sand boils were observed along the right bank of the Feather River, left bank of the Wadsworth Canal, and Sutter Bypass levees during these two flood events. A catastrophic levee break occurred on the right bank of the Feather River near Shanghai Bend at the southern end of Yuba City during the 1955 flood event with severe economic effects and the loss of 38 lives. Moderately high water events occurred in 1995 and 2006. Light seepage and pin boils developed during these two events. Section 1.2 of this report gives a summary of the levee performance history during flood events. More detailed information may be found in chapter 2 of the ULE P1GER report for levee segments covered under the ULE program and Appendix E of the NULE GAR report for the Sutter triangle levees. Tables summarizing the performance history and constructed modifications/improvements of the SBLS from Periodic Inspection Report No. 1 (2010) are provided in Enclosure B of this report. Table 3-1 shows the peak river stage for the Feather River at Yuba City gage station. The peak stage of record for the Feather River occurred during the December 1955 Flood with a peak stage of about 78.5 feet at the Yuba City gage station.

Table 3-1 Peak River Stages at the Feather River Yuba City Gage

Event	**Peak River Stage at the Feather River Yuba City Gage (Elevation in feet, NAVD 1988)**
1986	75.3
1995	66.8
1997	77.5
1999	52.3
2000	51.8
2006	66.8

Note: Normal river level elevation is 36 to 37 feet.

4 GEOLOGY, GEOMORPHOLOGY, GROUNDWATER, AND SEISMICITY

The following discussion of regional and local geology was taken from Chapter 3 of the ULE P1GER report, with minor modifications.

4.1 Regional Geology

The levees within the SBFS are located in the central portion of the Sacramento Valley, which comprises the northern half of the Great Valley Geomorphic Province of California. The SBFS includes levees near the center of the Sacramento Valley (Wadsworth Canal and Sutter Bypass), levees near active river channels (Feather River) as well as some levees near the east margin of the valley (Feather River North). The Wadsworth Canal sits on the flanks of the Sutter Buttes, a small isolated volcanic range located in the center of the Sacramento Valley.

The Sacramento Valley lies between the northern Coast Ranges to the west and the northern Sierra Nevada to the east, and was a depositional basin throughout most of the late Mesozoic and Cenozoic. An estimated 2+ vertical miles of sediments were deposited in the Sacramento area during cyclic transgressions and regressions of a shallow sea that once inundated the valley. This thick sequence of clastic sedimentary rock units, derived from erosion of the adjoining easterly and westerly highlands from the Late Jurassic, with interspersed Tertiary volcanics, form the bedrock units now deeply buried in the mid-basin areas of the valley. These bedrock units were covered by coalescing alluvial fans during the Pliocene-Pleistocene era by the major ancestral rivers of the Sacramento Valley (Sacramento, Feather, Yuba, Bear, and American) that funneled huge volumes of sediments into the Sacramento basin. Periodically, volcaniclastic sediments and tuffs were also broadly deposited during this time. Late Pleistocene and Holocene alluvial deposits now cover the low-lying areas, consisting mainly of reworked fan and stream materials that were deposited by meandering rivers prior to the construction of the existing flood control system.

From the mid-1800's to the early 1900's, hydraulic mining in the Sierra Nevada introduced massive amounts of mining debris into the Feather, Yuba, and Bear Rivers. This debris backfilled river channels and raised channel elevations. Mining debris was also transported and deposited atop the more consolidated Pleistocene-to Holocene-age deposits during numerous flood events. Many (although not all) levees along the major ancestral rivers of the Sacramento Valley were deliberately built near the river channel to increase the flow velocity during flood events to "flush out" the mining debris. Much (although not all) of that debris has been flushed out, resulting in the rivers eroding the bottom and sides of their channels. Erosion of the bottom and sides of the river channel tends to worsen underseepage over time.

4.2 Local Geology

State-sponsored regional geologic mapping, at a scale of 1:250,000, of the Chico Quadrangle (Saucedo and Wagner, 1992) and Sacramento Quadrangle (Wagner, Jennings, Bedrossian, and Bortugno, 1987) indicate within the project area geologically recent (Quaternary-age) alluvial/fluvial deposits fill the floodplains of the Sacramento and Feather Rivers. These deposits consist of Holocene Alluvium and Holocene Basin Deposits, as well as late Pleistocene alluvial fan and terrace deposits of the Modesto and Riverbank Formations. Per Helley and Harwood (1985), these Quaternary deposits are variably dissected and overlain by younger Quaternary (Historical) deposits consisting of channel, floodplain, and artificial fill (levees and mine tailings). The Historical deposits date from approximately 1800 to 1937.

Cropping out adjacent to the younger fluvial deposits of the north-westerly portion of the project area are the Pleistocene volcanic rock and sediments of the Sutter Buttes. To the north and east of the younger fluvial deposits are outcrops of Plio-Pleistocene volcanic sediments informally known as the "Tuffs of Oroville." Additionally, fluvial deposits of the Pliocene Laguna Formation occur as scattered outcrops located at the base of the easterly-adjoining highlands and are the oldest geologic unit in the local project vicinity.

The generalized geologic map units in the project region are detailed below with descriptions typically summarized from Helley and Harwood (1985). The map symbol for each mapped geologic unit is noted after the formal name of the unit. Typically, each younger geologic unit is deposited into broad channels cut into the progressively older geologic units. Map symbols used on plan and profile drawings in the DWR ULE reports and SBFCA FRWL Improvement Project are slightly different since they are based on the geomorphologic mapping (see paragraph 4.3 below), which is more detailed.

- **Holocene (Historical) Artificial Fill (L, T).** Historical Artificial Fills (less than 150-years old) are culturally-emplaced deposits of varying amounts of clay, silt, sand, and gravel from local sources. These deposits include levee structures (L) and dredge tailings (T). Dredge tailings are located along the northern-most reach of the Feather River.
- **Holocene (Historical) Alluvial Deposits (Ra).** Historical Alluvial Deposits occur generally between the Feather River channel levees and on the land side. These deposits also occur in historical stream and overflow channels that transport high stage water flow across the ground surface outboard of the levees. The deposits consist of silt and sand with traces of gravel. The upper few feet of these deposits (particularly those derived from the Feather River) are anticipated to be filled with debris derived from upstream hydraulic mining activities.
- **Holocene Alluvium (Qa).** Holocene (<11,000 years before present [ybp]) alluvial deposits are present within the floodplains of the Sacramento River, Feather River, and lesser streams and water courses in the area. These sediments were deposited into and long channels incised into the older latest-Pleistocene formations of similar fluvial origin. The alluvium includes sand and gravel deposits of the active and abandoned stream

channels, as well as sands, silts, and minor gravel lenses deposited as overbank deposits during high-water stages.

- **Holocene Basin Deposits (Qb).** Basin Deposits primarily dominate in the western portion of the project area. The Wadsworth Canal and a majority of the Sutter Bypass are underlain by these deposits. Closer to the Feather River, Basin Deposits are less extensive and are mapped as scattered exposures overlying the Modesto and Riverbank formations. These fluvial sediments consist of fine-grained silt and clay, and represent the distal facies of Holocene alluvial deposits in the area.
- **Pleistocene Modesto Formation (Qm).** The youngest Pleistocene fluvial deposits in the project area are termed the Modesto Formation. The Modesto Formation is exposed at the ground surface predominantly along the landside of most of the Feather River levees and to a lesser degree along the eastern edge of the Sutter Buttes. This formation underlies the younger Basin Deposits east of Sutter Buttes and most of the Feather River channel alluvium. These deposits are recognized by distinct alluvial terraces, alluvial fans and abandoned channel ridges that lie topographically above and outboard of the Holocene alluvial deposits. The Modesto Formation generally consists of unconsolidated gravel, sand, silt and clay and can be divided into two members; an upper member (12,000 to 26,000 ybp) showing poor soil development and a lower member (30,000 to 50,000 ybp) characterized by thicker soils with a developing argillic B horizon. Hardpan may be present near the top of each member of the Modesto Formation as an indicator of the upper boundary with the overlying alluvium. On the western side of the Feather River, the Modesto Formation is a common source of fresh water, as coarse-grained deposits are thick and have good hydraulic connection.
- **Pleistocene Riverbank Formation (Qr).** The Riverbank Formation has limited exposures on the western side of the Feather River at the extreme northern and southern ends of the river. However, the Riverbank Formation is predominantly separated from the Feather River alluvial deposits by the Modesto Formation. The Riverbank Formation consists primarily of gravel, sand and silt and can typically be distinguished from the Modesto by topographic position and presence of a thick, well-developed soil horizon. The Riverbank Formation is subdivided into the Upper and Lower members, each associated with periods of geologic stability (Helley and Harwood, 1985). Hardpan may be present near the top of each member. The Riverbank formation is estimated to be 130,000 to 450,000 years old. The Riverbank Formation can be a source for fresh water in the Feather River North area, but the interbedded nature of the fine- and coarse-grained units and the varying degree of connectivity between coarse-grained beds may limit groundwater production at some locations.
- **Pleistocene Sutter Buttes Volcanic Sediments (QPs) and Rocks (QPv).** These deposits primarily occur as a peripheral topographic ring that surrounds the Sutter Buttes and are separated from the Basin Deposits of the SBFS area by the Modesto and Riverbank Formations. These deposits consist predominantly of volcaniclastic sediments and lahars and to a lesser degree andesitic rocks.

- **Plio-Pleistocene Tuffs of Oroville (QPto).** The "Tuffs of Oroville" consist of interbedded volcaniclastic deposits of gravel, sand, and tuff (volcanic ash) deposited to the south and west of the town of Oroville.

4.3 Geomorphology

A detailed geomorphology study was conducted for the Wadsworth Canal, Sutter Bypass, and Feather Rivers under the DWR ULE program. Results of that study are in Enclosure D of this report. A preliminary geomorphology study of the Cherokee Canal and the Sutter Triangle levees has been conducted under the DWR NULE program, although no reports or maps will be prepared until a more detailed study of those levees has been conducted.

4.4 Groundwater

The SBFS project area is located along the eastern boundary of the East Butte and Sutter Subbasin, which comprises part of the greater Sacramento Valley Groundwater Basin. Historical mine tailing deposits and historical to Holocene stream channel and floodplain deposits upon which the levees were constructed are highly permeable and allow for large volumes of groundwater recharge within the subbasin.

DWR maintains an internet water data library (http://www.water.ca.gov/waterdatalibrary/), which includes groundwater depth measurements from monitoring wells throughout the state. The DWR data and additional information from the Butte County Groundwater Management Plan indicate groundwater within the project area typically flows from north to south. The data also show relatively stable groundwater elevations within the last 40 to 60 years, although there is a typical seasonal fluctuation in groundwater elevation with peaks typically in the winter to spring months and drops in the summer and fall months. The winter and spring peaks indicate groundwater recharge during the precipitation season, and the summer and fall drops indicate the lack of rainfall and extraction of groundwater for domestic and irrigation uses. The DWR water data library indicates groundwater levels within the project area vary between 3 and 30 feet below ground surface. Pore-pressure dissipation tests completed during cone penetration test (CPT) advancement show groundwater levels in the Feather River south area vary between 10 and 32 feet below ground surface and groundwater levels in the Feather River north area vary between 8 and 46 feet below ground surface. Groundwater levels are expected to fluctuate due to variations in precipitation, nearby river stage, irrigation, and withdrawal.

4.5 Seismicity

The SBFS project area is located in a relatively low area of seismic risk for California. Nearby faults, such as those of the Foothills Fault System are located 10 to 20 miles east in the foothills of the Sierra Nevada; however, these faults are considered to have a small likelihood for seismic activity, and may be considered active over very long periods. A portion of this fault was active

after the first filling of Oroville Dam. The Great Valley Fault System is a blind thrust fault on the western edge of the Sacramento Valley, about 34 miles from the SBFS levees. This fault system is also considered to be active.

5 GEOTECHNICAL RISK-BASED ANALYSIS METHODOLOGY

The following sections discuss the risk-based geotechnical analyses performed to evaluate the existing levees. Effects of utility penetrations, encroachments, erosion and animal activity were considered in the engineering judgment portion of the analysis. Underseepage and slope stability analyses were primarily used to develop the expected performance of each reach.

5.1 Risk Based Analysis Method

The probability of poor performance was evaluated by assessing the foundation and embankment materials and assigning values for the probability moments of the random variables considered in the analyses. The First-Order-Second-Moment (FOSM) method, as recommended in ETL 1110-2-556, "Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies" dated 28 May 1999, was followed during the evaluation of the existing conditions of each levee unit. In this approach, the uncertainty in performance is taken to be a function of the uncertainty in model parameters. The standard deviations of a performance function were estimated based on the expected values (means) and the standard deviation of the random variable means. The performance functions considered were slope stability and underseepage piping stability. Through-levee seepage is discussed in section 5.4 of this report.

The final result of the FOSM is a reliability index, Beta (β), representing the amount of standard deviation of the performance function by which the expected value exceeds the limit equilibrium state. The limit equilibrium state for the slope stability and underseepage piping stability was defined using a factor of safety of 1.0. The standard deviation and variance of the performance function are calculated from the standard deviation and variance of the foundation and embankment parameters using the Taylor's series method based on a Taylor's series expansion of the performance function about the expected values. The partial derivatives were calculated numerically using an increment of plus and minus one standard deviation centered on the expected mean value. The variance of the performance function was obtained by summing the products of the partial derivatives of the performance function considering the variance of the corresponding parameters. For the existing condition of the levee, the probability of failure Pr(f) was expressed as a function of the river water elevation and other factors including soil strengths, permeabilities, and subsurface stratification. Reliability (R) is defined as:

$$R = \left(1 - \Pr(f)\right)$$

The combined geotechnical conditional probability of poor performance, considering the probability of poor performance due to underseepage failure, slope stability and judgment probability is

$$\Pr(f) = 1 - ((1-\Pr(f)_{us})*((1-\Pr(f)_{st}) * (1-\Pr(f)_{jd}))$$

Where: $Pr(f)$ = total probability of poor performance

$Pr(f)_{us}$ = probability of poor performance due to underseepage

$Pr(f)_{st}$ = probability of poor performance due to slope stability (in steady state condition)

$Pr(f)_{jd}$ = judgment probability of poor performance

A set of conditional-probability-of-poor performance versus floodwater-elevation graphs were developed as related to underseepage piping, stability and judgment.

The probability of geotechnical poor performance of a levee is conditional on the uncertainties associated with hydrologic and hydraulic aspects of determining the water surface profile during a flood. These uncertainties can be combined with the geotechnical uncertainties in the @RISK model. This is accomplished, for economic purposes, through estimation of two index elevations for each levee reach within the study area. These index elevations are defined as follows:

The Probable Non-Failure Point (PNP) is the water elevation below which it is highly likely that the levee would not fail.

The Probable Failure Point (PFP) is the water elevation above which it is highly likely that the levee would fail.

The terms "highly likely that the levee would fail" is defined by the ETL as having 85% probability of occurrence. Therefore, the probability of failure at the PNP is 15% and the probability of failure at the PFP is 85%. It should be noted that only for flood damage economic studies the probability of poor performance curve at 85% should be assumed to correspond to PFP and probability of poor performance of 15% shall be assumed to correspond to PNF. These performance curves shall be not used to predict failure for studies other then flood damage economic studies.

The Probability of Poor Performance of the stability of a slope (P_{rf}) is defined as the probability that the critical failure surface could be loaded to the limit equilibrium state. This infers the slope is loaded to its maximum capacity.

The reaches to be analyzed were selected considering the soil profiles based on the available subsurface investigation and the deterministic calculations on cross sections where the geotechnical conditions were considered critical (such as thin impervious blanket, thick aquifer, soft material in the levee or top foundation layer).

5.2 Underseepage Reliability

Subsurface conditions based on past investigations as described previously, geomorphology of the area, and past history were considered in selection of the most critical reaches of each levee unit. Generally the conditions in the Sutter Basin consist of a natural waterside berm of sands and silts and a natural top blanket consisting of silts grading to clay in the basin with the permeability decreasing with distance to the basin. The impervious blanket thickness, soil types (for determination of the permeability ratio), and aquifer thickness were considered for selection of the cross section representing a characteristic reach of every levee unit. Existing subsurface investigation showing the location of the borings, soil profiles and boring logs are those used by the ULE study and the FRWL Improvement Project and are provided in Enclosure J. The expected value, standard deviation and the coefficient of variation of the permeability ratios between the horizontal permeability through the sandy aquifer and vertical permeability of the impervious blanket, blanket thickness and thickness of the sandy aquifer for each reach and for the each index point are provided in Enclosure D. The information was based on soil profiles developed using existing subsurface investigation. Underseepage analysis was performed using the blanket theory as described in the Corps ETL 1110-2-556. Finite element analyses using SEEP2D program part of the GMS version 6 were developed to independently check the blanket theory results. Statistical analysis was used for each reach in determination of the coefficients of variation of the permeability ratios an, blanket thickness and thickness of the underlying aquifer as shown on Enclosure C. A critical gradient $i_c = 0.80$ was used considering the unit weight of the blanket 112pcf. The unit weight of the blanket was considered the same for all sections analyzed. The standard deviation for the blanket thickness and the thickness of the sand layer in the foundation was calculated for each index point of each levee unit and was used in underseepage reliability evaluation. The phreatic line obtained by the SEEP2D program using the finite element method was also used in the stability analysis for each water elevation.

Reliability analysis was performed using Taylor's Series Method. In the Taylor method, random variables are quantified by their expected values, standard deviations, and correlation coefficients. The variables used in the generalized equation for underseepage analysis are shown on Figure 5-1 and are as follows:

$$X_3 = \sqrt{z * d * \left(\frac{k_f}{k_b}\right)}$$

$$i_o = \frac{h_0}{D_b} = \frac{H\left(\frac{k_f}{k_b} D_f D_b\right)}{D_b\left[C_R \frac{e^{2L_R} - 1}{e^{2L_R} + 1} + x_2 + \left(\frac{K_f}{K_{bL}} D_f D_{bL}\right)\right]}$$

Where

$$h_0 = \frac{H * L_e}{L_1 + L_2 + L_e}$$

$$L_1 = C_R * \frac{e^{2L_R} - 1}{e^{2L_R} + 1}$$

$$Pr(F) = P(i_{critical} < i_o)$$

Where: X_3 = C_R = effective exit distance

z = D_b = blanket thickness (it is assumed that the blanket thickness is the same on the waterside and landside D_b=D_{bl}=D_{br})

d = D_f = aquifer thickness

k_f = horizontal permeability of the aquifer

k_b = vertical permeability of the blanket

k_f/k_b = permeability ratio between horizontal permeability of the aquifer and vertical permeability of the impervious blanket

L_R = actual length of the riverside blanket

L_L = actual length of landside blanket assumed infinite (∞)

H = total head on levee

h_0 = water head at the landside levee toe

i_0 = upward seepage gradient through the landside blanket

L_1 = effective length of the waterside blanket

L_2 = X_2 = base width of natural blanket beneath the levee embankment (X_2)

L_e = C_R when the landside length of the natural blanket is assumed infinite

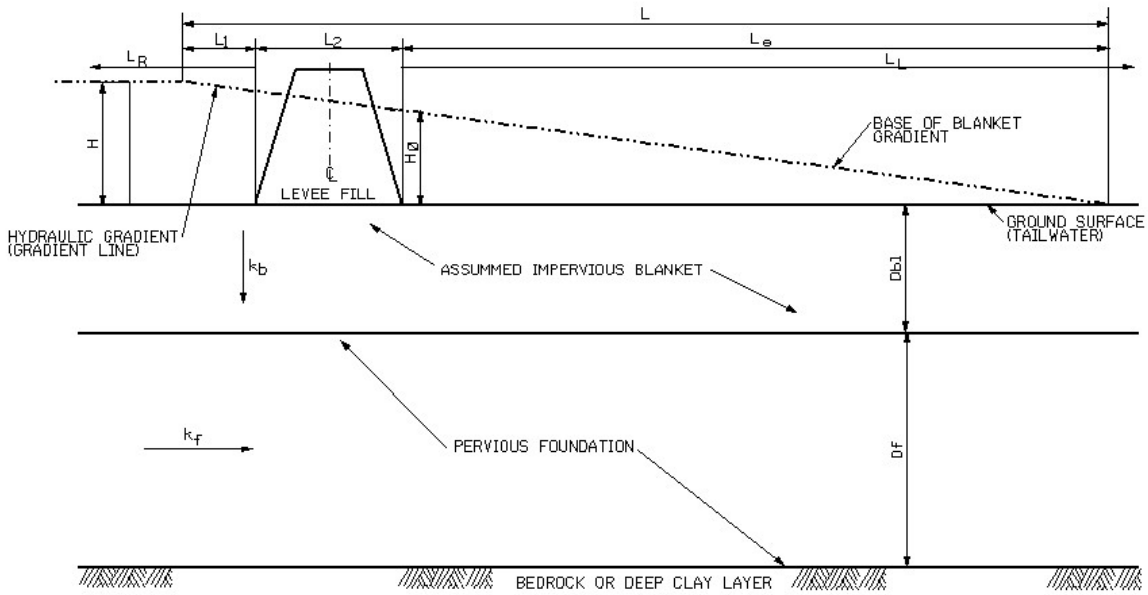

Figure 5-1 Underseepage Analysis – Blanket Theory

Seepage gradients were calculated for a range of river stages from the landside toe elevation to the top of the levee. From previous studies, the Taylor Series method appears to be more conservative and appropriate for this level of investigation. The index points for the risk analysis were selected based on deterministic analyses using the final element method developed by the SEEP2D program.

Permeability ratios between the horizontal permeability of the sand layer and vertical permeability of the impervious blanket, used in the blanket R&U analyses were based on a statistical analysis of the permeability of different foundation soils shown in the borings within the considered reach based the subsurface investigation and recommendations of the previous studies listed in Section 1.3.

The Sacramento District has developed a standard EXCEL workbook for the preparation of fragility curves. The mean, standard deviation, and coefficient of variation for the blanket thickness, pervious layer thickness, and the permeability ratio (horizontal permeability of the pervious layer divided by the vertical permeability of the blanket layer) are calculated for each index point using nearby soil borings on the first sheet in the workbook. Those parameters are then transferred to the second sheet in the workbook for the actual blanket theory calculations, with one potential exception. If the standard deviation is higher than the mean, then the mean minus one standard deviation will be a negative number, which is not physically possible. In that case, the coefficient of variation will be over 100. To avoid this problem, the workbook limits

the coefficient of variation to a maximum of 98. If the coefficient of variation is 98, then the standard deviation is recalculated on the second sheet in the workbook based on the maximum allowed coefficient of variation. For this study, the permeability ratio was the parameter most often impacted by a large standard deviation. Soils deposited by river systems are highly variable compared to engineered materials like concrete and steel, and high standard deviations are not unexpected when dealing with soil materials.

Exit gradients calculated using blanket theory are highly sensitive to blanket layer thickness. For meandering river systems, it is not uncommon to have large differences in the blanket layer thickness; in this study, two soil borings along the Feather River show blanket layer thicknesses greater than 100 feet. Unusually large blanket layer thickness values will significantly impact the mean and cause the standard deviation to be large. To eliminate this effect, soil borings near the index points with unusually large blanket layer thickness (over 31 feet) were not used to calculate the random variables and statistical parameters. Soil borings with blanket layer thickness greater than 31 feet are the exception and not the rule in the SBLS. Basing the calculations on the borings with the thinner blanket layer is more representative of the conditions that are likely to cause an underseepage failure.

The detailed results of the underseepage reliability analyses for each index point are provided in Enclosure E.

5.3 Slope Stability Reliability

A sensitivity study was done to determine which parameters in the slope stability calculations were most influential. For this study, those variables are soil strength and unit weights of the soil in the levee embankment and in the foundation. Statistical descriptors for these variables were determined using available site-specific information and published statistical data. The piezometric lines or pore pressures for each water elevation were determined using the finite element program SEEP2D.

5.3.1. Cases Analyzed and Methods Used for Analyses

The cases analyzed for stability risk analyses considered long-term conditions with steady state seepage along the landside slope of the levee. The phreatic surface developed for the steady state condition was determined using the SEEP2D finite element computer program developed as part of the GMS. The limit equilibrium computer program “UTEXAS4” was used to perform the stability analyses. Circular failure surfaces were assumed and the embankment was modeled as homogeneous. All analyses consisted of running a search routine to identify the critical failure surface using the Spencer’s Method. Five random variables were defined for each unit. Stability analyses were performed for different assumed river stages. Details of the results of the stability risk analysis are provided in Enclosure E.

5.3.2 Soil Strength Parameters

Soil strength parameters used in the stability analyses were the drained soil parameters as determined in previously studies listed. The coefficient of variation for soil strength parameters and unit weight of the fill material in the levee or the top impervious blanket were obtained using methodologies outlined in ETL 1110-2-556, and those proposed by Harr in the "Reliability-Based Design in Civil Engineering", and Duncan in the "Manual for Geotechnical Engineering Reliability Calculations". Cohesion of 50 psf was considered for the embankment fill when the levee embankment was constructed of sandy materials, to avoid shallow slipping surfaces close to the infinite slope failure.

5.4 Through Seepage Analysis

The through-levee seepage performance mode was not included in the development of fragility curves. The levees along the Wadsworth Canal and the Sutter Bypass are comprised mostly of clays and sandy clays with some zones of silty sand. The west levee of the Feather River is variable with regards to soil type. The Maintenance Area 3 segment and the southern portion of the Levee District 1 segment are composed of sandy silt and sandy clay. The upstream portion of the Levee District 1 segment is composed of silty sand, sandy silt, and some zones of sand. The Levee District 9, Maintenance Area 16, and Maintenance Area 7 segments are composed of sandy silt and sandy clay. The Hamilton Bend segment is composed of gravel and sand, with a fines content between 2 and 10 percent, but this segment has a crest width of about 60 feet. The Cherokee Canal levee is composed mostly of clay, silt, and sandy silt, with occasional small pockets of silty sand. Clay, sandy clay, and sandy silt levees are unlikely to experience through-levee seepage distress due to the low permeability of those soils. While silty sand and sand levees can be susceptible to through-levee seepage distress, there is almost no history of this performance mode causing levee distress in the two levee systems covered under the SBFS. The only reported incidence of distress due to through-levee seepage in these levees was saturation and bulging of the landside levee slope of the Feather River in downtown Yuba City during the 1986 flood. A landside stability berm was constructed in this area by the local sponsor after that flood, and a cutoff wall was constructed through the levee in this area by the Corps of Engineers after the 1997 flood. Due to the mosty fine-grained levee soils, the lack of history of through-levee seepage distress, the levee improvements in the only reported location of through-levee seepage distress, and the enlarged levee section of the pervious Hamilton Bend segment, it was determined that through-levee seepage is unlikely to be a major contributor to the probability of failure of the levees in this study.

5.5 Judgment Base Reliability Analysis

A judgment based conditional probability function was based on existing conditions of the levee such as the impact of encroachments, vegetation, existing cracks and holes due to animal burrows, and based on the past history of sand boils, or slope failures. Generally past experience with poor performance at utility crossing and rodent activity indicates the risk of failure is pretty

significant in the analyzed areas. Impact of erosion on the levee performance was also included in the judgmental reliability analysis. The judgment-based curve is included for each analyzed levee cross section and in the combined curve.

In June 2009, an expert elicitation was conducted for the purpose of developing the geotechnical judgment portion of the curves for the American River Common Features project for various conditions of the levee regarding vegetation, encroachments, rodents activity, penetrations and erosion. This expert elicitation was conducted in accordance with ETL 1110-2-561, "Appendix E, Expert Elicitation in Geological and Geotechnical Applications" 31 January 2006. The members of the expert elicitation team were highly recognized professional specialists, representing the LMAs of those levee systems, and specialists in erosion and in geotechnical issues. The expert elicitation focused on the judgment part of the geotechnical risk and uncertainty curves for the flood control structures. The expert elicitation was conducted over a three-day period in which the most representative reaches of each basin of the study were discussed. The expert elicitation team discussed and reached consensus on the impact of different factors of the judgment curve, such as:

a) the vegetation on the levees and within the levee right of way
b) penetrations through the levee and foundation
c) encroachments into the levee and levee right-of-way
d) erosion of the riverbank and waterside slopes of the levee
e) animal burrows

The expert elicitation also concluded that up to a certain water elevation, the risk of poor performance as determined by analyses or considered in the judgment portion of the curves may not necessarily coincide with the risk of failure. Based on historical performances of the levees, it appears that the risk of failure as determined in the analyses may be conservative and the poor performance of a levee may not lead to a catastrophic levee failure, even if damage to the levee embankment needs to be repaired after the flood to bring the levee back to the pre-flood performance. Consequently, the risk of catastrophic failure may be reduced based on the historical past performance, and consequently the curves may be altered. The conclusion reached by the panel was that the risk of failure as a function of stage of the river may be reduced by 50% when the river reached 4-5 feet above the landside toe, by 30% when the river stage is up to 8-9 feet above the landside levee toe, and by 10% when the river reaches 11-12 feet above the landside toe. Geotechnical R&U curves for poor performance and risk of failure considering the conclusions of the expert elicitation were provided for further analysis in HEC-FDA. The judgmental curves for the existing conditions are provided in Enclosure E.

5.6 Combined Reliability Analysis

The total conditional probability of failure as a function of floodwater elevation has been developed by combining the probability of failure functions for three failure modes;

underseepage, slope instability, and judgment. The reliability is the probability of no failure due to each mode considered in the calculations. The analysis also assumed that no flood fighting is employed.

5.7 Soil Parameter Selection

The soil parameters used for underseepage and slope stability were assigned function of the type of the materials in the upper impervious blanket and in the aquifer underneath. The expected values were selected based on design charts in the EM 1110-2-1913, values used by the geotechnical report for the Feather River West Levee Improvement Project, and on values recommended by the Guidance for the DWR ULE program. All presumptive relationships were considered when selecting initial values (note that they are all very similar); however, seepage modeling was performed by varying these presumptive values to produce flow nets, which realistically match the generalized subsurface conditions. Therefore, the final values utilized may not be the same as the presumptive value used to begin the modeling process.

5.8 Reach Selection

Reaches were selected based on a geotechnical evaluation of the subsurface profile boring logs. The critical points are locations in each project phase that have the most significant risk of failure. The reaches were chosen to represent sections of levee with similar levee and foundation conditions.

Reaches were identified using the following criteria:

- Similar foundation blanket type (e.g. clay, silt, etc, a change may indicate a different reach)
- Similar foundation blanket or pervious layer thickness (e.g. the absence of a blanket or the absence of a pervious layer constitutes a difference reach)
- Significant changes in layer thickness, such those that result of a geomorphology difference (e.g. soil deposits with a major change in layer heterogeneity)

Experience has also shown that smaller reaches provide more consistent means and standard deviations, which represent actual geomorphological related subsurface conditions.

6 EVALUATION OF EXISTING GEOTECHNCIAL CONDITIONS

The SBLS levees completely encircle the Sutter Basin (Plate 1). The levee system is approximately 65 miles long. This levee system is broken into reaches by the ULE P1GER report, except for the Cherokee Canal levee, which is not included in the ULE study.

The Sutter Triangle levees tie into high ground at both ends at the Sutter Buttes (Plate 1). This levee system is approximately 10 miles long. This system is not included in the ULE study.

The height of the levees ranges from 4to 30 feet. The landside slopes are typically2H:1V. Portions of the system have landside slopes as steep as 1.5H:1V. The waterside slopes are typically 2.5H:1V to 4H:1V, with a typical slope of 3H:1V. The levee crown width ranges from 10 to 70 feet and are typically 16 to 20 feet. In the highly urbanized area of Yuba City, the Levee District 1 Sutter County segment has buildings, fences, roads, and utility poles located in close proximity to the levee. In rural areas, unpermitted fence encroachments are common. More detailed descriptions of the levees in the ULE study are in Section 2 of the ULE P1GER report. More detailed descriptions of the levees in the NULE study are in Appendix C (Cherokee Canal) and Appendix E (Sutter Triangle) of the NULE GAR report.

6.1 Past Performance and Levee Modifications/Improvements

Section 1.2 of this report gives a brief summary of the levee performance history during flood events. More detailed information may be found in chapter 2 of the ULE P1GER report for levee segments covered under the ULE program and Appendix E of the NULE GAR report for the Sutter triangle levees. Tables summarizing the performance history and constructed modifications/improvements of the SBLS from Periodic Inspection Report No. 1 (2010) are in Enclosure B of this report.

6.2 Explorations

The ULE P1GDR (2008) and SGDR (2010) and the SBFCA GDR (2012) reports summarize explorations for the majority of the project. The Cherokee Canal left levee, Wadsworth Canal right levee, and the Sutter Bypass left levee upstream of Wadsworth Canal are included in the DWR NULE project, but no NULE explorations have been conducted at this time. Nine soil borings were conducted for the Cherokee Canal left levee for this Feasibility Study. The boring logs are included in Enclosure F of this report.

6.3 SBLS Seismic Evaluation

The fragility curves were developed following ETL 1110-2-566, which does not include a seismic component. Sacramento District has developed a draft manual for seismic deformation evaluation of levees which is currently under review by Corps Headquarters, the Risk Management Center (RMC) and the Engineering Research and Development Center (ERDC). The recommendation of the proposed manual is to design for seismic loading only levees loaded permanently by high water levels. Levees subject to intermittent loading will only be evaluated for liquefaction potential and seismic deformation. We recommend the Sponsor identify an emergency borrow area to reconstruct the levee within 3 months to a limited level of protection (10% (1/10) Annual Chance Exceedance (ACE)). Additional information on the seismic evaluation is given in section 8.6.3 of this report.

6.4 Deterministic Analysis

Deterministic slope stability and foundation underseepage analyses were conducted at thirteen cross-sections along the Sutter system corresponding to the reaches identified in Paragraph 6.1 as the basis for the risk based analyses and to identify the index points for each reach. In some cases, the deterministic analyses were conducted at the index points for this study and in other cases the deterministic analyses were conducted a short (half-mile or less) distance away from the index point. The purpose of the deterministic analysis was to verify the deterministic analyses conducted under the two outside studies and as a “check” for the fragility curves prepared under this study.

The Groundwater Modeling System (GMS) computer program was used for all analysis seepage and stability analysis. GMS is a model wrapper program that incorporates a graphical user interface (GUI). The modeler builds the subsurface model in GMS and the subsurface model is exported to the appropriate analysis module. The GMS program includes modules such as SEEP2D for finite-element seepage modeling, and UTEXAS4 for slope stability analysis.

For this project, topographic cross-sections were cut from triangulated irregular network (TIN) 3D surfaces using AutoCAD, which derived the TIN surface from the Comp Study topography identified in Section 2.0. This CADD cross section was combined with boring stick logs exported to CADD format from the gINT boring log program. The combined CADD file containing the appropriate boring logs and topographical cross-section was imported into the GMS program. Once in GMS the modeler imported the topography layer from CADD to object layers in GMS.

Enclosure G presents the graphical output from the deterministic analyses.

7 GEOTECHNICAL FRAGILITY CURVES

7.1 Reach Selection

The ULE P1GER (2008) report divides the SBLS into forty reaches. Reach selection grouped portions of the levee into segments with similar performance, previous repairs, or geomorphology. For the purposes of the SBFS, we grouped the ULE-developed reaches into ten larger reaches with similar subsurface conditions, and added one reach each for the Cherokee Canal left levee, Wadsworth Canal right levee, and Sutter Bypass left levee upstream of Wadsworth Canal, which are not in the ULE study. The resulting thirteen reaches were developed in consultation with the project hydraulic engineer and economist. Note that the levee reaches used to develop the fragility curves are different than the levee segments listed in section 1.1 of this report. The levee segments are determined by levee maintaining agency, while the levee reaches were developed for analysis based on the criteria listed in section 5.6 of this report.

The thirteen reaches are as follows:

Wadsworth Canal (left): ULE A and B

Sutter Bypass Upper: ULE C, D, E, and F

Sutter Bypass Lower: ULE H, I, J, K, and L

Feather River South (near Bear) = ULE M, N, O, P,Q ,and R

Feather River Abbot/Connor Lakes: ULE S, T1, and T2

Feather River Shanghai Bend: ULE U, V, W, X, Y, Z1, Z2, Z3, and Z4

Feather River North LD9: ULE AA, BB, CC, DD, and EE

Feather River North Middle: ULE FF, GG, HH, II, JJ, KK, and LL

Feather River North Canal: ULE JJ, KK, and LL

Feather River North Hamilton Bend: ULE MM, NN, OO, QQ, RR, and SS

Cherokee Canal: ULE Not applicable

Wadsworth Canal (right): ULE Not applicable

Sutter Bypass (upstream) : ULE not applicable

Table 7-1 provides a location summary of the index points associated with these reaches. The index point locations are shown on Plates 2 through 9 of this report. These reaches are described in subsections of 7.2 through 7.14, including a short explanation of the rationale of the reach selection.

Table 7-1. Index Point Location Information

Index Point Number	Reach Name	PLM	NAD83_N	NAD83_E
1	Wadsworth Canal (left)	0.84	2170954.8600	6629916.3000
2	Sutter Bypass Upper	6.20	2158851.0000	6631970.0000
3	Sutter Bypass Lower	17.30	2113476.9763	6655398.0817
4	Feather River South (near Bear)	4.92	2106963.5800	6679261.2400
5	Feather River Abbott/Connor Lakes	3.99	2127081.8143	6676331.1294
6	Feather River Shanghai	9.31	2156078.1800	6673804.9800
7	Feather River North LD9	0.52	2188213.8800	6668679.4100
8	Feather River North Middle	0.90	2224154.3700	6664999.3400
9	Feather River North Canal	2.90	2233626.2500	6664328.5400
10	Feather River North Hamilton Bend	0.51	2288660.9600	6662820.2400
11	Cherokee Canal	9.50	2301045.9480	6637006.2610
12	Wadsworth Canal (right)	0.50	2168750.0000	6627910.0000
13	Sutter Bypass (upstream)	4.0	2168110.0000	6626590.0000

7.2 Wadsworth Canal (left)

The section describes the reach selection and modeling criteria for the Wadsworth Canal left levee from the Sutter Bypass (PLM 0.00) upstream to the East Interceptor Canal (PLM 4.66).

Reach Selection: The ULE report identifies two reaches for this levee: Reaches A and B. In Reach A, the levee is shorter, and the height reduces toward the upstream end. Reach B south of Franklin Road is a taller levee and is characterized by relatively thin sand layers layers in the foundation. The critical index point for the Wadsworth Canal left bank levee was considered towards the downstream (taller) end since the hydraulic head is greater and more susceptible to underseepage than a shorter levee. The statistical parameters for blanket and pervious layers were developed using soil types identified in soil borings from the ULE P1GER report. There is a forty to fifty foot deep, 3000 feet long, soil-cement-bentonite cutoff wall at the southern end of this reach. The index location is situated upstream from the cutoff wall at PLM 0.83.

Selection of Cross-Section: The cross-section at PLM 0.83, was selected to represent the portion of the reach not protected by a cutoff wall; however, the statistical variation of the parameters of the blanket and sand (thickness and permeability) considered all borings within the reach, including those in the area with a cut-off wall.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the impervious blanket in the vicinity of the selected index point varies between 3 and 10.5 feet and consists of clay and silt blanket overlaying a silty sand aquifer 2-11 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-2.

Table 7-2 Permeabilities, Wadsworth Canal (left)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Thin Clay Blanket	3.9×10^{-4}	1.12	9.8×10^{-4}	0.28	4
Thick Clay Blanket	9.8×10^{-6}	0.028	2.5×10^{-6}	0.0071	4
Silty Sand (SM)	9.8×10^{-3}	2.8	9.8×10^{-4}	0.28	10
Sand with Silt (SP-SM)	4.02×10^{-3}	11.4	4.02×10^{-4}	1.14	10

The standard deviation and coefficient of variation for the permeability ratios (between the horizontal permeability of the sandy aquifer and vertical permeability of the impermeable upper blanket), blanket thickness and sandy aquifer thickness are summarized in Table 7-3 as follows.

Table 7-3 Random Variables, Wadsworth Canal (left)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	7	2	29

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permeability Ratio (k_f/k_b)	493	455	92
Foundation Sand thickness (d)	7	3	43

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-4

Table 7-4 Stability Random Variables, Wadsworth Canal (left)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	31	4	12
Levee Unit Weight γ (pcf)	125	6	5
Blanket Layer Cohesion c (psf)	150	50	33
Blanket Layer Unit Weight γ(pcf))	115	6	5
Blanket Layer Φ(degrees)	28	3	12

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-1. The underseepage performance mode accounts for most of the risk of failure for this levee segment. This is consistent with the performance history of excessive seepage and boils over the downstream portion of this levee, where it is tallest.

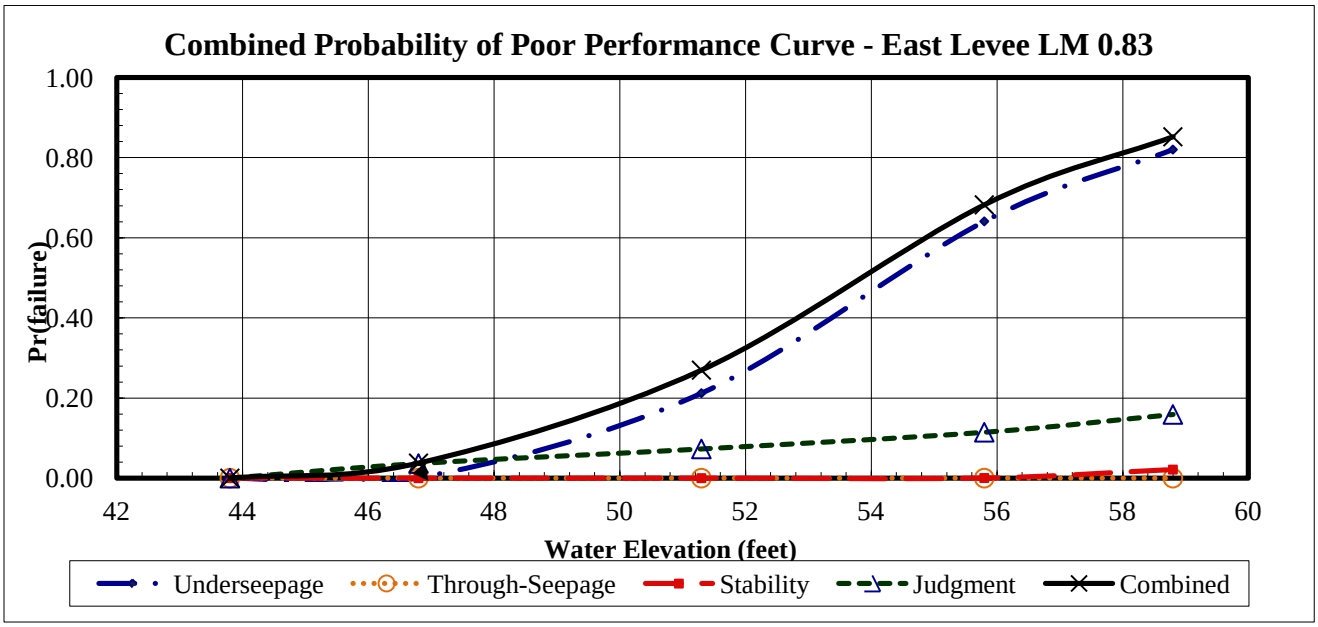

Figure 7-1 Combined R&U, Wadsworth Canal (left)

7.3 Sutter Bypass; Upper Reach

The section describes the reach selection and modeling criteria for the Sutter Bypass Upper Reach, from PLM 4.40 at the Wadsworth Canal downstream to PLM 12.7 at Gilsizer Slough.

Reach Selection:

The Sutter Bypass has experienced many seepage problems over the years. The channel was blasted out of the hardpan clay and the levees were built adjacent to the cut. This reduces the waterside blanket to almost zero. The Bypass channel crosscuts the geology of the region, with the orientation of the natural flood overbank deposits from the Feather, Yuba and Bear Rivers passing roughly perpendicular to the channel and levee. The results are that the Sutter Bypass has similar subsurface conditions and performance during flood events over the entire segment.

Within the Sutter Bypass, geomorphically, Gilsizer Slough stands out as a place to separate reaches. Gilsizer Slough is an historically major drainage in the Sutter Basin, and intersects the bypass near the midpoint. For this reason, the bypass was divided into two reaches; the Upper Reach and the Lower Reach.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the impervious blanket in the vicinity of the upper reach index point varies between 4.8 and 14 feet and consists of clay, sandy clay, and occasional silty sand

overlaying a sand and silty sand aquifer 3-10 feet thick. The borings used for the R&U analyses for the upper reach are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-5.

Table 7-5 Permeabilities, Sutter Bypass (Upper)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay/Sandy Clay Blanket (CL)	$9.8x10^{-6}$	0.028	$2.5x10^{-6}$	0.007	4
Silty Sand Blanket (SM)	$4.2x10^{-4}$	1.2	$1x10^{-4}$	0.3	4
Silty Sand Aquifer(SM)	$1x10^{-3}$	3	$1x10^{-4}$	0.3	10
Sand with Silt Aquifer (SP-SM)	$3.5x10^{-3}$	10	$3.5x10^{-4}$	1	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-6 as follows.

Table 7-6 Random Variables, Sutter Bypass (Upper)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	10	4	40
Permeability Ratio (k_f/k_b)	725	650	90
Foundation Sand thickness (d)	10	6	60

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-7

Table 7-7 Stability Random Variables, Sutter Bypass (upper)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	31	4	12
Levee Unit Weight γ (pcf)	125	6	5
Blanket Layer Cohesion c (psf)	150	50	33
Blanket Layer Unit Weight γ(pcf))	115	6	5
Blanket Layer Φ(degrees)	28	3	12

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-2. The underseepage performance mode accounts for most of the risk of failure for this levee reach. This is consistent with the performance history of excessive seepage, boils and ground heaving near the toe of this levee.

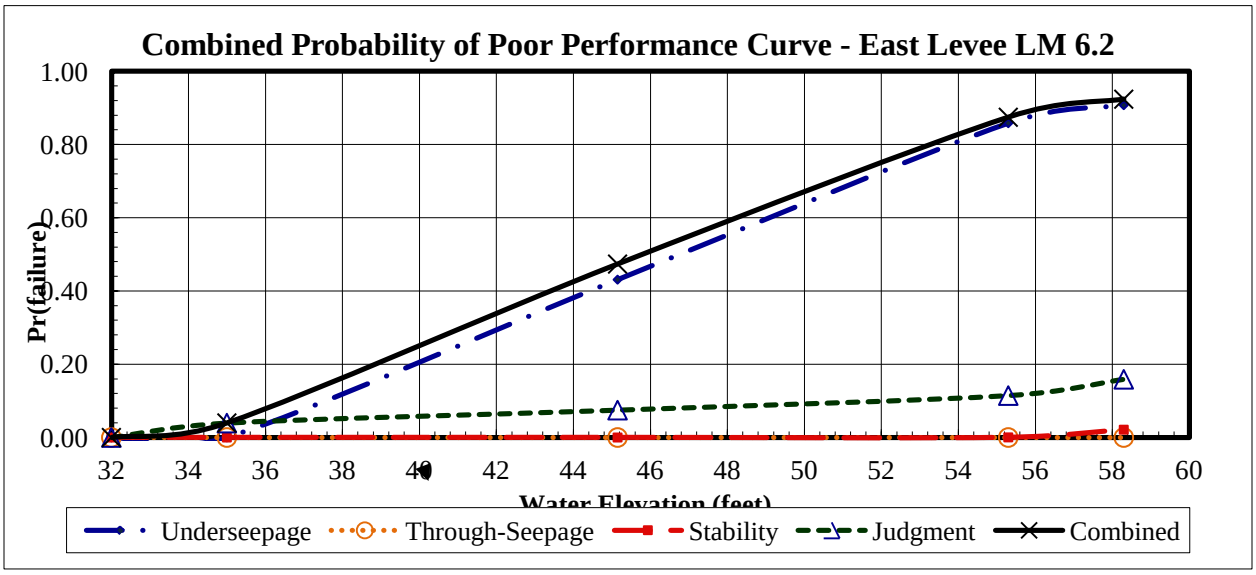

Figure 7-2 Combined R&U, Sutter Bypass (Upper)

7.4 Sutter Bypass (Lower)

The section describes the reach selection and modeling criteria for the Sutter Bypass Lower Reach.

Reach Selection:

The Sutter Bypass has experienced many seepage problems over the years. The channel was blasted out of the hardpan clay and the levees were built adjacent to the cut. This reduces the waterside blanket to almost zero. The Bypass channel crosscuts the geology of the region, with the orientation of the natural flood overbank deposits from the Feather, Yuba and Bear Rivers passing roughly perpendicular to the channel and levee. The results are that the Sutter Bypass has similar subsurface conditions and performance during flood events over the entire segment.

Within the Sutter Bypass, geomorphically, Gilsizer Slough stands out as a place to separate reaches. Gilsizer Slough is an historically major drainage in the Sutter Basin, and intersects the bypass near the midpoint. For this reason, the bypass was divided into two reaches; the Upper Reach and the Lower Reach.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the impervious blanket in the lower reach varies between 4 and 26.4 feet and consists of clay, silt, sandy clay, and sandy silt overlaying a sand and silty sand aquifer 3-28 feet thick. The borings used for the R&U analyses for the lower reach are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-8.

Table 7-8 Permeabilities, Sutter Bypass (Lower)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay/Sandy Clay Blanket (CL)	$9.8x10^{-6}$	0.028	$2.5x10^{-6}$	0.007	4
Silty Sand Blanket (SM)	$1.4x10^{-4}$	0.4	$3.5x10^{-5}$	0.1	4
Silty Sand Aquifer(SM)	$1x10^{-3}$	3	$1x10^{-4}$	0.3	10
Sand with Silt Aquifer (SP-SM)	$3.5x10^{-3}$	10	$3.5x10^{-4}$	1	10
Sand Aquifer (SP)	$9.8x10^{-3}$	28	$9.8x10^{-4}$	2.8	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-9 as follows.

Table 7-9 Random Variables, Sutter Bypass (Lower)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	15	10	67
Permeability Ratio (k_f/k_b)	1117	1095	98
Foundation Sand thickness (d)	13	13	98

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-10.

Table 7-10 Stability Random Variables, Sutter Bypass (lower)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	31	4	12
Levee Unit Weight γ (pcf)	125	6	5
Blanket Layer Cohesion c (psf)	150	50	33
Blanket Layer Unit Weight γ(pcf))	115	6	5
Blanket Layer Φ(degrees)	28	3	12

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-3. The underseepage performance mode accounts for most of the risk of failure for this levee reach.

This is consistent with the performance history of excessive seepage, boils and ground heaving near the toe of this levee.

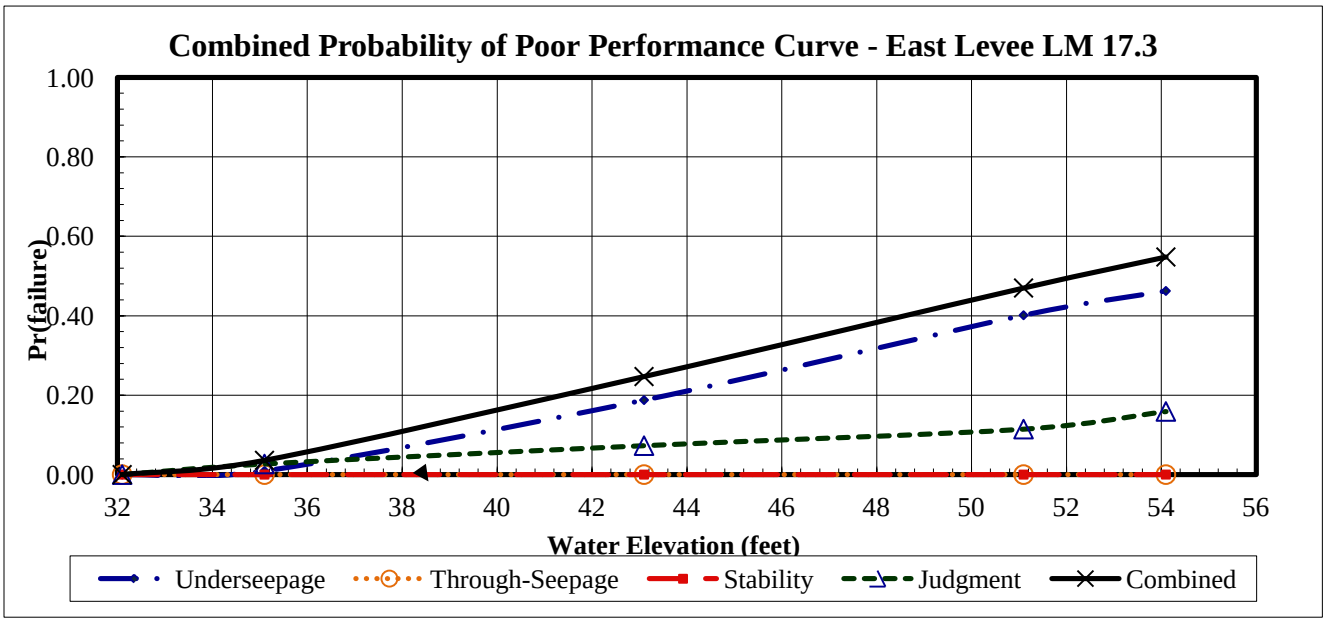

Figure 7-3 Combined R&U, Sutter Bypass (Lower)

7.5 Feather River South (near Bear)

The section describes the reach selection and modeling criteria for the Feather River South (near Bear) reach.

Reach Selection:

This reach is characterized by geomorphology dominated by the interaction between the Bear and Feather River systems since the Pleistocene, and therefore is named after the Bear River.

Selection of Cross-Section: The cross-section FEATHER RIVER SOUTH (near Bear) was selected to represent the most vulnerable location in the reach and is located at PLM 4.92.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the impervious blanket in the vicinity of the index point varies between 14 and 26 feet and consists of silt, clay, sandy silt, and sandy clay overlaying a sand, gravel, and silty sand and gravel aquifer 17-89 feet thick. The borings used for the R&U analyses for the upper reach are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-11.

Table 7-11 Permeabilities, Feather River South (near Bear)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Thick Clay/Sandy Clay/Sandy Silt Blanket (CL, ML)	$9.8x10^{-6}$	0.028	$2.5x10^{-6}$	0.007	4
Sandy Silt Blanket (ML)	$1.97x10^{-4}$	0.56	$4.9x10^{-5}$	0.14	4
Silty Sand Aquifer(SM)	$3.5x10^{-4}$	1	$3.5x10^{-5}$	0.1	10
Sand Aquifer	$3.5x10^{-3}$	10	$3.5x10^{-4}$	1	10
Sand and Gravel Aquifer (SP-SM, GW-GM)	$1x10^{-2}$	30	$1x10^{-3}$	3	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-12 as follows.

Table 7-12 Random Variables, Feather River South (near Bear)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	22	5	23
Permeability Ratio (k_f/k_b)	2172	1977	91
Foundation Sand thickness (d)	73	28	38

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-13

Table 7-13 Stability Random Variables, Feather River South (near Bear)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	29	1	5
Levee Unit Weight γ (pcf)	120	6	5
Blanket Layer Cohesion c (psf)	150	17	11.5
Blanket Layer Unit Weight γ(pcf))	120	6	5
Blanket Layer Φ(degrees)	31	4	11.5

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-4. The underseepage performance mode accounts for much of the risk of failure for this levee reach. This is consistent with the performance history of excessive seepage and boils during flood events.

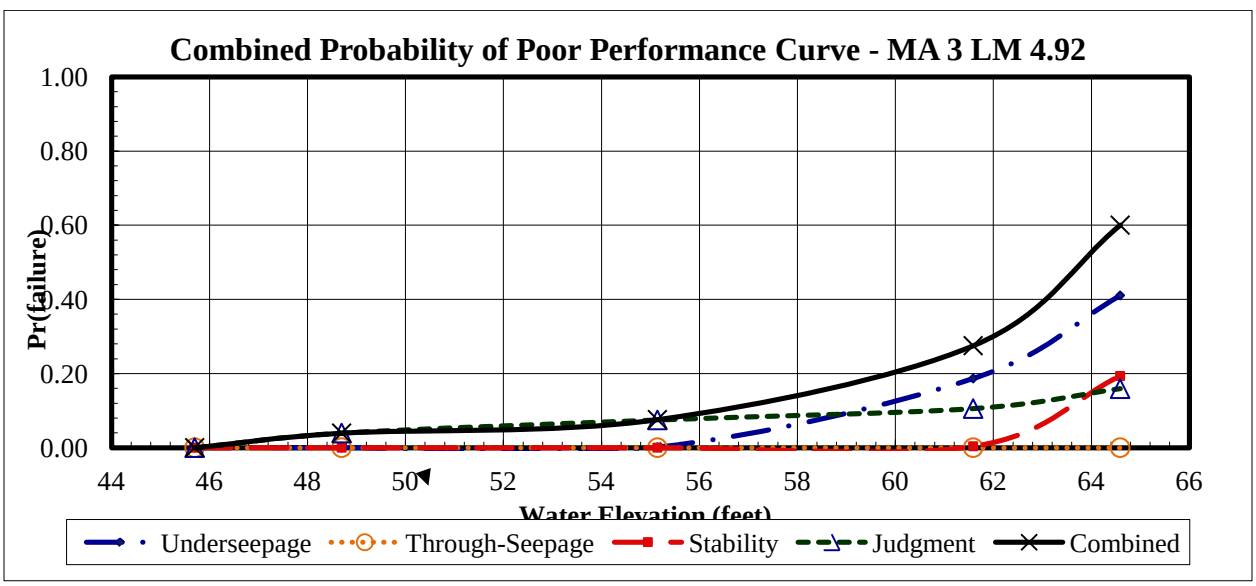

Figure 7-4 Combined R&U, Feather River South (near Bear)

7.6 Feather River South – Abbot/Conner Lakes Reach

The section describes the reach selection and modeling criteria for the Feather River South – Abbot/Connor Lakes reach.

Reach Selection:

This reach of levee was constructed near historic marshland (Abbot and Connor Lakes). The levees here have typically had underseepage problems. Relief wells and a recent setback levee with a cutoff wall in the foundation was constructed to mitigate for hydraulic and underseepage concerns over a portion of this reach; however most of this reach does not have any seepage mitigation measures in place. This reach is located from PLM 6.25 (LD1) downstream to PLM 2.74 (LD1) and is about 4.4 miles long.

Selection of Cross-Section: The cross-section was selected to represent the portion of the reach most likely to breach. This section is located at PLM 3.99.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the blanket varies between 5 and 25.5 feet and consists of clay, sandy clay, and silty sand overlaying a silty sand and gravel aquifer 3-97 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-14.

Table 7-14 Permeabilities, Feather River South (Abbott/Connor Lakes)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Thin or Sandy Clay Blanket (CH, CL, ML)	1.4×10^{-5}	0.04	3.5×10^{-6}	0.01	4
Clay Blanket (CL)	9.8×10^{-6}	0.028	2.5×10^{-6}	0.007	4
Silty Sand Blanket (SM)	3.5×10^{-4}	0.4	3.5×10^{-5}	0.1	4
Silty Sand Aquifer (SM)	9.8×10^{-4}	2.8	9.8×10^{-5}	0.28	10

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Sand Aquifer	$3.5x10^{-3}$	10	$3.5x10^{-4}$	1	10
Sand and Gravel Aquifer (SP-SM, GW-GM)	$2.5x10^{-2}$	70	$2.5x10^{-3}$	7	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-15 as follows.

Table 7-15 Random Variables, Feather River South (Abbott/Connor Lakes)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	14	9	66
Permeability Ratio (k_f/k_b)	10526	10315	98
Foundation Sand thickness (d)	26	25	98

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-16

Table 7-16 Stability Random Variables, Feather River South (Abbott/Connor Lakes)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	29	1	5

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Unit Weight γ (pcf)	120	6	5
Blanket Layer Cohesion c (psf)	150	17	11.5
Blanket Layer Unit Weight γ(pcf))	120	6	5
Blanket Layer Φ(degrees)	31	4	11.5

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-5. The underseepage performance mode accounts for much of the risk of failure for this reach. This is consistent with the performance history of excessive seepage and boils during flood events.

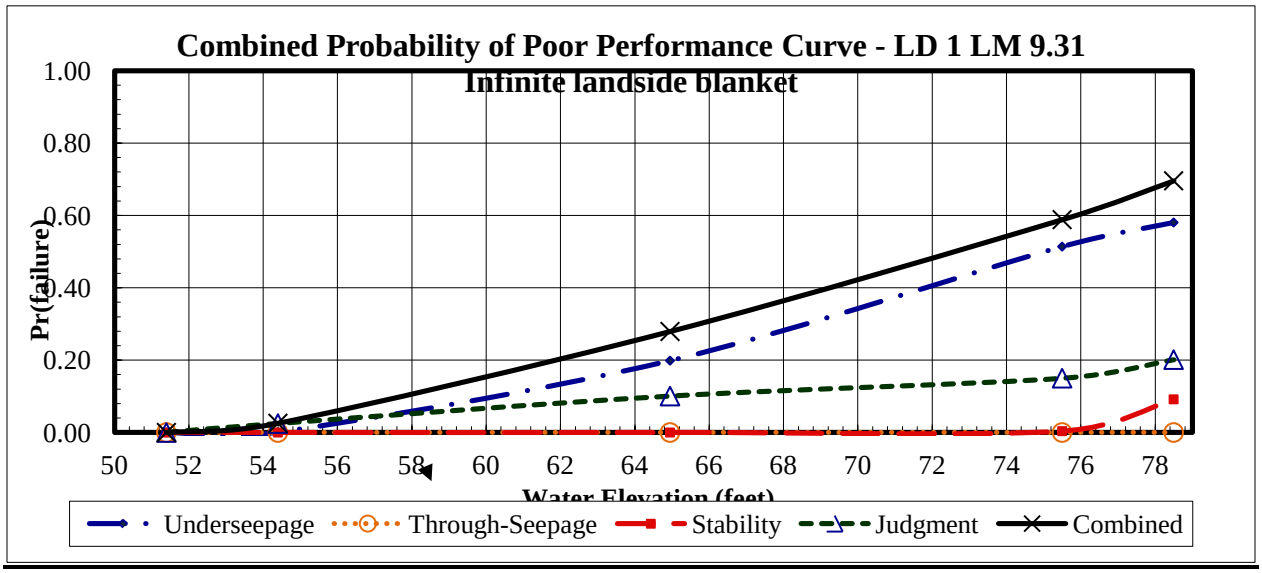

Figure 7-5 Combined R&U, Feather River South (Abbott/Connor Lakes)

7.7 Feather River South – Shanghai Reach

The section describes the reach selection and modeling criteria for the Feather River South – Shanghai Reach.

Reach Selection:

This segment represents the reach nearest to Yuba City where several previous levee strengthening projects have been completed from PLM 16.65 (LD1) downstream to PLM 6.25 (LD1) and is about 9.9 miles long. Levee strengthening projects include relief wells just upstream of Shanghai Bend, a cutoff wall upstream of the relief wells (with a slight overlap), and a stability berm within downtown Yuba City. This levee breached just north (upstream) of Shanghai Bend at approximate PLM 11.8 during the 1955 flood. Portions of this reach have had no levee strengthening projects.

Selection of Cross-Section: The cross-section at PLM 9.31 of LD1 was selected to represent the portion of the reach not protected by a cutoff wall or relief wells; however, the parameters of the blanket and sand thickness were partially derived from the borings in these areas solely for the purpose of developing reasonable statistical parameters.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the blanket varies between 8.5 and 31 feet and consists of clay, silt, and sandy silt overlaying a sand and silty sand aquifer 2.5-30 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-17.

Table 7-17 Permeabilities, Feather River South (Shanghai)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay Blanket (CL)	$9.8x10^{-6}$	0.028	$2.5x10^{-6}$	0.007	4
Silt/Clay Blanket (CL, ML)	$1.4x10^{-5}$	0.04	$3.5x10^{-6}$	0.01	4
Sandy Silt Blanket (ML)	$1.9x10^{-4}$	0.56	$4.9x10^{-5}$	0.14	4
Silty Sand Aquifer (SM)	$9.8x10^{-4}$	2.8	$9.8x10^{-5}$	0.28	10
Silty Sand Aquifer (SM)	$4.2x10^{-4}$	1.2	$4.2x10^{-5}$	0.12	10
Sand Aquifer (SP)	$4.9x10^{-3}$	14	$4.9x10^{-4}$	1.4	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-18 as follows.

Table 7-18 Random Variables, Feather River South (Shanghai)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	17	9	53
Permeability Ratio (k_f/k_b)	773	758	98
Foundation Sand thickness (d)	15	13	87

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-19.

Table 7-19 Stability Random Variables, Feather River South (Shanghai)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	29	1	5
Levee Unit Weight γ (pcf)	120	6	5
Blanket Layer Cohesion c (psf)	150	17	11.5
Blanket Layer Unit Weight γ(pcf))	120	6	5
Blanket Layer Φ(degrees)	31	4	11.5

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-6. The underseepage performance mode accounts for much of the risk of failure for this reach. This is consistent with the performance history of excessive seepage and boils during flood events.

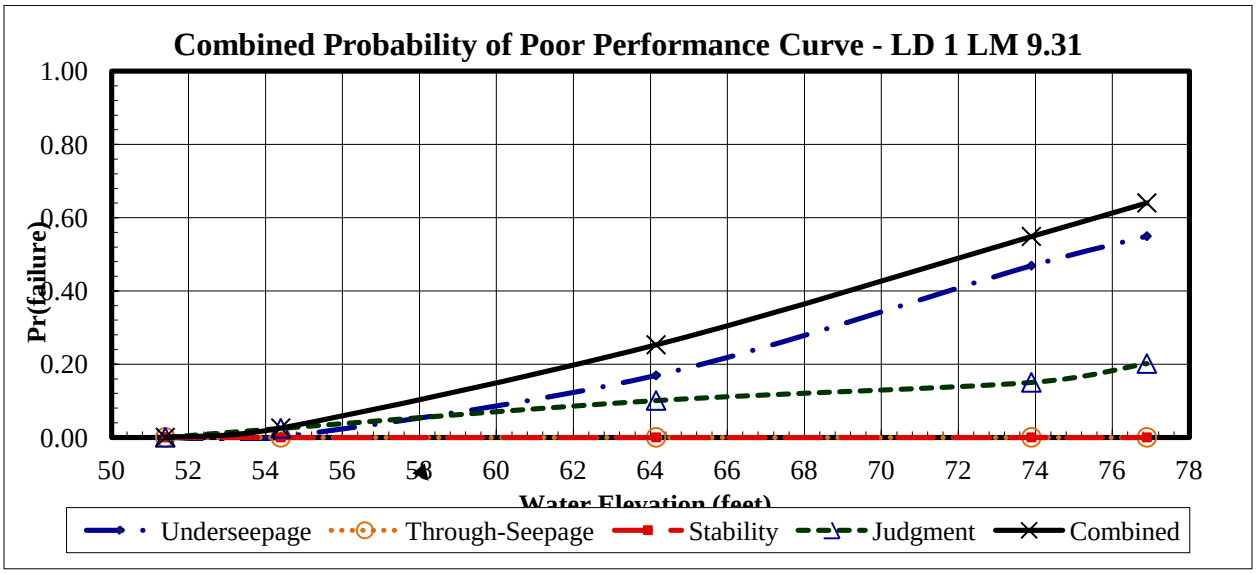

Figure 7-6 Combined R&U, Feather River South (Shanghai)

7.8 Feather River North – LD9 Reach

The section describes the reach selection and modeling criteria for the Feather River North – LD9 Reach.

Reach Selection:

This reach was selected to model the reach north of Yuba City that has experienced distress during flood events but has not had previous seepage or stability improvements, and is not adjacent to the Sutter Butte Canal. This reach is identified as PLM 5.6 downstream to PLM 0.0 of LD9, and is 5.6 miles long.

Selection of Cross-Section: The cross-section was selected to represent the portion of the reach most likely to breach based on previous screening analysis, and is located at PLM 0.52 of Levee District 9.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the blanket varies between 7.5 and 20 feet and consists of clay, silt, and sandy clay overlaying a sand and silty sand aquifer 3.5-37 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-20.

Table 7-20 Permeabilities, Feather River North – LD9

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay Blanket (CL)	$9.8x10^{-6}$	0.028	$2.5x10^{-6}$	0.007	4
Silt/Clay Blanket (CL, ML)	$1.9x10^{-4}$	0.56	$4.9x10^{-5}$	0.14	4
Sandy Clay Blanket (SC)	$1.9x10^{-3}$	5.6	$4.9x10^{-4}$	1.4	4
Silty Sand Aquifer (SW-SM)	$4.9x10^{-3}$	14	$4.9x10^{-4}$	1.4	10
Sand Aquifer (SW)	$9.8x10^{-3}$	28	$9.8x10^{-4}$	2.8	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-21 as follows.

Table 7-21 Random Variables, Feather River North – LD9

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	13	5	38
Permeability Ratio (k_f/k_b)	1730	1217	70
Foundation Sand thickness (d)	28	17	61

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-22.

Table 7-22 Stability Random Variables, Feather River North – LD9

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	29	4	13
Levee Unit Weight γ (pcf)	120	48	40
Blanket Layer Cohesion c (psf)	150	11	7
Blanket Layer Unit Weight γ(pcf))	120	16	13
Blanket Layer Φ(degrees)	31	12	40

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-7. The underseepage performance mode accounts for much of the risk of failure for this reach. This is consistent with the performance history of excessive seepage, and boils during flood events.

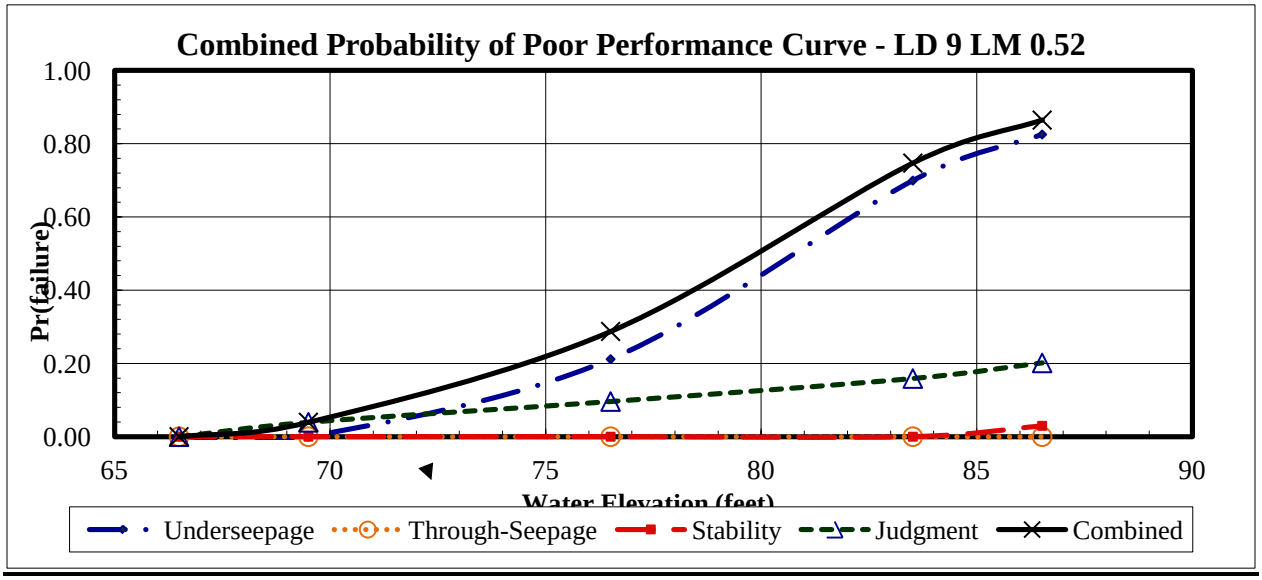

Figure 7-7 Combined R&U, Feather River North – LD9

7.9 Feather River North – Middle Reach

The section describes the reach selection and modeling criteria for the Feather River North – Middle Reach.

Reach Selection:

This reach was selected to model the reach within the agricultural area north of Yuba City that has not experienced any distress during flood events and is not adjacent to the Sutter Butte Canal. This reach is identified as PLM 2.8 downstream to PLM 0.0 of MA 16 and PLM 6.24 downstream to PLM 5.6 of LD9, and is approximately 3.44 miles long.

Selection of Cross-Section: The cross-section at PLM 0.09 of MA 16 was selected to represent this reach.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the blanket varies between 3 and 15 feet and consists of silty clay and clay overlaying a sand and silty sand aquifer 1.5-30 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-23.

Table 7-23 Permeabilities, Feather River North - Middle

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay/Silt Blanket (CL, ML)	$9.8x10^{-6}$	0.028	$2.5x10^{-6}$	0.007	4
Thin Clay/Silt Blanket (CL, ML)	$4x10^{-5}$	0.114	$1.1x10^{-5}$	0.0284	4
Silty Sand Aquifer (SM)	$4.9x10^{-3}$	14	$4.9x10^{-4}$	1.4	10
Sand Aquifer (SP-SM)	$9.8x10^{-3}$	28	$9.8x10^{-4}$	2.8	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-24 as follows.

Table 7-24 Random Variables, Feather River North - Middle

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	6	5	76
Permeability Ratio (k_f/k_b)	2633	1742	56
Foundation Sand thickness (d)	16	8	53

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-25.

Table 7-25 Stability Random Variables, Feather River North - Middle

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	31	4	12
Levee Unit Weight γ (pcf)	125	6	5
Blanket Layer Cohesion c (psf)	150	50	33
Blanket Layer Unit Weight γ(pcf))	115	6	5
Blanket Layer Φ(degrees)	28	3	12

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-8. The underseepage performance mode accounts for much of the risk of failure for this levee reach.

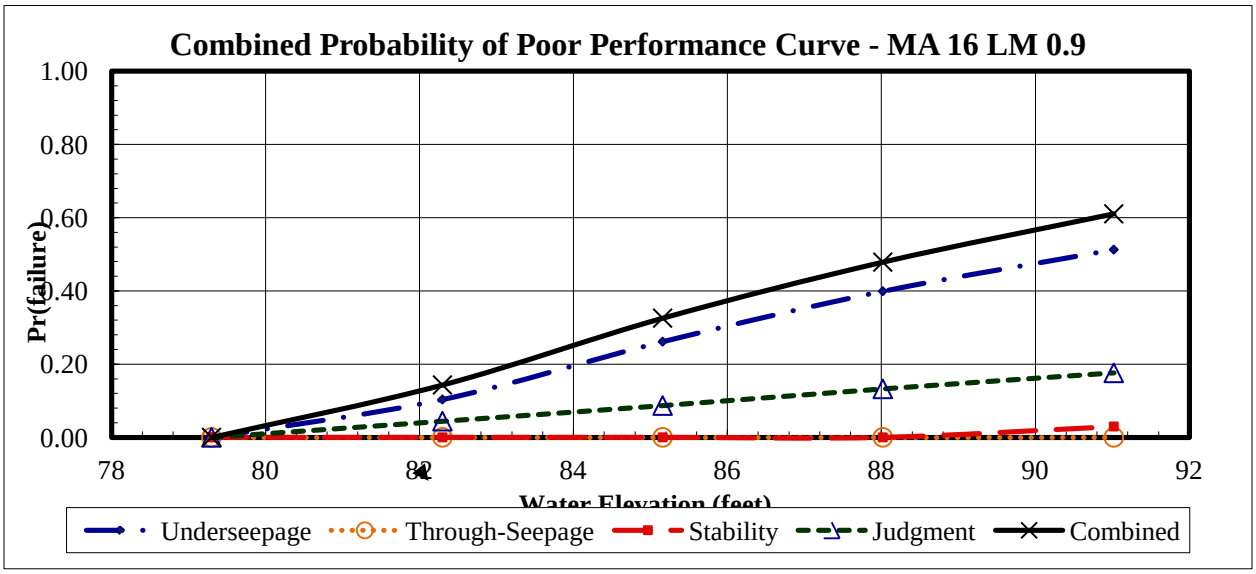

Figure 7-8 Combined R&U, Feather River North - Middle

7.10 Feather River North – Canal Reach

The section describes the reach selection and modeling criteria for the Feather River North-Canal Reach.

Reach Selection:

This reach represents the portion of the North Feather River levee that is abutted by the Sutter Butte Canal from PLM 2.65 downstream to PLM 0 of MA7, and PLM 4.09 downstream to PLM 2.8 of MA16. This reach is approximately 3.94 miles long.

Selection of Cross-Section: The cross-section selected to represent the levee with the irrigation canal is at PLM 2.9 of MA 16.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the blanket varies between 8 and 20 feet and consists of silt, clay, sandy silt, and sandy clay overlaying a sand and silty sand aquifer 3-18 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-26.

Table 7-26 Permeabilities, Feather River North - Canal

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Thin Clay/Silt Blanket (CL, ML)	$3.9x10^{-4}$	1.12	$9.8x10^{-5}$	0.28	4
Clay/Silt Blanket (CL, ML)	$9.8x10^{-6}$	0.028	$2.5x10^{-6}$	0.007	4
Silty Sand/Clayey Sand Blanket (SC, SM)	$1.9x10^{-4}$	0.56	$4.9x10^{-5}$	0.14	4
Silty Sand Aquifer (SM)	$4.9x10^{-3}$	14	$4.9x10^{-4}$	1.4	10
Sand Aquifer (SP-SM)	$9.8x10^{-3}$	28	$9.8x10^{-4}$	2.8	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-27 as follows.

Table 7-27 Random Variables – Feather River North - Canal

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	13	5	41
Permeability Ratio (k_f/k_b)	1053	1032	98
Foundation Sand thickness (d)	12	5	45

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-28.

Table 7-28 Stability Random Variables – Feather River North Canal

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	29	1	5
Levee Unit Weight γ (pcf)	120	6	5
Blanket Layer Cohesion c (psf)	150	17	11.5
Blanket Layer Unit Weight γ(pcf))	120	6	5
Blanket Layer Φ(degrees)	31	4	11.5

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-8. The underseepage and judgment performance modes account almost equally for the risk for this levee reach. In addition to the canal adjacent to the landside toe, there are numerous culverts through this levee, many of which were installed in the 1940's.

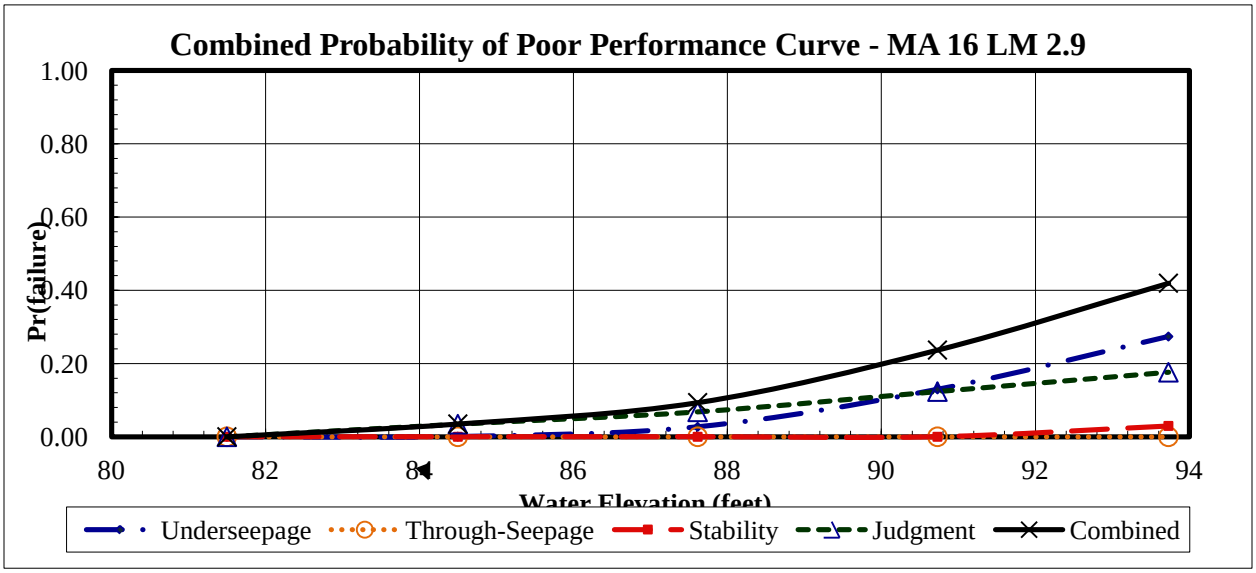

Figure 7-9 Combined R&U, Feather River North - Canal

7.11 Feather River North – Hamilton Bend Reach

The section describes the reach selection and modeling criteria for the Feather River North-Hamilton Bend Reach.

Reach Selection:

This reach is characterized by deposits of dredge tailings (silty and clayey gravel to small cobble size) beneath the levee from roughly PLM 1.20 downstream to PLM 0 (MA 7/Hamilton Bend Unit) and PLM 12.07 downstream to 2.65 (MA 7) for a total of roughly 8.8 miles. The MA 7/Hamilton Bend Unit levee was mostly constructed from the dredge tailings.

Selection of Cross-Section: The cross-section selected to represent the portion of the segment most likely to breach is where the levee is relatively tall at MA 7/Hamilton Bend Unit PLM 0.51.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the blanket varies between 8.5 and 12 feet and consists of clay, sandy silt, sandy clay, and clayey sand overlaying a silty sand and gravel aquifer 10-60.5 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-29.

Table 7-29 Permeabilities, Feather River North – Hamilton Bend

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay Blanket (CL)	9.8×10^{-6}	0.028	2.5×10^{-6}	0.007	4
Sandy Silt/Sandy Clay Blanket (CL, ML)	1.4×10^{-5}	0.04	3.5×10^{-6}	0.01	4
Clayey Sand Blanket (SC)	1.9×10^{-4}	0.56	4.9×10^{-5}	0.14	4
Silty Sand and Gravel Aquifer (SM, GM)	4.9×10^{-3}	14	4.9×10^{-4}	1.4	10
Sand/Gravel Aquifer (SP-SM, SP, GM, GP)	2.5×10^{-2}	70	2.5×10^{-3}	7	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-30 as follows.

Table 7-30 Random Variables – Feather River North – Hamilton Bend

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	12	13	26
Permeability Ratio (k_f/k_b)	11742	11507	98
Foundation Sand thickness (d)	30	21	70

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-31.

Table 7-31 Stability Random Variables – Feather River North – Hamilton Bend

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	29	1	5
Levee Unit Weight γ (pcf)	120	6	5
Blanket Layer Cohesion c (psf)	150	17	11.5
Blanket Layer Unit Weight γ(pcf))	120	6	5
Blanket Layer Φ(degrees)	31	4	11.5

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-10. The underseepage performance mode accounts for almost all of the risk for this levee reach. This is

consistent with the foundation conditions of a thin blanket overlying a highly pervious sand and gravel layer.

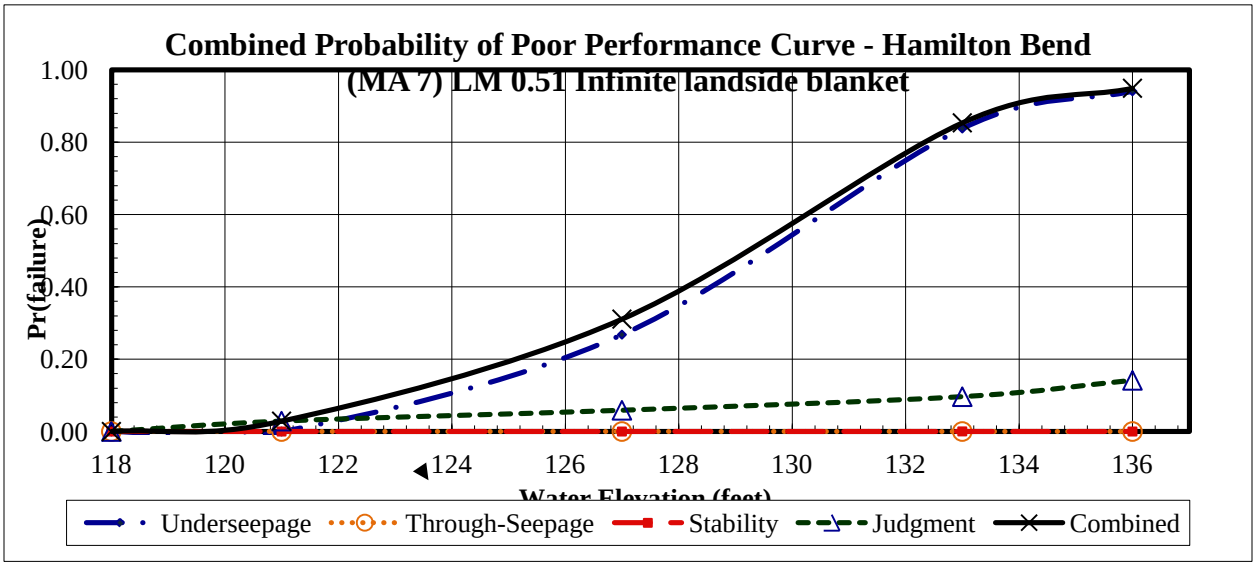

Figure 7-10 Combined R&U, Feather River North – Hamilton Bend

7.12 Cherokee Canal

The section describes the reach selection and modeling criteria for the Cherokee Canal left levee from PLM 9.9 upstream to PLM 6.10.

Reach Selection:

This reach consists of the entire portion of the levee that is within the SBFS. Boring logs on this levee from the Corps' Feasibility Study are in Enclosure D.

Selection of Cross-Section: The cross-section at PLM 9.50 was selected to represent the reach. It is the location of the boring most downstream, and at the location of the tallest portion of the levee. This location overtopped in 1986 due to flooding induced by debris build-up at the railroad bridge immediately downstream.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the blanket varies between 3 and 19 feet and consists mostly of silt and sandy silt with some low-plasticity clay overlaying a sand, silty sand, and clayey sand aquifer 1.5-14.5 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-32.

Table 7-32 Permeabilities, Cherokee Canal

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay Blanket (CL)	$9.8x10^{-6}$	0.028	$2.5x10^{-6}$	0.007	4
Silt Blanket (ML)	$1.4x10^{-5}$	0.04	$3.5x10^{-6}$	0.01	4
Sandy Silt/Clayey Sand Blanket (ML, SC)	$1.9x10^{-4}$	0.56	$4.9x10^{-5}$	0.14	4
Silty Sand/Clayey Sand Aquifer (SM, SC)	$3.5x10^{-4}$	1	$3.5x10^{-5}$	0.1	10
Sand Aquifer (SP, SW)	$3.5x10^{-3}$	10	$3.5x10^{-4}$	1	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-33 as follows.

Table 7-33 Random Variables – Cherokee Canal

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	8	5	63
Permeability Ratio (k_f/k_b)	417	409	98
Foundation Sand thickness (d)	9	5	56

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-34. For this reach, the levee cohesion was varied instead of the foundation cohesion. The foundation consists mostly of silt and sandy silt soils with low to no cohesion.

Table 7-34 Stability Random Variables – Cherokee Canal

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	28	1	5
Levee Unit Weight γ (pcf)	120	6	5
Levee Cohesion c (psf)	150	17	11.5
Blanket Layer Unit Weight γ(pcf))	115	6	5
Blanket Layer Φ(degrees)	29	3	11.5

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-11. The underseepage performance mode accounts for almost all of the risk for this levee reach, although the risk is lower than other reaches in the study. This is consistent with the low levee height and the lack of poor underseepage performance history with this portion of levee.

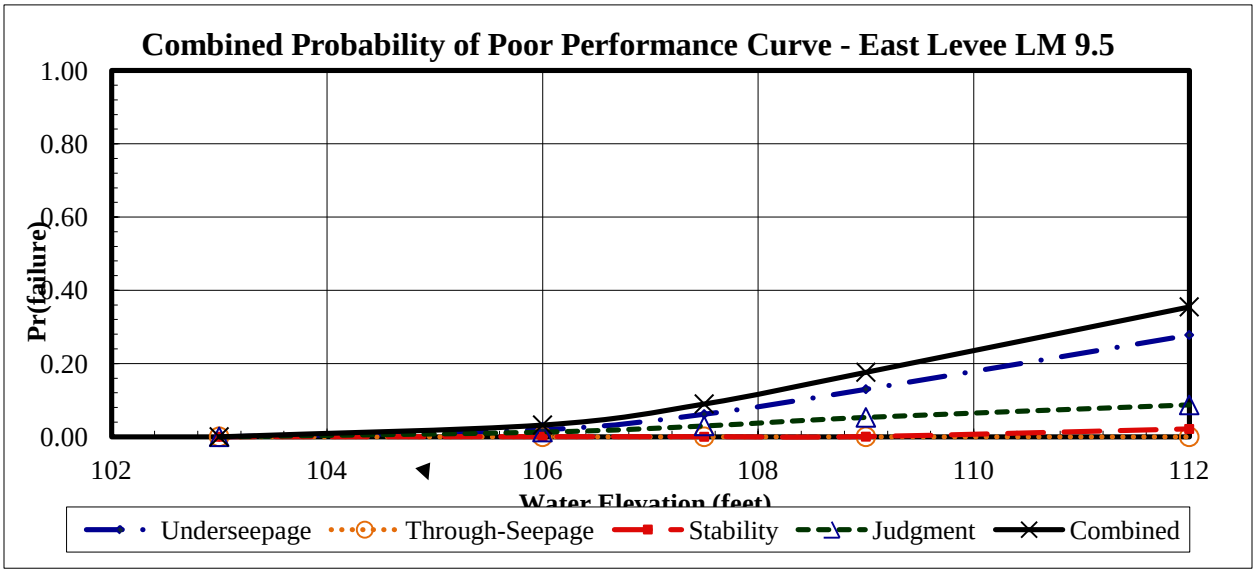

Figure 7-11 Combined R&U, Cherokee Canal

7.13 Wadsworth Canal (right)

There are no existing soil borings along the right levee of the Wadsworth Canal. This levee was added to the Feasibility Study recently at the request of the local sponsor, and this levee is included in the NULE program, which has not had explorations conducted. This levee only protects agricultural land – the small town of Sutter is located on high ground at the base of the Sutter Buttes – so economic damages from a breach would be insufficient to justify Federal interest in modifying or strengthening the levee. Due to the lack of potential economic damages and the time/funding restraints of the 3-3-3 Pilot Study, we decided to base the fragility curve on existing borings on the left levee of the Wadsworth Canal. The canal is about 300 feet wide (levee crest centerline to levee crest centerline).

Reach Selection: One reach, from PLM 0.00 to 4.66, was used for this levee, due to the lack of subsurface data.

Selection of Cross-Section: The cross section at PLM 0.50 was selected to represent this reach. This levee increases in height from about 5 feet at the upstream end to 20 feet at the downstream end, and the left bank levee has experienced seepage and boils during floods at the downstream end.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. Since this index point is located downstream of the index point on the left side of the canal, the underseepage statistical parameters for this reach were determined using more borings within the cutoff wall extent on the left side. The thickness of the blanket varies between 4 and 10 feet and consists of clay, silt, sandy clay, and sandy silt, overlaying a sand, silty sand, and clayey sand aquifer 3-28 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-35.

Table 7-35 Permeabilities, Wadsworth Canal (Right)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay Blanket (CL)	9.8×10^{-6}	0.028	2.5×10^{-6}	0.007	4
Silt Blanket (ML)	4.9×10^{-5}	0.14	1.2×10^{-5}	0.035	4
Silty Sand Blanket (ML)	4.9×10^{-4}	1.4	1.2×10^{-4}	0.35	4

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Silty Sand Aquifer (SM)	$4.9x10^{-4}$	1.4	$4.9x10^{-5}$	0.14	10
Sand with Silt/Clay Aquifer (SP-SC, SP-SC)	$4.9x10^{-3}$	14	$4.9x10^{-4}$	1.4	10
Sand Aquifer (SP)	$9.8x10^{-3}$	28	$9.8x10^{-4}$	2.8	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-36 as follows.

Table 7-36 Random Variables – Wadsworth Canal (Right)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	7	2	29
Permeability Ratio (k_f/k_b)	1244	1219	98
Foundation Sand thickness (d)	13	11	85

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-37.

Table 7-37 Stability Random Variables – Wadsworth Canal (Right)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	32	4	13

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Cohesion c (psf)	10	4	40
Levee Unit Weight γ (pcf)	125	9	7
Blanket Layer Φ(degrees)	28	4	13
Blanket Layer Cohesion c (psf)	100	40	40

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-12. The underseepage performance mode accounts for almost all of the risk for this levee reach. This is consistent with the thin blanket layer compared to the levee height near the index point and the history of excessive seepage and boils in the downstream part of this reach.

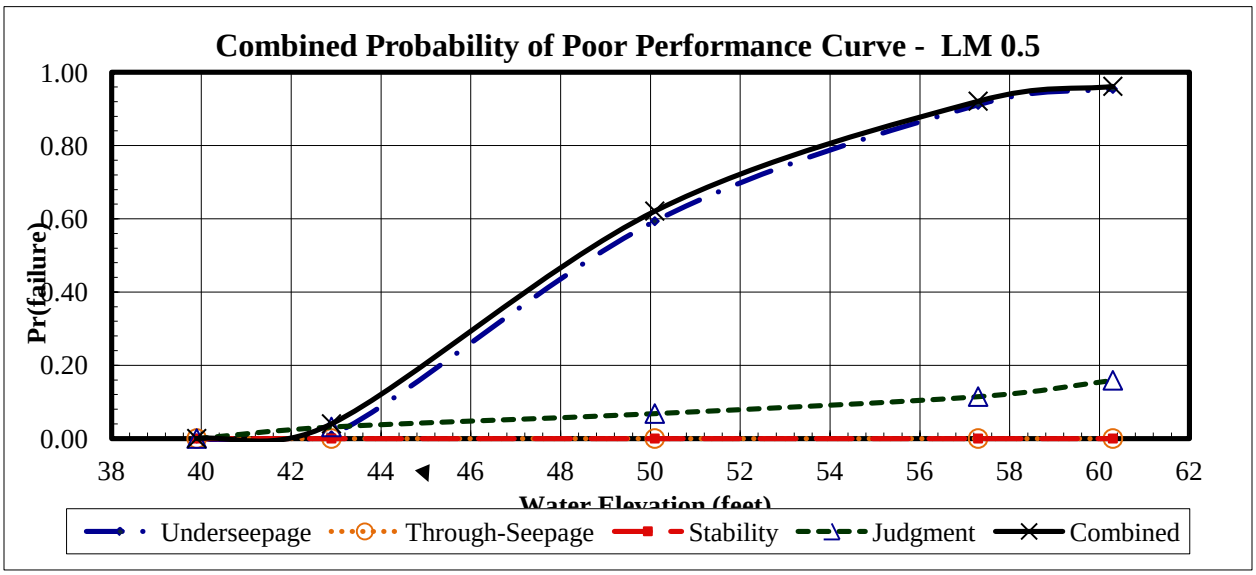

Figure 7-12 Combined R&U, Wadsworth Canal (Right)

7.14 Sutter Bypass (upstream)

There are no existing soil borings along the left levee of the Sutter Bypass upstream of Wadsworth Canal. This levee was added to the Feasibility Study recently at the request of the local sponsor, and this levee is included in the NULE program, which has not had explorations

conducted. This levee only protects agricultural land – the small town of Sutter is located on high ground at the base of the Sutter Buttes – so any economic damages from a breach would be insufficient to justify Federal interest in modifying or strengthening the levee. Due to the lack of potential economic damages and the time/funding restraints of the Pilot Study, we decided to base the fragility curve on existing borings on the Sutter Bypass downstream of the Wadsworth Canal.

Reach Selection: One reach, from PLM 0.00 to 4.31, was used for this levee, due to the lack of subsurface data.

Selection of Cross-Section: The cross section at PLM 4.0 was selected to represent this reach. The levee height and levee geometry do not vary significantly over this reach, and this cross section is just upstream of the Wadsworth Canal, not far from the closest soil boring on the Sutter Bypass downstream of the Wadsworth Canal.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. Since there are no soil borings in this levee reach, the same borings, permeabilities, and statistical parameters were used for this reach as for the Sutter Bypass (Upper) Reach. The permeabilities are summarized in Table 7-38 and the random variables are shown on Table 7-39 (identical to Tables 7-5 and 7-6 respectively).

Table 7-38 Permeabilities, Sutter Bypass (Upstream)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay/Sandy Clay Blanket (CL)	$9.8x10^{-6}$	0.028	$2.5x10^{-6}$	0.007	4
Silty Sand Blanket (SM)	$4.2x10^{-4}$	1.2	$1x10^{-4}$	0.3	4
Silty Sand Aquifer(SM)	$1x10^{-3}$	3	$1x10^{-4}$	0.3	10
Sand with Silt Aquifer (SP-SM)	$3.5x10^{-3}$	10	$3.5x10^{-4}$	1	10

Table76-39 Random Variables – Sutter Bypass (Upstream)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	10	4	40
Permeability Ratio (k_f/k_b)	725	650	90
Foundation Sand thickness (d)	10	6	60

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-40. The stability parameters used for this reach were based solely on the closest boring to the index point, whereas the stability parameters used for the Sutter Bypass (Upper) Reach were based on borings further downstream, closer to that index point.

Table 7-40 Stability Random Variables – Sutter Bypass (Upstream)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	28	3	12
Levee Unit Weight γ (pcf)	115	6	5
Blanket Layer Cohesion c (psf)	200	66	33
Blanket Layer Unit Weight γ (pcf)	115	6	5
Blanket Layer Φ(degrees)	28	3	12

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-13. The underseepage performance mode accounts for almost all of the risk for this levee reach at low water surface elevations; underseepage and stability both contribute to the risk at high water elevations. Even though the same random variables were used for this reach as for the Sutter Bypass (Upper) Reach, the underseepage curve is slightly different because the levee at this

index point is about 6 feet shorter than the levee at the Sutter Bypass (Upper) index point. This is consistent with the thin blanket layer compared to the levee height near the index point.

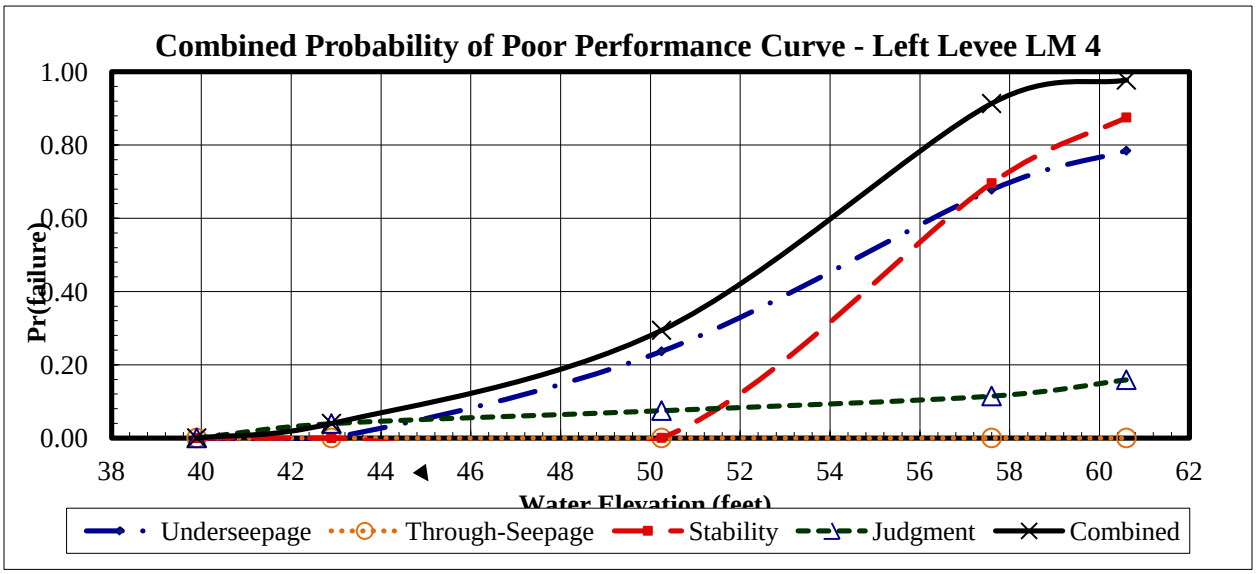

Figure7-13 Combined R&U, Sutter Bypass (Upstream)

8 GEOTECHNICAL ASPECTS OF FEASIBILITY STUDY ALTERNATIVES

8.1 General

Eight draft alternatives for reducing the flood risk within the SBFS system levees were developed as part of the Feasibility Study. The plan formulation process, including description of the draft array of alternatives, screening of alternatives, and the recommended Tentatively Selected Plan (TSP), is covered in detail in Chapter 3 of the main Feasibility Study report. During the screening of the draft array of alternatives, geotechnical recommendations for seepage and stability remediation for fix-in-place alternatives and seepage controls for non-fix in place alternatives (e.g. new ring levees, setback levees, etc.) were developed based in large part using engineering judgment. This Class 4 (reconnaissance level) approach was used to equalize the potential differences between seepage controls recommended for segments with existing geotechnical data, and those that had no subsurface data (non-fix-in-place measures). The approach assumed that cutoff walls were the primary method for seepage control, and the design of the measures (e.g. length, depth, percentage of reach, etc) was selected using judgment and the principal of most likely minimum and maximum for each value. After identifying a range, a expected mean value was selected again using judgment based on experience. This approach was used for evaluation of the draft array of alternatives only, and a memorandum documenting this action is in Enclosure H of this report. The design of the final array of alternatives was based on a Class 3 (feasibility level) conventional approach using existing subsurface explorations and deterministic seepage and stability analyses.

The remainder of this chapter in the Geotechnical Appendix to the Feasibility Study discusses the geotechnical aspects of the final array of alternatives. The final array of alternatives is:

- Alternative SB-1: No action
- Alternative SB-7: Fix-in-Place Feather River Levees: Sunset Weir to Laurel Avenue
- Alternative SB-8: Fix-in-Place Feather River Levees: Thermalito Afterbay to Laurel Avenue

8.2 Minimum Levee Design Criteria

Minimum levee design criteria from four sources (EM 1110-2-1913, Sacramento District Geotechnical Levee Practice, DWR Urban Levee Design Criteria, and the Code of California Regulations (CCR) Title 23 Division 1) is shown on Plate 10. The criteria are slightly different between the sources; in summary, the requirements are for a crest width of 10-20 feet, sideslopes of 2H:1V to 3H:1V, a landside easement of 10-20 feet, and a waterside easement of 15 feet. The Sacramento District Geotechnical Levee Practice and DWR Urban Levee criteria are for newly-

constructed levees; exceptions may be allowed on a case-by-case basis for the reconstruction/improvement of existing levees. The Sacramento District allows a narrower crest width for existing levees that have improvements constructed to address seepage and stability concerns, although we generally will not go narrower than 15 feet to allow for 2-way pickup truck traffic on the levee crest. The Sacramento District also will accept whatever landside or waterside easement the local sponsor has. In cases where there is no existing landside easement, we require a minimum easement of 10 feet in urban areas. In conjunction with the Sacramento District Levee Safety Program Manager, the following minimum levee template criteria were adopted for this Feasibility Study:

- Crest width: 15 feet
- Landside slope: 2H:1V
- Waterside slope: 3H:1V where levee is being reshaped or relocated; existing slope at other locations
- Landside easement: 15 feet or the existing easement
- Waterside easement: 15 feet

The existing landside and waterside easements along the FRWL are not known at this time. Sponsors/LMAs frequently do not have records of their easements, and experience on other projects shows the work to determine the existing easements can take up to a year to complete. The Feasibility Study Real Estate maps were produced assuming a 15-foot waterside easement over the entire FRWL, a 15-foot landside easement in the urban area of Yuba City (between SBFCA stations 821+00 to 1135+00), and a 20-foot landside easement outside of Yuba City, except at one location where there is an existing 10-foot bench between the landside levee toe and the Sutter Butte Canal. At that location, a 10-foot landside easement is shown on the Real Estate Maps. The existing easements will be researched during the Planning and Engineering Design (PED) phase to develop a record of the existing easements and determine what easements need to be purchased.

8.3 Alternative SB-1: No Action

Under the No Action alternative, the existing condition of the levees as described in Chapters 1 and 7 of this report will continue into the future. The FRWL will continue to experience seepage-related distress during future flood events. Floodfighting will continue to be an expense for the LMAs and PL 84-99 rehabilitation assistance will continue to be an expense for the Federal Government (as long as the levees are active in the program). Individuals and critical infrastructure within the SBLS will remain at high risk from future flood events.

8.4 Alternatives SB-7 and SB-8 (in Relation to the SBFCA FRWL Improvement Project)

8.4.1 General

Due to the time and funding constraints of the Pilot Study process, the Feasibility Study Project Delivery Team (PDT) relied heavily on the SBFCA FRWL Improvement Project design reports for the proposed improvements, plans, quantity take-offs, and cost estimates for developing the Feasibility level design and cost estimate for Alternatives SB-7 and SB-8. Currently the SBFCA FRWL Improvement Project is at the 90% design level for the Contract C area between Shanghai Bend and Live Oak (LD 1 PLM 11.08 to MA16 PLM 2.87, SBFCA station 844+00 to 1625+00). The areas between Laurel Avenue and Shanghai Bend (MA3 PLM 3.64 to LD 1 PLM 10.66, SBFCA station 180+00 to 832+00), and Live Oak to Thermalito Afterbay outlet channel (MA 7 PLM 0.00 to Hamilton Bend PLM 1.20, SBFCA station 1625+00 to 2367+00) are at the 65% design level. The Feasibility Study design and cost estimate are based on the SBFCA 65% design submittal; the 90% design for the Contract C area was submitted in October 2012, and the Feasibility Study effort needed to get underway in July 2012 to stay on schedule. While design modifications between 65% and 90% submittals can and do occur, a 65% design submittal is more detailed than the usual Feasibility-level design, and the contingency added to the Feasibility Study cost estimate is expected to account for changes between the 65% design and the final design.

8.4.2 Remediation Measures

Where the existing levee meets the geotechnical seepage and stability criteria, due to either an existing cutoff wall or levee geometry/subsurface conditions, no remediation is needed. Where remediation is needed, cutoff walls are the primary feature of the SBFCA project for remediating geotechnical deficiencies of the existing FRWL for the following reasons:

- Cutoff walls are highly effective when constructed properly
- Cutoff walls do not require the acquisition of additional permanent real estate
- Cutoff walls do not require maintenance once constructed
- Cutoff walls constructed by the conventional open-trench method are cost comparable to landside seepage berms
- Cutoff walls have minimal long-term environmental impact primarily due to their location within the existing levee footprint.

Early in their design process, the SBFCA design team evaluated two primary measures for remediation of the FRWL. In general, the measures were a fully-penetrating soil-bentonite (SB) cutoff wall and a shallow SB cutoff wall combined with a seepage berm or relief wells (both alternatives include a partial levee degrade to obtain the needed working platform width). A reach-by-reach cost comparison between the two measures showed a fully-penetrating SB cutoff wall was the least cost measure for most reaches (see Chapters 8 and 9 in the main Pre-Design Formulation Report). However, site conditions dictated selection of a different measure for some reaches or portions of reaches. Those conditions are summarized in the following bullets.

- A cutoff wall with a full levee degrade is proposed where the levee has a severe burrowing rodent infestation just north of Yuba City and to prevent having to use the more expensive Deep Mixing Method (DMM) for cutoff wall construction due to depth just north of Shanghai Bend.

- Jet grout cutoff walls are proposed at locations where it is not practical to construct a conventional SB cutoff wall (i.e. bridges, railroad crossings, and the Yuba City Water Treatment Plant).
- Seepage berms by themselves are used in the northernmost end of the FRWL because a conventional SB cutoff wall may not be constructible through the cobble levee.
- Partially penetrating cutoff walls combined with seepage berms or relief wells are used in the southern end of the FRWL because fully-penetrating cutoff walls would need to be too deep to be cost-effective.

The Feasibility Study PDT modified the SBFCA 65% plans to address some minor differences between the SBFCA 408 project and the recommended Feasibility project (see section 8.5 of this report for details of the modifications). The modified SBFCA 65% plans are given in Appendix M of this report, but are provided as a separate file. Table 8-1 lists the proposed remedial measures from the SBFCA 65% plans from downstream to upstream. There are overlaps at the transitions between remedial measures (for example, an SB cutoff wall to a jet grout cutoff wall).

Table 8-1 Proposed Remedial Measures, SBFCA FRWL Improvement Project, 65% Plans

Location (PLM)	Location (SBFCA Stationing)	Remedial Measures
MA3 PLM 3.26 to MA3 PLM 4.19	180+00 to 230+00	Degrade levee to approximately half-height, SB cutoff wall (depth 27 ft), reconstruct levee, seepage berm, culvert replacement
MA3 PLM 4.19 to LD1 PLM 3.24	230+00 to 451+00	Degrade levee to approximately half-height, SB cutoff wall (depth 33 to 88 ft), reconstruct levee, culvert removal, culvert replacement
LD PLM 3.24 to LD1 PLM 3.71	451+00 to 476+00	Degrade levee to approximately half-height, SB cutoff wall (depth 41.5 ft), reconstruct levee, seepage berm, culvert removal
LD1 PLM 3.71 to LD1 PLM 4.61	476+00 to 513+50	No work (Star Bend setback levee/cutoff wall) *(Note: See paragraph 8.4.3 for additional information on the Star Bend area)*
LD1 PLM 4.61 to LD1 PLM 10.66	513+50 to 832+00	Degrade levee to approximately half-height, SB cutoff wall (depth 40 to 73 ft), reconstruct levee, new relief wells (sta 545+00 to 570+00 only), culvert removal, culvert replacement
LD1 PLM 10.66 to LD1 PLM 11.08	832+00 to 844+00	No work (Shanghai Bend setback levee/cutoff wall)
LD1 PLM 11.08 to LD1 PLM 12.21	844+00 to 898+00	Degrade entire levee, SB cutoff wall (depth 85 ft), reconstruct levee, rehabilitation or replacement of existing relief wells, culvert replacement

Location (PLM)	Location (SBFCA Stationing)	Remedial Measures
LD1 PLM 12.21 to LD1 PLM 12.70	898+00 to 923+75	Degrade levee to approximately half-height, SB cutoff wall (depth 44'), reconstruct levee, culvert replacement
LD1 PLM 12.70 to LD1 PLM 14.34	923+75 to 1006+04	Encroaching structure demolition (existing Yuba City cutoff wall)
LD1 PLM 14.34 to LD1 PLM 14.38	1006+04 to 1007+90	Jet grout cutoff wall (depth 41') at railroad and Fifth St. bridges
LD1 PLM 14.38 to LD1 PLM 14.61	1007+90 to 1023+70	Culvert removal (existing Yuba City cutoff wall)
LD1 PLM 14.61 to LD1 PLM 14.70	1023+70 to 1028+30	Stability berm, fill in unused tunnel at 10th Street bridge
LD1 PLM 14.70 to LD1 PLM 15.64	1028+30 to 1077+85	Culvert replacement (existing Yuba City cutoff wall)
LD1 PLM 15.64 to LD1 PLM 15.98	1077+85 to 1096+00	Degrade levee to approximately half-height, SB cutoff wall (depth 40 ft), reconstruct levee, culvert replacement
LD1 PLM 15.98 to LD1 PLM 16.03	1095+80 to 1098+30	Jet grout cutoff wall (depth 40 ft) at water treatment plant, culvert replacement
LD1 PLM 16.03 to LD1 PLM 16.63	1098+10 to 1129+98	Degrade levee to approximately half-height, SB cutoff wall (depth 40 to 77 ft), reconstruct levee, culvert replacement
LD1 PLM 16.62 to LD1 PLM 16.64	1129+49 to 1130+67	Jet grout cutoff wall (depth 77 ft), stoplog structure installation at railroad track crossing
LD1 PLM 16.64 to LD9 PLM 6.14	1130+20 to 1455+00	Degrade levee to approximately half-height, SB and DMM cutoff wall (depth 29 to 120 ft), reconstruct levee, culvert removal, culvert replacement *(Note: Alternative SB-7 ends at station 1433+83)*
LD9 POM 6.14 to MA 16 PLM 0.01	1455+00 to 1461+00	Degrade entire levee, SB cutoff wall (depth 35 ft), reconstruct levee
MA16 PLM 0.01 to MA16 PLM 3.15	1461+00 to 1625+00	Degrade levee to approximately half-height, SB cutoff wall (depth 26 to 62 ft) , reconstruct levee, culvert removal, culvert replacement
MA16 PLM 3.15 to MA16 PLM 4.06	1625+00 to 1673+00	Culvert replacement (short levee, no adjacent canal)
MA 16 PLM 4.06 to MA7 PLM 1.83	1673+00 to 1769+31	Degrade levee to approximately 20 to 50% of height, SB cutoff wall (depth 26 to 48 ft), reconstruct levee with shallower sideslopes, culvert replacement

Location (PLM)	Location (SBFCA Stationing)	Remedial Measures
MA7 PLM 1.83 to MA7 PLM 2.66	1769+31 to 1813+33	Culvert replacement (short levee, no adjacent canal)
MA7 PLM 2.66 to MA7 PLM 4.34	1813+33 to1900+50	Degrade levee to approximately 20 to 50% of height, SB cutoff wall (depth 18 to 73 ft), reconstruct levee, culvert removal, culvert replacement
MA7 PLM 4.33 to MA7 PLM 4.40	1900+00 to 1904+00	Jet grout cutoff wall (depth 78 ft) at Gridley bridge
MA7 PLM 4.39 to MA7 PLM 11.85	1903+50 to 2292+00	Degrade levee to approximately half-height, SB and DMM cutoff wall (depth 17 to 90 ft), reconstruct levee, culvert removal, culvert replacement
MA7 PLM 11.81 to MA7 PLM 12.06	2290+00 to 2303+00	Seepage berm (170 ft wide)
MA7 PLM 12.06 to Hamilton Bend PLM 0.51	2303+00 to 2330+75	Culvert removal (short, wide levee)
Hamilton Bend PLM 0.51 to Hamilton Bend PLM 1.20	2330+75 to 2367+00	Seepage berm (100-120 ft wide), culvert removal

The remainder of this section of this report gives locations only in SBFCA stationing, since PLMs are not shown in the SBFCA project geotechnical reports and the 65% design plans.

8.4.3 Star Bend

Star Bend is a 90-degree bend in the Feather River and the FRWL located approximately 8.7 miles south (downstream) of downtown Yuba City (SBFCA stations 478+50 to 512+00). As stated in paragraph 1.2.4.3 of this report, a setback levee with a 40 to 65-foot deep SB cutoff wall through the foundation was constructed at Star Bend by the LMA in 2008. The project sponsor would like to obtain reimbursement credit for the setback levee/cutoff wall under the Feasibility Study. Since the construction of setback levees with cutoff walls in the foundation is more expensive than fixing existing levees in place, the SBFS did not include a setback levee at Star Bend in any of the Study alternatives. The sponsor will only get reimbursement credit based on the cost of fixing the Star Bend levee in place by degrading the levee to approximately half it's height and constructing an SB cutoff wall with a depth of 65 feet.

8.5 Feasibility Study Modifications to SBFCA FRWL Improvement Project 65% Design Submittal

The SBFCA FRWL project design is being thoroughly reviewed at every phase for the 408 modification process. The design A/E firms (Wood Rodgers, HDR, MHM, Blackburn Consulting, and URS) do internal quality control review, and additional review is conducted by SBFCA, DWR, the Central Valley Flood Protection Board, and the Sacramento District. An Independent Panel of Experts (IPE) provides external and Safety Assurance Review (SAR). For the Feasibility Study, the PDT reviewed the 65% submittal to determine if it includes any improvements that are beyond Federal interest (and would be 100% sponsor cost) and if any improvements do not meet minimum study criteria. For the geotechnical discipline , nothing in the submittal was determined to be beyond Federal interest. However, three items, not directly geotechnical but related to levee safety, do not meet minimum Corps requirements. Those three items are discussed below.

8.5.1 Vegetation Removal

The Corps conditions for acceptance of a major/minor modification under the 408 process do not require all Corps requirements to be met. The Corps will approve proposed modifications under 408 as long as the levee integrity will not be reduced and any levee improvements may be credited to the Sponsor as long as the improvements are in agreement with the Feasibility Study approved improvement plan. The FRWL currently has mature trees on the both the levee slopes and within 15 feet of both the landside and waterside levee toes, with the majority of the trees being within 15 feet of the toes. The SBFCA plans include removal only of trees required to do the project construction. The Feasibility Study proposed plan for ETL 1110-2-571 compliance is for complete removal of all vegetation from the vegetation free zone as shown in the ETL. The PDT developed a cost estimate for removal of the woody vegetation from the levee vegetation free zone. Tree removal (and associated mitigation) costs were based on an estimate done by SBFCA. The estimated cost of ETL 1110-2-571 compliance by removal of woody vegetation is within the overall Feasibility Study cost contingency. A memorandum documenting this action is in Enclosure I of this report.

8.5.2 Landside Easement at the Sutter Butte Canal

At four locations (about 3.3 miles total length), the Sutter Butte Canal is adjacent to the landside levee toe, without a landside access easement. These locations are, from downstream to upstream:

- Station 1430+00 to 1449+00
- Station 1610+50 to 1623+00
- Station 1675+00 to 1765+80
- Station 1904+00 to 1957+00

The upstream location has a small landside bench, approximately 10 feet wide, between the levee toe and the canal. This bench can provide a 10-foot minimum required landside easement with some minor regrading. The PDT evaluated four options to obtain a landside easement at the other three locations. The options are:

1. Cut a horizontal bench into the landside levee toe at the cutoff wall degrade elevation and construct a retaining wall to replace the lower levee slope
2. Replace the levee with a floodwall
3. Realign the levee 15 feet to the waterside
4. Relocate the canal away from the levee toe

Option 3 was selected for the two downstream locations. At the third location (station 1675+00 to 1765+80), the levee is adjacent to the river at the upstream end of the location (station 1753+00 to 1765+80). Option 3 was selected for the downstream portion of this location (station 1675+00 to 1753+00) and option 4 was selected for the upstream portion of this location (station 1753+00 to 1765+80). Typical cross sections were prepared for all four locations and cost estimates were prepared for the selected option at each location. The Civil Design Appendix contains additional discussion of this issue.

8.5.3 Landside Slope Protection for Levee Superiority

The definition of levee superiority per EC 1110-2-6066 (Design of I-Walls, 31 October 2010) is the increment of additional height added to a flood risk management system to increase the likelihood that when the design event is exceeded, controlled flooding will occur at the design overtopping section. Since alternatives SB-7 and SB-8 are based on an existing levee profile, the design top of levee was reviewed relative to the modeled mean water surface profiles to determine the likely initial overtopping location. The initial overtopping in the alternative SB-7 footprint will likely occur between SBFCA stations 547+00 to 604+60. The initial overtopping in the footprint only covered by alternative SB-8 will likely occur between SBFCA stations 1582+00 to 1601+00. These locations are in non-urbanized areas and initial overtopping is estimated to occur between the mean 0.5% (1/200) ACE and 0.2% (1/500) ACE events. Within these 1-mile sections, the landside levee slope will be covered with an anchored High Performance Turf Reinforcement Mat (HPTRM). This design will increase the erosion resistance of the landside levee slope at the initial overtopping locations.

8.6 Overview of SBFCA Geotechnical Analysis

8.6.1 Existing Conditions

The Geotechnical Analyses for Pre-Design Formulation Report (PFR) (Appendix D of the PFR, dated August 2011), includes seepage and slope stability analyses for the existing condition of the FRWL. The PFR divided the levee into 41 reaches. One cross section was analyzed per reach. The analyses were conducted to determine which portions of the levee require remediation and to evaluate the effectiveness of various remedial measures. Analyses were

conducted at two water surfaces; the design water surface (DWS) and the hydraulic top of levee (HTOL). The DWS is defined as the 0.5% (1/200) Annual Chance of Exceedance (ACE) upstream of station 461+00 (located just downstream of the Star Bend setback levee) and the 1% (1/100) ACE downstream of station 461+00. (California state law, enacted in 2007 (SB 5), requires urban levees (defined as levees in areas of 10,000 people or more) to be designed to the 0.5% (1/200) ACE). Note that the DWS used in the SBFCA geotechnical design is not the project authorized water surface as described in the Hydraulic Appendix. The hydraulic top of levee (HTOL) is defined as the lowest of:

- The 0.5% (1/200) ACE plus 3 feet water surface upstream of station 461+00 and the 1% (1/100) ACE plus 3 feet water surface downstream of station 461+00
- The 0.2% (1/500) ACE water surface
- The levee crest elevation

One foot was added to the appropriate water surface elevations to evaluate remediation measures. The DWS+1 foot elevation was compared with the project authorized water surface at selected locations along the Feather River and the elevations agree within a foot.

For each cross section, analyses were conducted in the following order:

- Seepage at the DWS
- Seepage at the HTOL
- Landside slope stability at the DWS
- Landside slope stability at the HTOL
- Rapid Drawdown slope stability

The seepage analyses were done first due to the performance history of the FRWL, which has experienced extensive seepage-related distress but little stability-related distress during floods. If a section did not meet criteria for any analysis, it was determined to be in need of remediation, and the remaining existing conditions analyses were not conducted. Each section found to be in need of remediation was then re-analyzed with two remediation measures in place, generally a cutoff wall and a seepage berm.

Section 4.0 of the Geotechnical Analysis for the PFR describes the methodology used to select sections and parameters for seepage and stability analyses. Table 4-4 of the Geotechnical Analysis for the PFR gives seepage exit gradient criteria for the SBFCA design. Section 5.0 of the Geotechnical Analysis for the PFR discusses analysis results. Tables 5-1A through 5-41B of the Geotechnical Analysis for the PFR summarize the levee/foundation characterization and the seepage/stability analysis results for each reach. Those tables are included in Enclosure J of this report. Stick log profiles of the FRWL are given in Appendix A of the Geotechnical Analysis for the PFR. Analysis cross sections are shown in Appendix B of the Geotechnical Analysis for the PFR. The Geotechnical Analysis for the PFR is in Enclosure M of this report, but is provided as a separate file for ease of review. Most cross sections analyzed did not meet the project seepage criteria. This agrees with the deterministic and probabilistic analyses done for this study and the deterministic analyses done for the DWR ULE study, which show underseepage to

be the primary contributor to poor performance of the FRWL. This also agrees with the performance history of extensive seepage-related distress on the FRWL.

8.6.2 With-Project Conditions

Two final geotechnical reports were submitted in October 2012; the Geotechnical Design Recommendations Report (GDRR) (2 volumes) and the Geotechnical Data Report (GDR). These reports cover the entire Feather River West Levee from the Sutter Bypass confluence upstream to the Thermalito Afterbay outlet channel. These reports are included in Enclosure M of this report, but provided as separate files. The final GDR includes results of all geotechnical explorations done under the SBFCA FRWL Improvement Project. The final GDRR includes a general description of the levees; past performance history; remedial measures constructed to date; seismic vulnerability analysis; and with-project seepage and slope stability analyses conducted to support the levee improvements as shown on the 65% project plans. Stick log profiles of the FRWL are given in Appendix A of the final GDRR. The stick log profiles with the final GDRR contain explorations conducted by the FRWL Improvement Project and the DWR ULE project subsequent to the submittal of the Geotechnical Analysis for the PFF. With-project seepage and slope stability analyses were conducted on one to six cross sections per SBFCA reach. Sections 6.0 and 7.0 of the final GDRR describe the methodology for the with-project seepage and slope stability analyses. Section 8.0 of the final GDRR describes the analysis results. Table 8-1 of the final GDRR summarizes results of those analyses, including sensitivity analyses conducted on several cross sections to evaluate the effects of different parameters (including blanket layer thickness, soil type, soil permeability, soil shear strength, seepage analysis boundary conditions, and cutoff wall tip elevation). This table is included as Enclosure K of this report. Appendix C of the final GDRR contains with-project seepage and slope stability analysis sections. The with-project seepage and slope stability analyses were conducted at the same water surface elevations used to evaluate remediation alternatives in the Geotechnical Analysis for the PFR (DWS+1 foot and HTOL+1 foot). All proposed alternatives for all design analysis sections meet Corps design criteria. The SBFCA project as designed meets all required Corps geotechnical design criteria.

Settlement analysis was not conducted for the FRWL Improvement Project. The FRWL is several decades old and will be rebuilt to the same height after degrade and cutoff wall installation.

8.6.3 Seismic Vulnerability Analysis

Seismic vulnerability analysis was conducted under both the DWR ULE and the SBFCA 408 projects. The ULE analysis covered all the levees within the SBLS, while the SBFCA analysis only covers the FRWL from Star Bend upstream to the Thermalito Afterbay outlet channel. The SBFCA 408 project analyzed more sections than the ULE project (44 versus 13, respectively) on

the FRWL upstream of Star Bend because the SBFCA project is in design, while the ULE project is in the study phase. Both projects used a similar methodology for their analysis:

- A liquefaction triggering analysis was conducted using the higher of the average winter and average summer water surface elevations of the appropriate waterway. The ULE evaluation used peak ground accelerations (PGA) for the 100, 200, and 500-year earthquakes obtained from the ULE project guidance document, while the SBFCA analysis only used the 200-year earthquake PGA from the ULE guidance document.
- Post-earthquake slope stability analysis was then conducted, using undrained shear strengths for fine-grained soils and post-liquefaction undrained shear strengths for coarse-grained soils that were expected to liquefy. If the post-earthquake slope stability Factor of Safety was less than 1.0, the section was considered compromised and no additional analysis was done.
- Otherwise, a pseudo-static earthquake slope stability analysis was conducted using a seismic coefficient. If the pseudo-static slope stability Factor of Safety was greater than 1.0, then the section was considered probably uncompromised and no additional analysis was done.
- Otherwise, a Newmark-type deformation analysis was done to estimate horizontal displacement, from which vertical displacement and freeboard loss were estimated.

Based on the estimated vertical displacement, a seismic vulnerability classification (probably uncompromised, possibly compromised, probably compromised, or compromised) was determined. The ULE and SBFCA projects used slightly different criteria to determine the vulnerability classification. The ULE criteria is based on the amount of vertical deformation in feet and the remaining freeboard above a 50% (1/2) ACE water surface elevation and the SBFCA criteria is based on the amount of vertical deformation in percent of levee height and the remaining freeboard above a 10% (1/10) ACE water surface elevation. Table 8-2 compares the ULE and SBFCA seismic vulnerability classification criteria.

Table 8-2 Seismic Vulnerability Classification Criteria

Vertical Deformation		Significant Damage to internal structures (i.e. cutoff walls)	Remaining Freeboard for Post-Seismic Evaluation		Seismic Vulnerability Class
ULE (ft)	SBFCA (percent of landside levee height)		ULE (50% (1/2) ACE water surface) (ft)	SBFCA (10% (1/10) ACE water surface) (ft)	
<1	<5	No	>1	>1	Probably Uncompromised

Vertical Deformation		Significant Damage to internal structures (i.e. cutoff walls)	Remaining Freeboard for Post-Seismic Evaluation		Seismic Vulnerability Class
1-3	<10	Possibly	>1	>1	Possibly Compromised
3-10	<20	Likely if existing	None	None	Probably Compromised
Unlimited (flow slide condition)	Unlimited, >10' (flow slide condition)	Yes	None	None	Compromised

Seismic vulnerability evaluation results from the SBFCA project are in Table 8-4 of the final GDRR and results from the ULE are in Tables 5-16 and 5-17 of the P1GER. SBFCA results are tabulated by reach while the ULE results are tabulated by a single station. The Sacramento District's geotechnical earthquake engineering expert reviewed the seismic vulnerability analyses performed for the ULE and SBFCA projects. His review is documented in a memorandum given in Enclosure L of this report. While there are minor differences between the ULE and SBFCA evaluations and the draft Corps of Engineers evaluation recommendations, the ULE and SBFCA evaluations are considered to be satisfactory. Table 8-3 of this report gives a comparison of the SBFCA and ULE seismic analysis results for reaches where both projects did an evaluation. The seismic vulnerability classifications are mostly the same between the two evaluations; the 3 differences are attributed to different soil borings being used for the two evaluations. As can be seen in Table 8-3 below and Table 8-4 of the final GDRR, some portions of the FRWL downstream of SBFCA station 1243+00 (located about 3 miles north of Yuba City) are predicted to experience significant deformation during a 200-year earthquake. The Sponsor is encouraged to identify emergency borrow area(s) to reconstruct the levee to a limited level of protection (10% (1/10) ACE) within 3 months after a significant earthquake.

Table 8-3 Comparison of SBFCA and ULE Seismic Vulnerability Class

SBFCA Reach	SBFCA Station Range	ULE Boring Location (SBFCA Station)	Seismic Vulnerability Class
8	598+87 to 654+75	626+31	Compromised (SBFCA)
			Possibly Compromised (ULE)

SBFCA Reach	SBFCA Station Range	ULE Boring Location (SBFCA Station)	Seismic Vulnerability Class
9	674+00 to 695+00	674+30	Probably Uncompromised (SBFCA and ULE)
13	845+00 to 927+00	861+17	Compromised (SBFCA and ULE)
15	954+00 to 968+00	959+03	Compromised (SBFCA and ULE)
18	1130+86 to 1136+00	1135+58	Possibly Compromised (SBFCA and ULE)
19	1213+85 to 1243+00	1229+81	Likely Compromised (SBFCA)
			Probably Uncompromised (ULE)
19	1213+85 to 1243+00	1238+43	Likely Compromised (SBFCA)
			Probably Uncompromised (ULE)
23	1503+83 to 1609+37	1508+51	Probably Uncompromised (SBFCA and ULE)
24	1609+37 to 1623+86	1615+61	Probably Uncompromised (SBFCA and ULE)
31	1902+00 to 1958+00	1907+37	Probably Uncompromised (SBFCA and ULE)
33	1989+00 to 2122+00	2076+95	Probably Uncompromised (SBFCA and ULE)
35	2182+00 to 2224+00	2187+00	Probably Uncompromised (SBFCA and ULE)
35	2182+00 to 2224+00	2212+09	Probably Uncompromised (SBFCA and ULE)

8.6.4 Conclusion

The Sacramento District recommends the SBFCA 408 project as shown on their 65% submittal plans (except for the items discussed in Section 8.4 of this report). The SBFCA geotechnical analysis is in conformance with Corps design requirements and procedures and we agree with their analysis and analysis results. The levee improvements shown on the SBFCA 65% submittal plans will perform as intended at the water surfaces used for the geotechnical analyses.

8.7 Borrow Sites

The SBFCA FRWL Improvement Project specifications include two primary material types: Type 1 levee fill, primarily used as a clay core for the reconstructed levee above the cutoff wall, and Type 2 levee fill, primarily used for shells for the reconstructed levee above the cutoff wall. Specifications for the two material types are as follows:

- Type 1 Levee Fill: USCS classification of CL, SC, or CH; maximum particle size of 2 inches; minimum 35% by weight passing the #200 sieve; maximum liquid limit of 60; plasticity index between 12 and 40.
- Type 2 Levee Fill: Maximum particle size of 2 inches; minimum 12% by weight passing the #200 sieve; maximum liquid limit of 45.

Based on geotechnical investigations and standard practice, an approximately 20% increase should be applied to the total demand (to account for all material swell, loss and shrinkage during excavation, transportation and placement, respectively) when estimating the borrow amount needed. The SBFCA project team estimated the amount of levee degrade material that is suitable for reuse on a reach-by-reach basis. The approximate percentages of levee degrade material suitable for reuse as levee fill are shown in Table 8-4.

Table 8-4 Percentage of Levee Degrade Material Suitable for Levee Fill

SBFCA Reach	Percentage for Levee Core (Type 1)	Fraction	Percentage for Levee Shell (Type 2)	Fraction
2A-North	5	0.05	95	0.95
2B	5	0.05	95	0.95
3	5	0.05	95	0.95

SBFCA Reach	Percentage for Levee Core (Type 1)	Fraction	Percentage for Levee Shell (Type 2)	Fraction
4	5	0.05	95	0.95
5	5	0.05	95	0.95
6	5	0.05	95	0.95
7	40	0.4	60	0.6
8	0	0	85	0.85
9	0	0	55	0.55
10	0	0	70	0.7
11	0	0	100	1
12	NA	NA	NA	NA
13	0	0	95	0.95
14	NA	NA	NA	NA
15	NA	NA	NA	NA
16	NA	NA	NA	NA
17	0	0	100	1

SBFCA Reach	Percentage for Levee Core (Type 1)	Fraction	Percentage for Levee Shell (Type 2)	Fraction
18	15	0.15	85	0.85
19	30	0.3	70	0.7
20	0	0	100	1
21	0	0	100	1
22	15	0.15	85	0.85
23	0	0	90	0.9
24	0	0	100	1
25	0	0	100	1
26	0	0	100	1
27	80	0.8	20	0.2
28	15	0.15	85	0.85
29	NA	NA	NA	NA
30	0	0	95	0.95
31	30	0.3	70	0.7

SBFCA Reach	Percentage for Levee Core (Type 1)	Fraction	Percentage for Levee Shell (Type 2)	Fraction
32	0	0	100	1
33	0	0	100	1
34	0	0	100	1
35	0	0	100	1
36	0	0	100	1
37	0	0	100	1
38	0	0	100	1
39	NA	NA	NA	NA
40	60	0.6	0	0
41	60	0.6	0	0

While some of the levee soils removed during degrading will be re-used to reconstruct the levee, it is anticipated that borrow material will be needed to meet the levee fill material specifications. The SBFCA FRWL Improvement Project has identified potential borrow sites (Plate 11) and is currently in the process of sampling and testing the sites to ensure they meet material requirements. Sites shown in yellow on Plate 11 are sites identified by the SBFCA team for their project, with sampling and testing ongoing. Properties shown in orange on Plate 11 are owned by the California Department of Transportation (CalTRANS) that have been identified as surplus. The CalTRANS sites could possibly be used as borrow for this project; the SBFCA team has not met with CalTRANS or conducted any sampling and testing of these sites.

8.8 Pipelines Crossing the Levee

There are numerous pipelines crossing the levee alignment, including electrical and telephone cables and various types of water lines (interior drainage gravity lines, interior drainage pump lines, water supply lines, and sewage disposal lines). Installation dates of the pipes vary between the 1930's and the early 2000's. Installation dates and details are not available for some of the pipes. Some of the pipes have not been maintained and some of them do not have a means of positive closure. The SBFCA design team evaluated each pipe based on installation date (known or unknown) and adherence to Corps criteria for pipelines crossing levees in EM 1110-2-1913. All pipes that are not currently being used will be removed. All active pipes known or suspected of being beyond their estimated service life will be removed and replaced to comply with Corps criteria, including routing above the design water surface for pressurized pipes and installing positive closure for all pipes. Pipes that are known to be recent installations will remain, although there may be minor modifications made to comply with Corps criteria. The Civil Design Appendix contains additional information on this issue.

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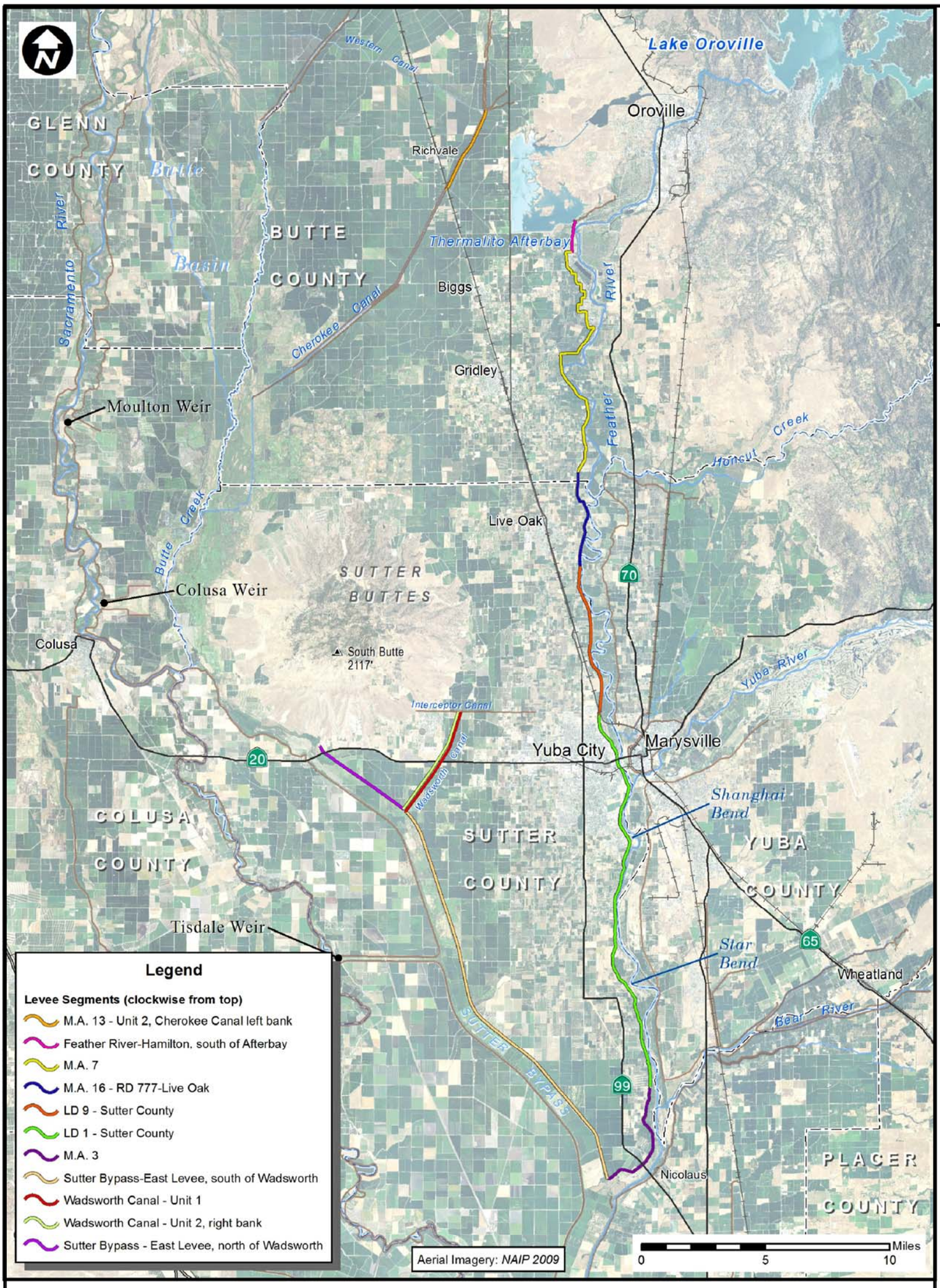
PLATES



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SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

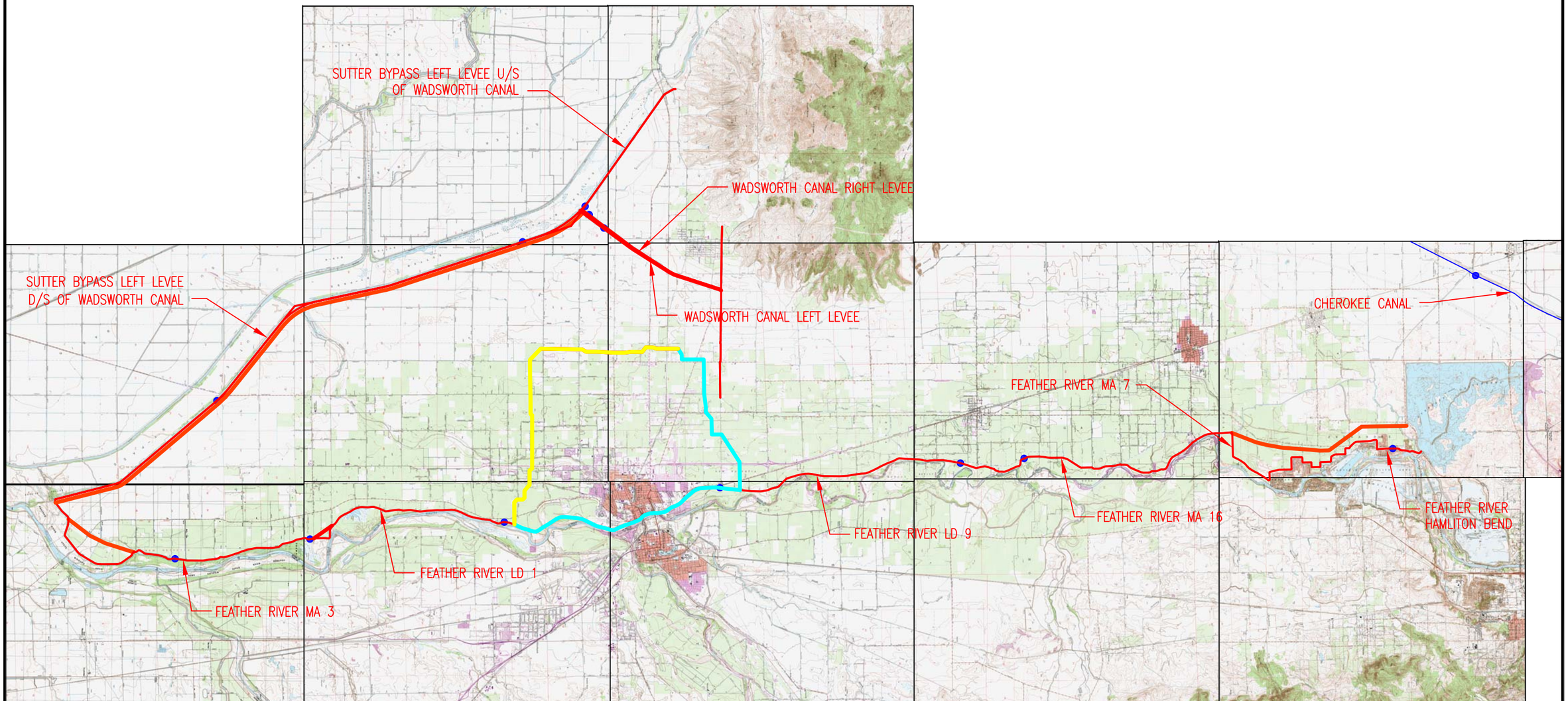
SEGMENT MAP

DATE: 8/20/2012

SCALE: 1"=2500'

PLATE-1

DWG-INFO



SCALE IN FEET

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DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

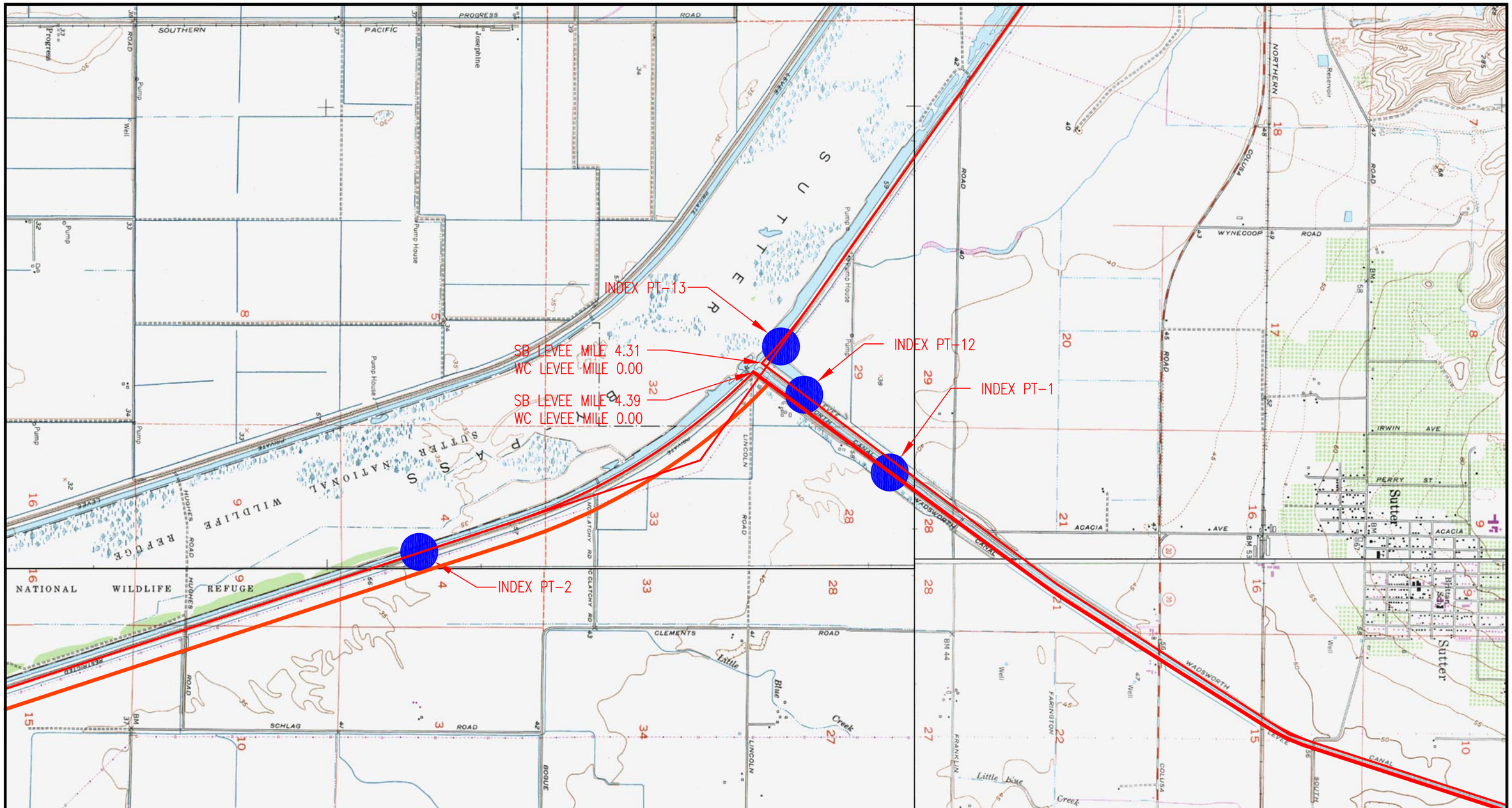
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

OVERALL STUDY MAP

DATE:	SCALE:	
8/20/2012	1"=15000'	PLATE-2

DWG-INFO



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SACRAMENTO DISTRICT
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SACRAMENTO, CALIFORNIA

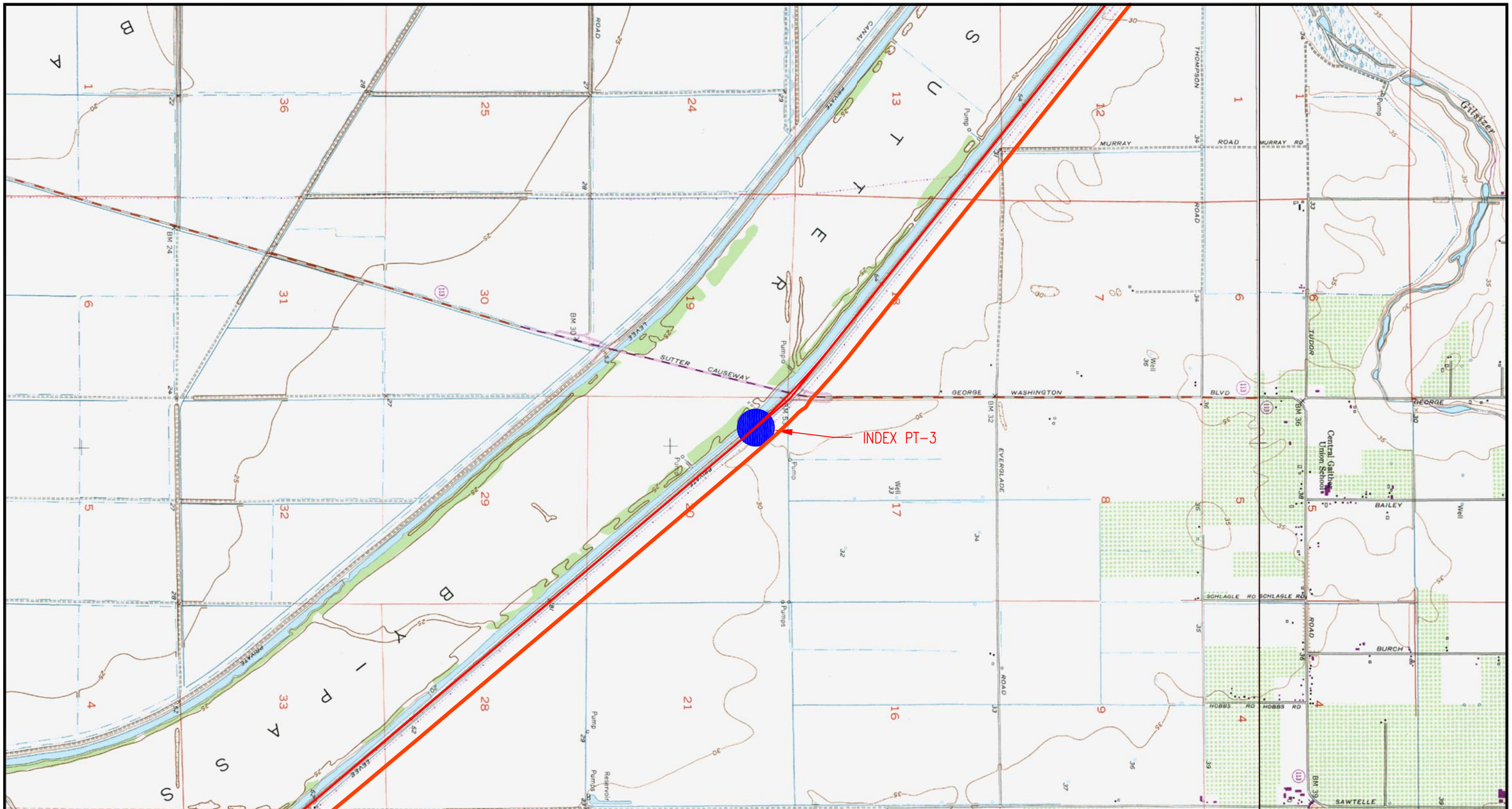
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

INDEX POINTS 1,2,12,13

DATE:	SCALE:	
8/20/2012	1"=2500'	PLATE-3

DWG-INFO



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DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
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SACRAMENTO, CALIFORNIA

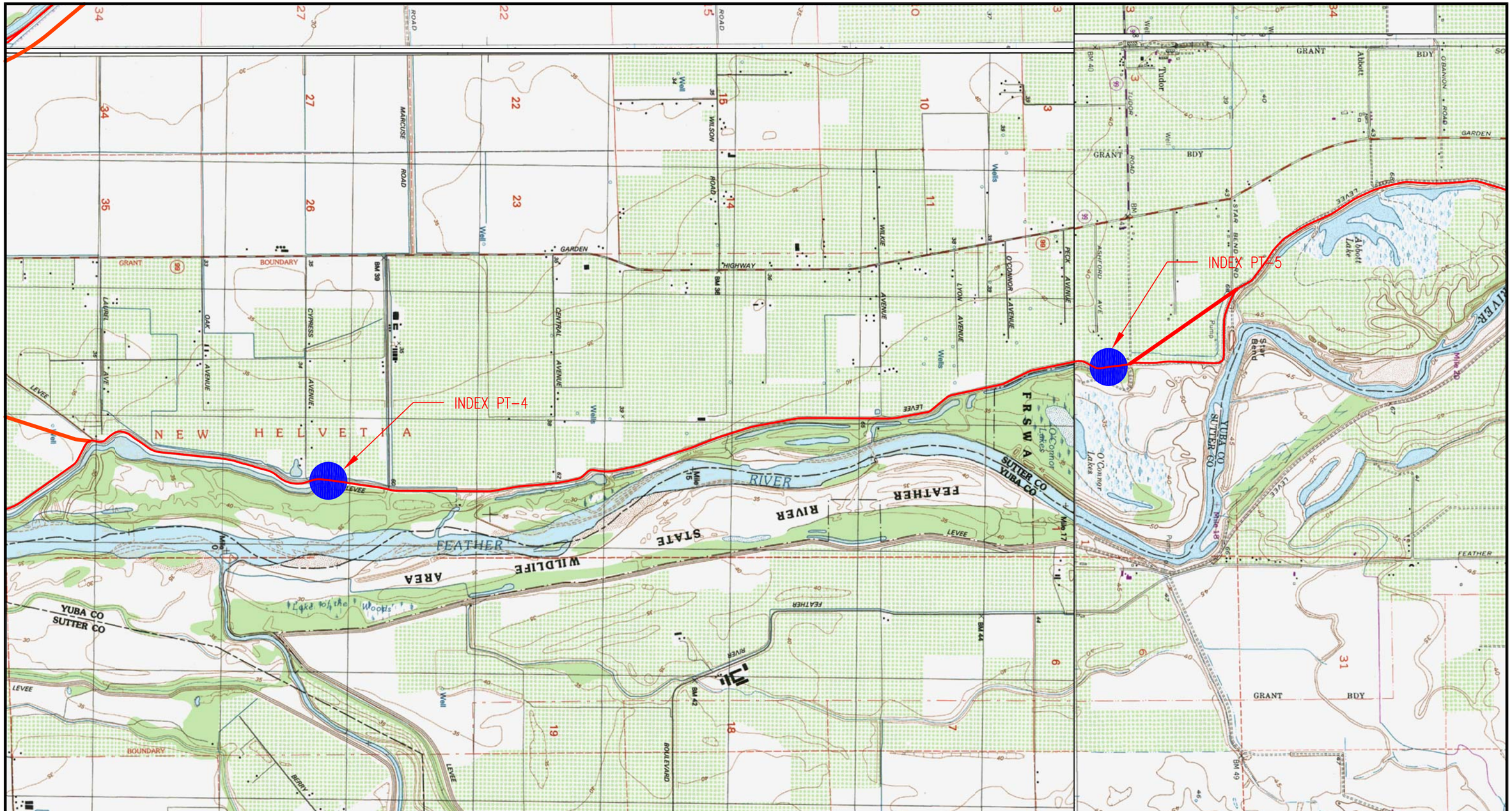
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

INDEX POINT 3

DATE:	SCALE:	
8/20/2012	1"=2500'	PLATE-4

DWG-INFO



SCALE IN FEET

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DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

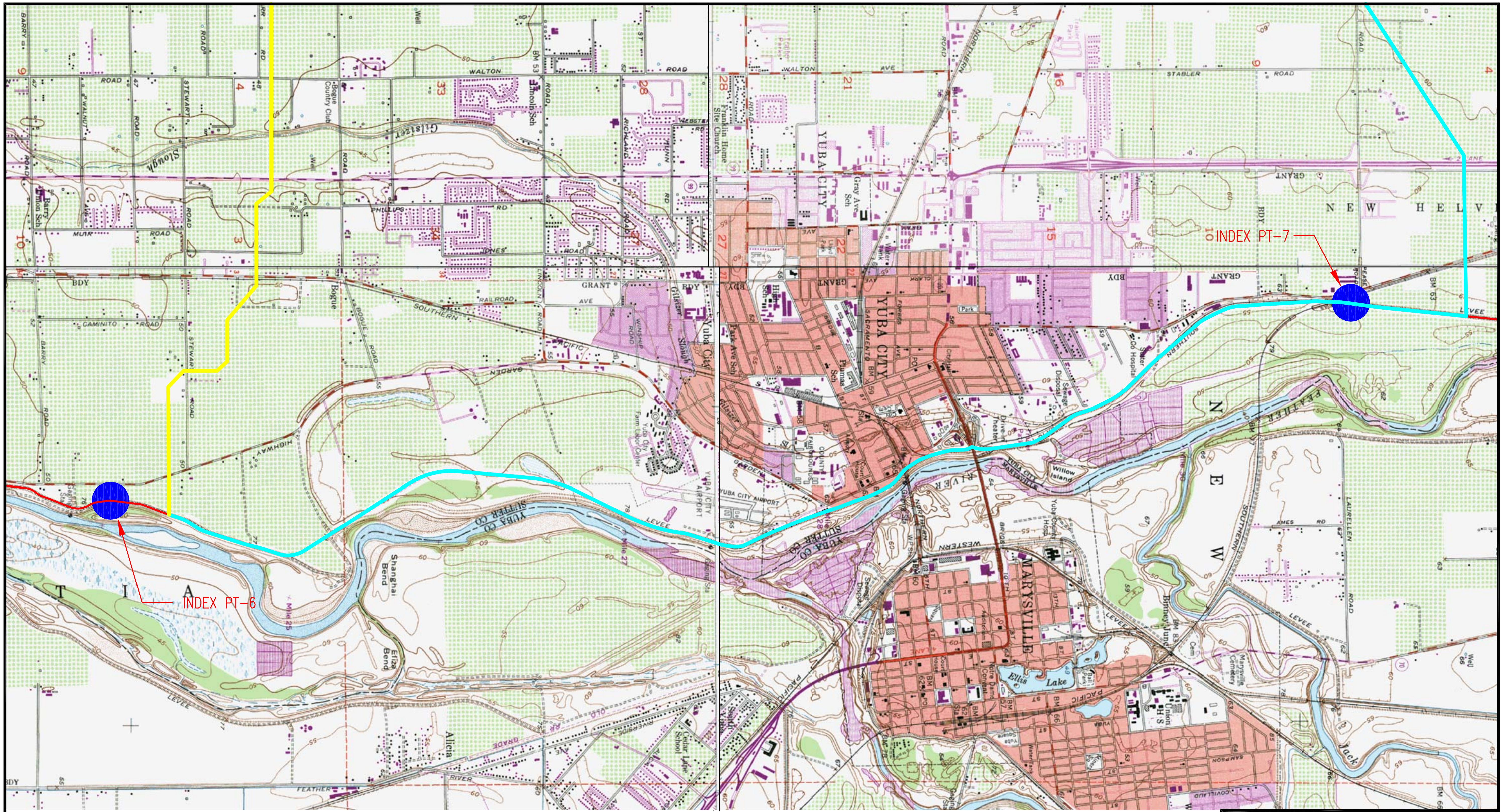
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

INDEX POINT 4, 5

DATE:	SCALE:	
8/20/2012	1"=2500'	PLATE-5

DWG-INFO



SCALE IN FEET

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DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
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SACRAMENTO, CALIFORNIA

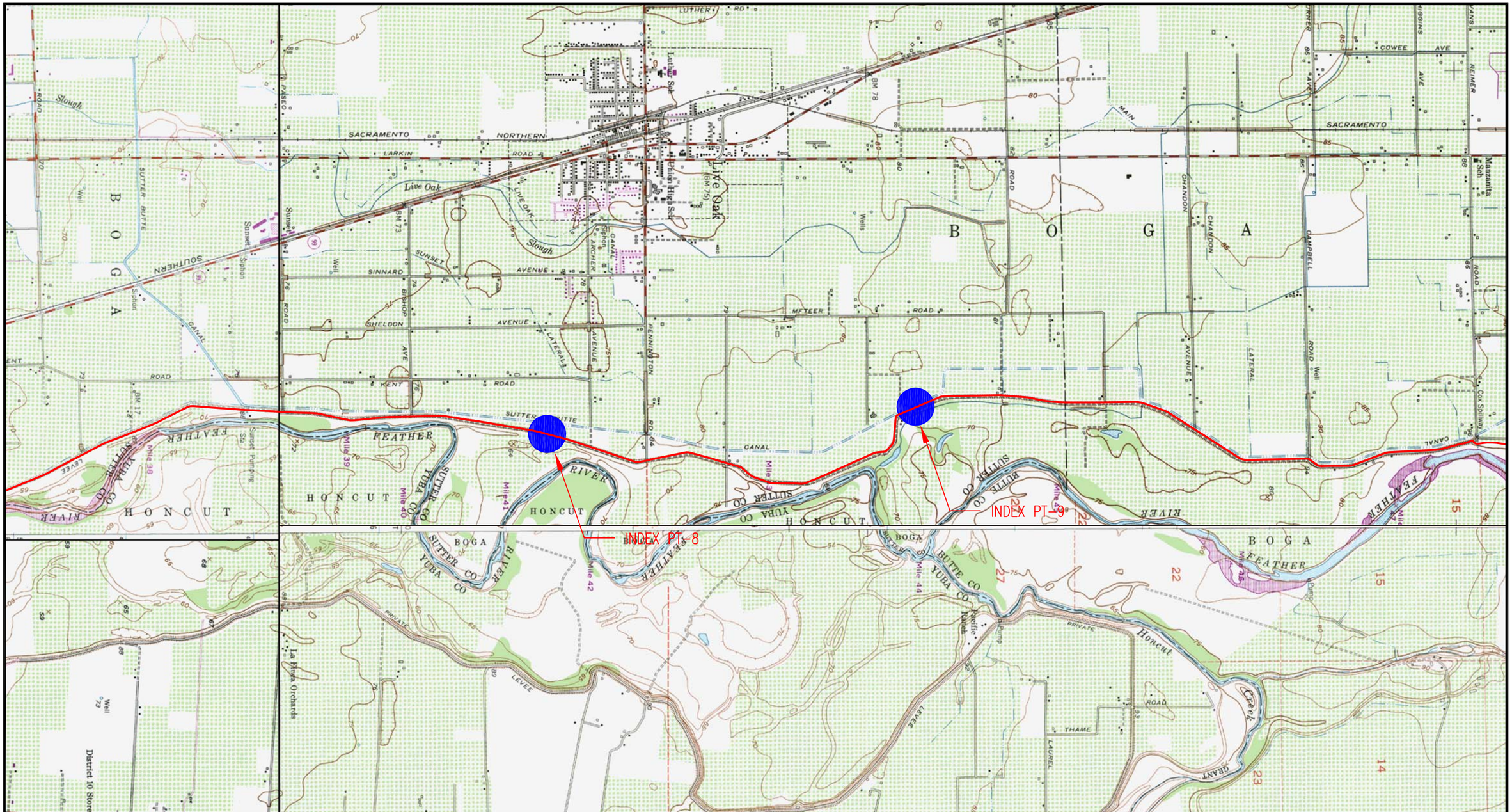
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

INDEX POINT 6, 7

DATE:	SCALE:	
8/20/2012	1"=2500'	PLATE-6

DWG-INFO



SCALE IN FEET

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DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

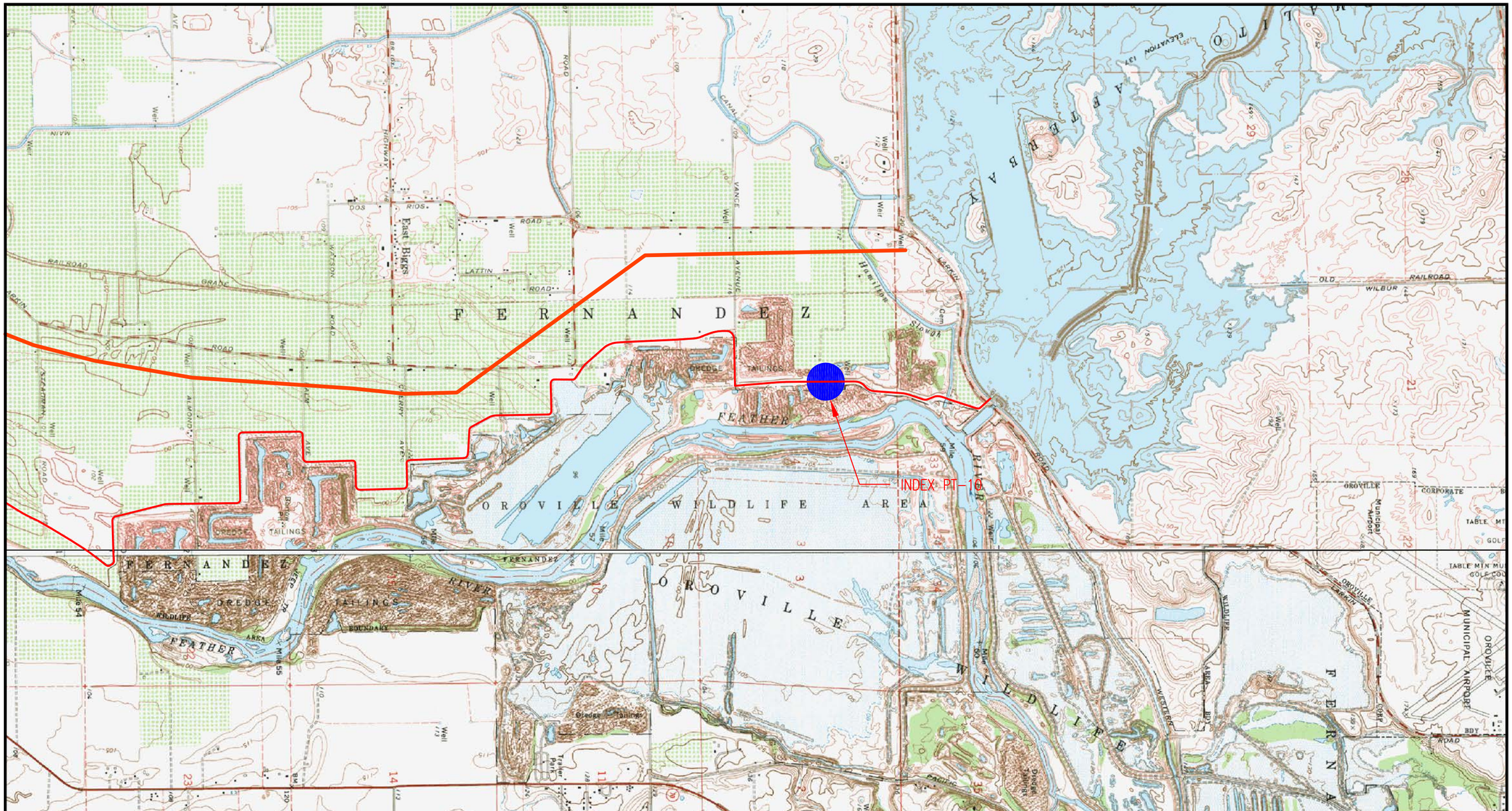
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

INDEX POINT 8, 9

DATE:	SCALE:	
8/20/2012	1"=2500'	PLATE-7

DWG-INFO



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CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

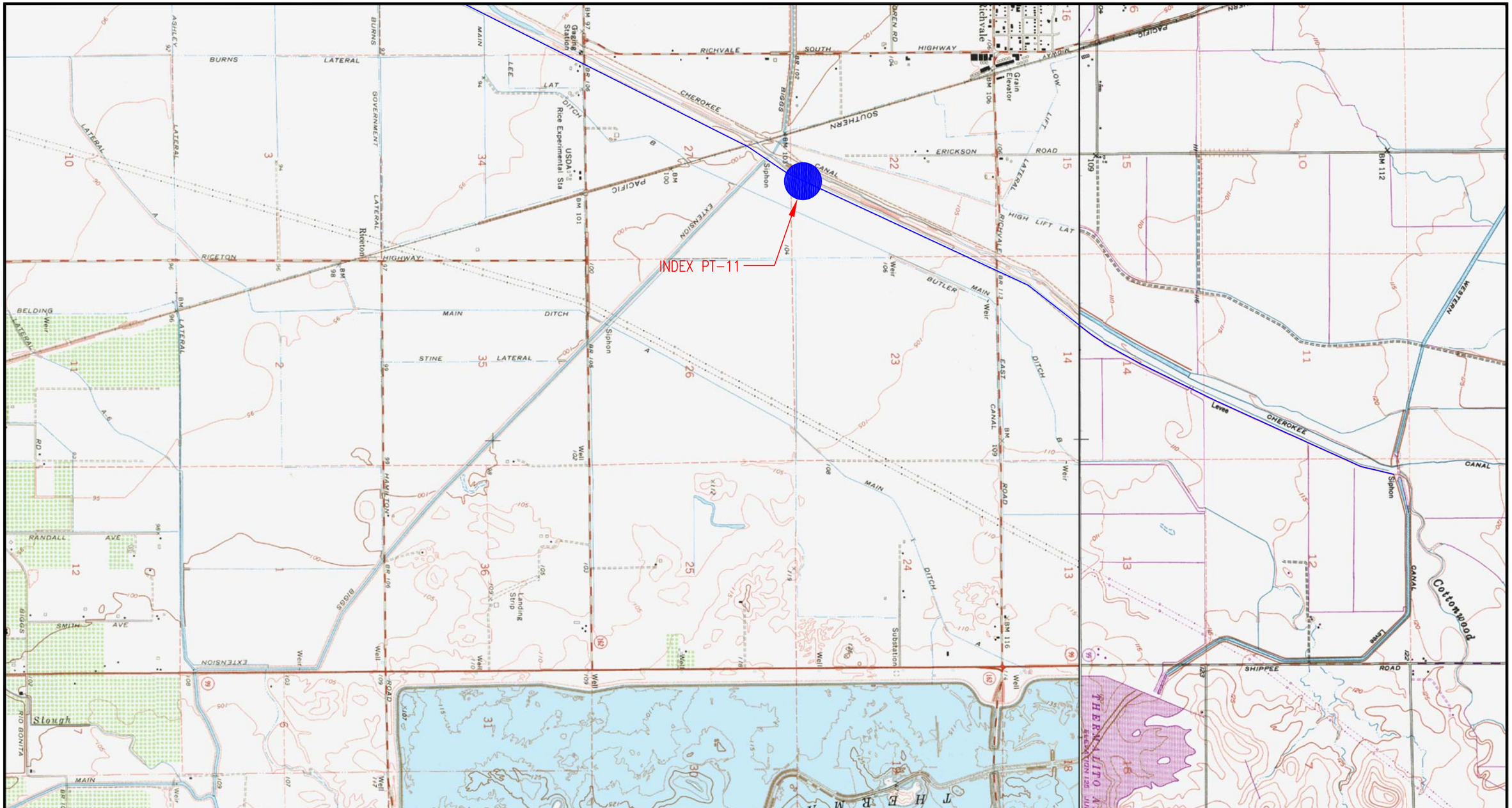
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

INDEX POINT 10

DATE:	SCALE:	
8/20/2012	1"=2500'	PLATE-8

DWG-INFO



SCALE IN FEET

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CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

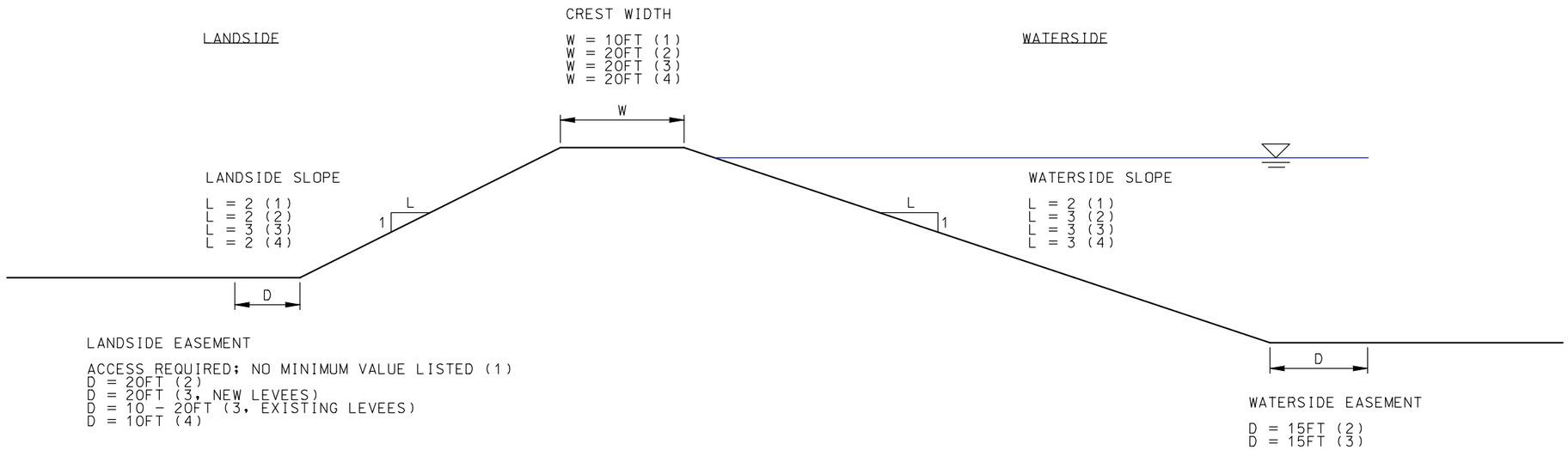
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

INDEX POINT 11

DATE:	SCALE:	
8/20/2012	1"=2500'	PLATE-9

DWG-INFO



REFERENCES

(1) EM 1110-2-1913, DESIGN & CONSTRUCTION OF LEVEES, APRIL 2000
(2) SPK, GEOTECHNICAL LEVEE PRACTICE (REFP10LO OR SOP3), 11 APRIL 2008
(3) DWR, URBAN LEVEE DESIGN CRITERIA, MAY 2012 (NEW LEVEES, EXCEPTIONS MAY BE ALLOWED FOR RECONSTRUCTION OF EXISTING LEVEES
(4) CCR TITLE 23, WATERS DIVISION 1, CVFPB REGULATIONS, 22 JAN 2010

Plate 10

US Army Corps of Engineers
Sacramento District

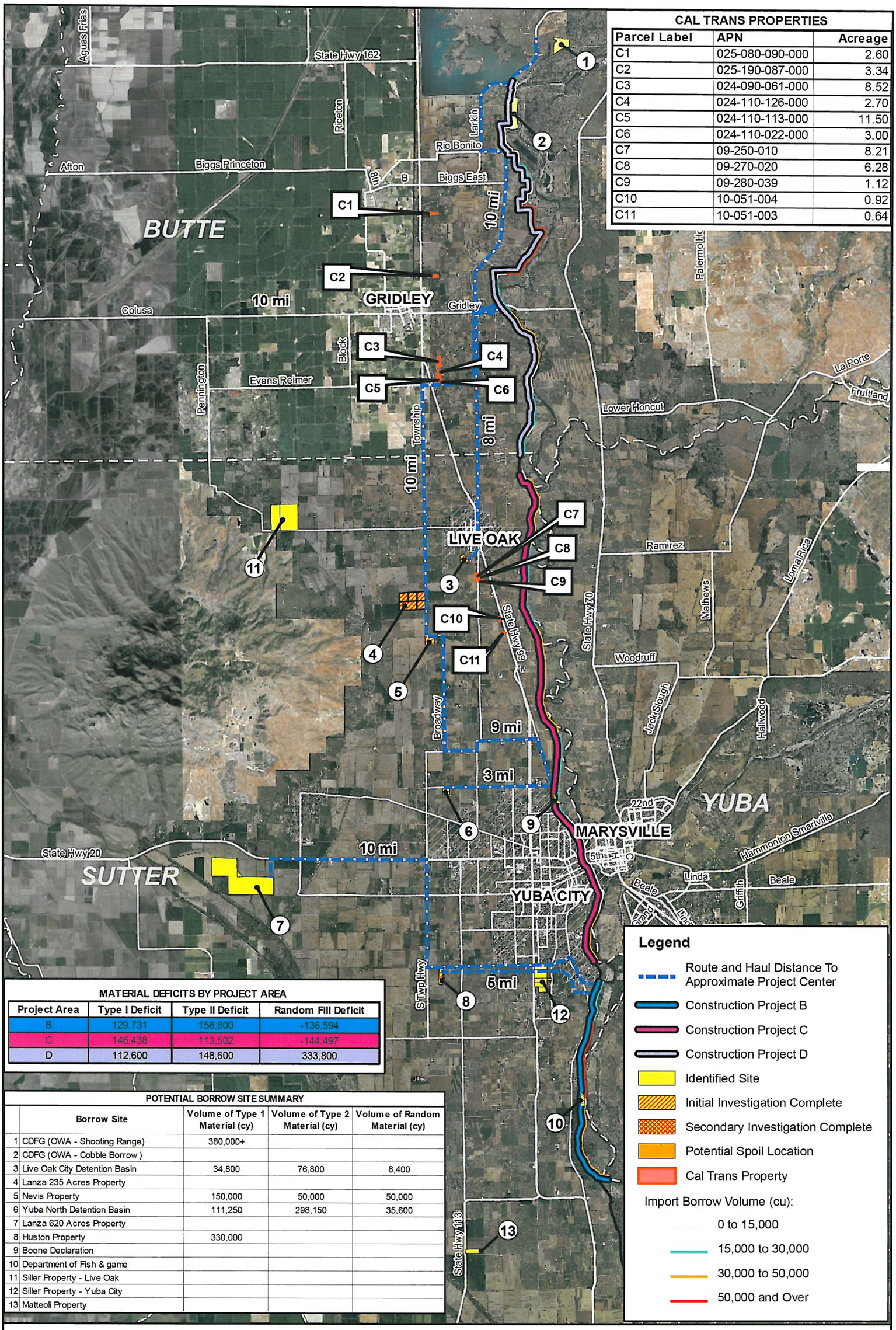
Designed by: TUNG LE
Dwn by: TUNG LE
Reviewed by: -
Submitted by: -
CHIEF, CIV ENGR DES SEC A
Date: -
Rev. -
Spec No.: -
Design file no: -
Drawing Code: -
File name:
Plot date: 14-NOV-2012
Plot scale: --

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 'J' STREET
SACRAMENTO, CA 95814-2922

SUTTER BUTTE COUNTY CALIFORNIA
SUTTER BASIN FEASIBILITY STUDY
CIVIL DESIGN APPENDIX
-
TYPICAL LEVEE GEOMETRIES
MINIMUM REQUIREMENTS
-

Sheet reference number:
—
Sheet - of -
AM-XX



CAL TRANS PROPERTIES

Parcel Label	APN	Acreage
C1	025-080-090-000	2.60
C2	025-190-087-000	3.34
C3	024-090-061-000	8.52
C4	024-110-126-000	2.70
C5	024-110-113-000	11.50
C6	024-110-022-000	3.00
C7	09-250-010	8.21
C8	09-270-020	6.28
C9	09-280-039	1.12
C10	10-051-004	0.92
C11	10-051-003	0.64

MATERIAL DEFICITS BY PROJECT AREA

Project Area	Type I Deficit	Type II Deficit	Random Fill Deficit
B	129,731	158,800	-136,594
C	146,438	113,502	-144,497
D	112,600	148,600	333,800

POTENTIAL BORROW SITE SUMMARY

	Borrow Site	Volume of Type 1 Material (cy)	Volume of Type 2 Material (cy)	Volume of Random Material (cy)
1	CDFG (OWA - Shooting Range)	380,000+		
2	CDFG (OWA - Cobble Borrow)			
3	Live Oak City Detention Basin	34,800	76,800	8,400
4	Lanza 235 Acres Property			
5	Nevis Property	150,000	50,000	50,000
6	Yuba North Detention Basin	111,250	298,150	35,600
7	Lanza 620 Acres Property			
8	Huston Property	330,000		
9	Boone Declaration			
10	Department of Fish & game			
11	Siller Property - Live Oak			
12	Siller Property - Yuba City			
13	Matteoli Property			

SUTTER BUTTE FLOOD CONTROL AGENCY
FEATHER RIVER WEST LEVEE PROJECT
PROJECT BORROW INFORMATION

NORTH

0 6,500 13,000
FEET

PRELIMINARY

WOOD RODGERS
DEVELOPING INNOVATIVE DESIGN SOLUTIONS
3301 C Street, Bldg. 100-B Tel: 916.341.7760
Sacramento, CA 95816 Fax: 916.341.7767

\\Sacfile01\jobs\Jobs\8455_HDR_Sutter_Butte_FCA\8455.001_FeatherRiverLevee_EIP\GIS\Tasks\FRWL-Potential Borrow Site Report\DavidLanzaProperties_20120717_V1.mxd 7/17/2012 9:03:20 AM rsubedi

FIGURE 1

Plate 11

ENCLOSURES

ENCLOSURE A

LEVEE PHOTOGRAPHS

WADSWORTH CANAL LEFT LEVEE

Photo 1. General view of the levee, looking upstream. Canal channel on the left.

Photo 2. General view of the levee, looking upstream.

Photo 3. Waterside levee slope and canal, looking north. High ground of Sutter Buttes in the background.

Photo 4. Landside levee slope, looking upstream.

Photo 5. Canal bank erosion, looking upstream.

SUTTER BYPASS LEFT LEVEE (DOWNSTREAM OF WADSWORTH CANAL)

Photo 1. General view of the levee, looking upstream. Bypass channel is on the left

Photo 2. Landside levee slope, looking downstream.

Photo 3 Ditch about 50 feet from the landside toe.

Photo 4. Typical waterside levee slope, looking upstream

Photo 5. Stability berm at the landside toe, looking upstream

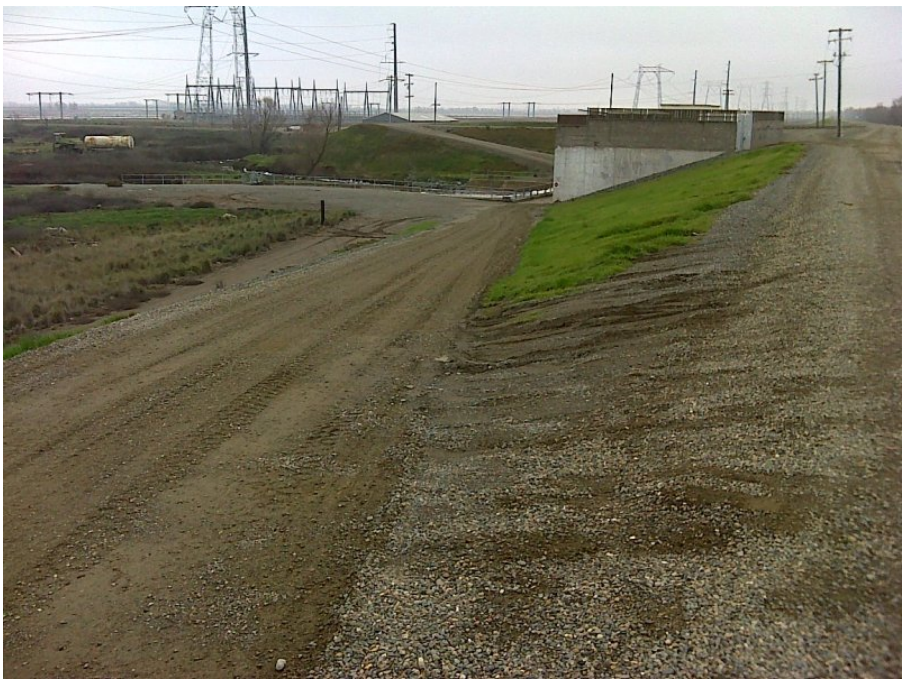


Photo 6. Pump Station No. 2, looking downstream

FEATHER RIVER SOUTH – MAINTENANCE AREA 3

Photo 1. General view of the levee, looking upstream. Feather River channel to the right.

Photo 2. Landside levee slope, looking downstream. Note electrical tower near the toe.

Photo 3. Ditch near the landside toe

Photo 4. Waterside levee slope, looking upstream.

FEATHER RIVER SOUTH – LEVEE DISTRICT 1

Photo 1. General view of the levee, looking upstream. Feather River channel on the right.

Photo 2. Waterside levee slope, looking upstream.

Photo 3. Landside levee slope, looking upstream.

Photo 4. Drainage ditch and power poles near the landside levee toe.

Photo 5. Encroachment into the landside levee slope in Yuba City.

Photo 6. Star Bend relief wells and relief well drainage ditch.

FEATHER RIVER NORTH – LEVEE DISTRICT 9

Photo 1. General view of the levee.

Photo 2. Railroad embankment crossing the levee alignment at the LD1/LD9 boundary.

Photo 3. Landside levee slope, looking downstream.

Photo 4. Waterside levee slope, looking upstream.

Photo 5. Sutter Butte Canal adjacent to the levee toe.

Photo 6. Sutter Butte Canal adjacent to the landside levee toe at the Sunset Pump Plant.

FEATHER RIVER NORTH – MAINTENANCE AREA 16

Photo 1. General view of the levee, looking upstream. Feather River channel to the right.

Photo 2. Waterside levee slope, looking upstream.

Photo 3. House at the landside levee toe.

Photo 4. Sutter Butte Canal adjacent to the landside levee toe.

Photo 5. Erosion/sloughing of the landside levee slope into the Sutter Butte Canal.

Photo 6. Landside levee slope with powerpoles near the toe, looking upstream.

FEATHER RIVER NORTH – MAINTENANCE AREA 7

Photo 1. General view of the levee, looking upstream. Feather River channel to the right.

Photo 2. Waterside levee slope, looking upstream.

Photo 3. Landside slope erosion/sloughing into the adjacent Sutter Butte Canal; house on waterside of levee.

Photo 4. Sutter Butte Canal adjacent to the landside levee toe.

Photo 5. Waterside levee slope at the location of the former Gridley Bridge.

Photo 6. Weir structure in Sutter Butte Canal adjacent to the landside levee toe.

FEATHER RIVER NORTH – HAMILTON BEND

Photo 1. General view of the levee embankment, looking upstream. Feather River channel to the right.

Photo 2. Waterside levee slope, looking upstream.

Photo 3. Landside levee slope, looking downstream.

Photo 4. Sutter Butte Canal Headgate Structure. Note gate stems and hoist mechanisms have been removed, leaving the gates “stuck” in the closed position.

Photo 5. Dredge tailings on the waterside of the levee. Note tailings are higher than the levee crest in some locations.

ENCLOSURE B

SBLS PERFORMANCE HISTORY AND IMPROVEMENTS/MODIFICATIONS (FROM PERIODIC INSPECTION REPORT NO. 1)

Table M-1: Summary of Levee Performance Issues

Levee Mile or Location	Year	Problem/Issue	Document	Page
Hamilton West Levee - HAM1				
12.3	1955	Levee "broke in 4 places and potholes appeared"	P1GDR	2-42
Maintenance Area 07 - MA07				
0.1 to 0.9	N/A	Underseepage and high groundwater during irrigation season due to high water level in canal	P1GER	2-11
1 to 1.2	1999	Several large holes opened up during construction of slurry wall	P1GDR	2-40
2.7 to 2.9	1986	Seepage and boils	P1GER	2-12
9.8	1986	Seepage and boils	P1GER	2-12
N/A	N/A	Landside seepage and boils at various locations	P1GDR	2-41
Maintenance Area 16 - MA16				
N/A	N/A	Landside seepage and boils at various locations	P1GDR	2-41
Levee District 9 - LD9S				
0 to 1.6	1996	Seepage	P1GDR	2.56
0 to 1.6	1997	Seepage	MEM-97	3
0.1 to 0.42	1966	Seven sinkholes from old stumps left during levee construction	P1GER	2-9
2.17	1955	"Severe leaks"	P1GDR	2-42
2.3	N/A	Heavy saturation and levees turning to "mush"	P1GDR	2-42
2.5	N/A	Heavy saturation and levees turning to "mush"	P1GDR	2-42
2.56 to 2.65	1982	Erosion and raveling of rock revetments	P1GDR	2-44
2.8 to 3.1	1997	Seepage	P1GER	2-10
3 to 3.2	1997	Clear-water pinhole boils	P1GDR	2-42
3.5 to 3.6	N/A	Heavy saturation	P1GER	2-10
3.65	1955	"Severe leaks"	P1GDR	2-42
3.8	1986	Landside seepage and sand boils	P1GER	2-10
4.55-5.46	1997	900-feet of irrigation ditch slumping at levee toe	MEM-97	2
4.63	1957	Seepage at and beyond waterside toe during irrigation	P1GDR	2-42
4.93	1957	Seepage at and beyond waterside toe during irrigation	P1GDR	2-42
5.1	1986	Landside seepage and sand boils	P1GER	2-11
5.4 to 5.7	1997	Landside embankment distress	P1GER	2-11
N/A	N/A	Landside seepage and boils at various locations	P1GDR	2-41
Levee District 1 - LD1S				
1.5	1986	Crack formed in levee	P1GDR	2-25
2.75 to 5.25	1997	Boils at landside levee toe	LTR -97	Sheet 1
3.8	1986	2,600-ft stretch of boils, soft wet ground w/in 100 ft of toe	P1GDR	2-25
3.8	1997	Seepage	P1GDR	2-25
4.1 to 5	1995	Clear seepage at and beyond levee toe	P1GDR	2-25
4.1 to 5	1997	200-foot stretch of boils	P1GDR	2-25
6.1	1986	Erosion of small trees on waterside berm, holes on top of berm, berm slope eroded	P1GDR	2-25
6.3 to 7.01	1997	26 sink holes, probably rodent-related	MEM-97	2
7.3	N/A	Waterside bank erosion encroached on levee section	P1GDR	2-25

Table M-1: Summary of Levee Performance Issues

Levee Mile or Location	Year	Problem/Issue	Document	Page
Levee District 9 - LD9S (continued)				
8	1986	Waterside levee toe, portions of boat ramp parking lot and subgrade eroded	P1GDR	2-25
8.13	1997	Bank erosion at pump structure at waterside levee	LTR -97	Sheet 1
10.8	1986	Seepage	P1GDR	2-25
10.8	1995	High water, seepage, boil	P1GDR	2-25
11.0 to 12.4	1909	Levee broke	P1GDR	2-25
11.0 to 12.4	1911	Levee broke	P1GDR	2-25
11.0 to 12.4	1955	Levee broke	P1GDR	2-25
11.0 to 12.4	1986	Boils	P1GDR	2-26
11.0 to 12.8	1995	Sand boil noted, relief wells are damaged/not maintained	MEM-95	1
11.2	1997	Heavy seepage and boils	LTR -97	Sheet 1
12.1 to 12.3	1997	Heavy seepage and boils	LTR -97	Sheet 1
12.8 to 14.5	N/A	Seepage	P1GER	2-7
14 to 15.5	1955	Seepage	P1GDR	2-26
14 to 15.5	1986	Saturated, unstable, bulging landside slope, water pouring from parking lot pavement cracks & floor slab, waterside erosion at toe	P1GDR	2-26
14.27 to 14.57	1997	Bank and levee erosion	LTR -97	Sheet 1
14.74 to 14.81	1997	Bank erosion	LTR -97	Sheet 1
14.95 to 15.55	1997	Heavy seepage	LTR -97	Sheet 1
10th St Bridge to 1,000 ft north	1995	Seepage 100 ft landside of levee and Von Geldern Way	MEM-95	1
RM 19	1995	Seepage at toe of levee and beyond	MEM-95	2
Maintenance Area 03 - MA03				
2.3 to 3.3	N/A	Excessive seepage	P1GDR	2-24
3.7	1986	Boil in drainage ditch near levee toe	P1GDR	2-25
3.7	1997	Heavy seepage entering drainage ditch near levee toe, sloughing of the drainage ditch	P1GDR	2-25
Sutter Bypass, E Levee - SBP2				
4.4 to 5.4	1997	Heavy seepage, soil heaving	P1GDR	2-13
5.4 to 13 (McClatchy Road to Gilsizer Slough)	1958	Landside toe - ground heaving with mud flow, sand boils, berm movement and cracks	P1GDR	2-13
5.4 to 13 (Oswald Rd to Gilsizer Slough)	1958	Longitudinal cracks along landside slope	P1GDR	2-13
12.7 to 14.6	N/A	Seepage and boils	P1GER	2-4
16.6 to 16.78	N/A	Critical seepage area	P1GDR	2-14
17.6	1997	Seepage	P1GDR	2-14
20 to 22.37	1986	Waterside erosion at toe and lower slope	P1GDR	2-14
21.88 to 22.07	2001?	Seepage, boils, sinkhole on landside berm	P1GER	2-4

Table M-1: Summary of Levee Performance Issues

Levee Mile or Location	Year	Problem/Issue	Document	Page
Wadsworth Canal – Unit 1, left bank - WAD1				
1.0	1997	Heavy seepage	P1GDR	2-9
0.0 to 0.6	1997	Seepage, pin boils	P1GDR	2-3
0.0 to 0.6	1998	Seepage, pin boils	P1GDR	2-3
N/A	N/A	WS berm erosion & rodent holes for much of levee reach	P1GDR	2-10
Interceptor Canal – Unit 2, east canal - INT2				
N/A	N/A	N/A	N/A	N/A

Key to Document Abbreviations

Author	Date	Title	Type	Abbrv
USACE Soil Design Chief	09/15/95	Memorandum for Civil Projects Management Section, Subject: Contract 3 Levee Seepage Investigations	Memo	MEM-95
Levee District 1	02/17/97	Levee District 1 to Honorable Vic Fazio, Summary of Repairs and Improvements required for the Feather River Levee of Levee District No. 1 of Sutter County	Letter	LTR -97
USACE, Chief of Soil Design Section	03/03/97	Memorandum For Civil Projects Management Section, Subject: Levee Performance Letters from LD 1 and MHM regarding LD9	Memo	MEM-97
URS Corporation (for DWR)	03/17/08	Draft Phase 1 Preliminary Geotechnical Evaluation Report (P1GER) Sutter Study Area Urban Levee Geotechnical Evaluations Program	Report	P1GER
URS Corporation (for DWR)	11/14/08	Phase 1 Geotech Data Report (P1GDR) Sutter Study Area Urban Levee Geotechnical Evaluations Program Contract	Report	P1GDR

Table I-1: Sutter County Levee Alterations/Modifications

Levee Mile or Location	Year Complete	Alteration/Modification	Document	Page	USACE Drawing	USACE Spec
Hamilton West Levee (HAM1)						
N/A	1954	Levee reconstructed	152	2	--	--
HAM1 and/or MA07						
Unknown	1963	Levee enlargement	152	2A	4-4-534	2949
Unknown	1965	Bank protection	152	2A	50-4-4118	3283
Site Mile 51.1	N/A	Bank protection	152	2A	50-4-5798	8367
Maintenance Area 07 (MA07)						
N/A	1954	Levee reconstructed	152	2	--	--
1 to 1.2	1999	Bentonite/shredded tire slurry wall and nine monitoring wells installed	P1GDR	2-40	--	--
3 to 3.2	N/A	50-foot deep by 3 ft thick waterside slurry cutoff trench on WS levee slope constructed, covered with impervious blanket & embankment fill	P1GDR	2-52	--	--
4.25	1970	Bank protection	152	2A	50-4-4377	3426
4.7 to 5.7	N/A	Backfill landside irrigation ditch	P1GDR	2-52	--	--
10.2 to 10.5	N/A	2,640 feet of levee crest raised up to 2 feet	P1GDR	2-52	--	--
Near Gridley Bridge	1956	Emergency levee repairs	152	2A	4-4-384	2059
1.93 miles upstream from Gridley Bridge	1956	Emergency bank protection	152	2A	4-4-424	2228
Maintenance Area 16 (MA16)						
Sta. 952+00 to 1380+00	1934	Levee enlargement	148	2	4-4-135	--
MA16 and LD9S						
Fm SPRR (2 mi N of Yuba City) to 12 mi N	1945	Levee enlargement	148	2	50-4-2193 and 4-4-267	--
8 mi N of Yuba City	1948	Berm fill, drainage ditch, and road approaches	148	2	4-4-292	

Table I-1: Sutter County Levee Alterations/Modifications

Levee Mile or Location	Year Complete	Alteration/Modification	Document	Page	USACE Drawing	USACE Spec
Levee District 9 (LD9S)						
2.17	N/A	Replaced levee center section with impervious material, landside slope bolstered with dredge tailing blanket, repaired waterside slopes	P1GDR	2-54	--	--
2.3	N/A	Levee fortified with rock	P1GDR	2-42	--	--
2.5	N/A	Levee fortified with rock	P1GDR	2-42	--	--
3.5 to 3.6	N/A	Levee fortified with rock	P1GER	2-10	--	--
3.65	N/A	Replaced levee center section with impervious material, landside slope bolstered with dredge tailing blanket, repaired waterside slopes	P1GDR	2-54	--	--
4.55-5.46	1997	900-feet of irrigation ditch backfilled	#72	2	--	--
4.65 to 5.05	1960	USACE constructed 4-5 foot high, 60-foot wide 2,100-foot long waterside levee toe berm fill	P1GDR	2-54	--	--
N/A	1960	Levee stabilization	148	N/A	4-4-508	2655
Sta. 952+00 to 1380+00	1934	Levee enlargement	148	2	4-4-135	--
Site Mile 34.0	1974	Bank protection and selective clearing	148	N/A	4-4-599	4815
Site Mile 39.5&41.5	1968	Bank protection	148	N/A	50-4-4078	3288
LD9S and LD1S						
Unknown	1960	Levee stabilization in Levee Districts 1 & 9	148	N/A	4-4-508	2655
Levee District 1 (LD1S)						
Sta. 49+40 to 1380+00	1939	Levee enlargement	144	N/A	44-172-1	--
Shanghai to Starr Bend	1940	Levee enlargement	144	N/A	4-4-205-1	--
2 mi south of Starr Bend to Bear River	1940	Levee enlargement	144	N/A	4-4-205-1	--
Downstream from Yuba City	1956	Emergency repair and reconstruction of 8,000 feet of destroyed levee	144	N/A	4-13-405	--
Starr Bend	1956	Emergency levee repairs and bank paving	144	N/A	--	--
Shanghi Bend	1957	Drainage pump and sump	144	N/A	4-4-438	2295
N/A	1940	USACE reconstructs levee	P1GDR	2-22	--	--
N/A	1952	Section of levee crown "surfaced for patrol road purposes"	144	N/A	--	--

Table I-1: Sutter County Levee Alterations/Modifications

Levee Mile or Location	Year Complete	Alteration/Modification	Document	Page	USACE Drawing	USACE Spec
1.5	1998	Seepage/stability berm constructed	P1GER	2-6	--	--
3.8	1998	Levee raised 1 ft, pervious toe drain & seepage/stability berm installed	P1GDR	2-25	--	--
3.8 to 4.5	1997	Raised levee	P1GDR	2-36	--	--
4.1 to 5	1997	Relief wells installed	P1GDR	2-25	--	--
7.2 to 8.2	1997	Installed toe drain and berm	P1GDR	2-36	--	--
8	1986	Levee raised 1 ft, pervious toe drain & seepage/stability berm installed	P1GDR	2-25	--	--
10.8	1956	Emergency levee repairs	P1GDR	2-25	4-4-433	2252
10.8	1986	LD1 constructed seepage/stability berm	P1GDR	2-25	--	--
10.8	1997	LD1 construct new levee with 25-ft deep slurry wall & 6-ft wide clay core	P1GDR	2-25	--	--
11.0 to 12.8	1957	USACE emergency levee reconstruction outboard of previous location, installation of 42 relief wells	P1GDR	2-25, 26 & 53	4-13-405 & 4-4-435	2256
11.0 to 12.4	1990	Yuba City installed shallow seepage interceptor system along southern portion of site and additional relief wells	P1GDR	2-26	--	--
12.8 to 14.3	1997	4,610 feet of slurry wall, 1,690 feet of toe drain and berm, and 2,700 feet of slurry wall installed	P1GDR	2-35	--	--
12.8 to 14.5	1998?	Impermeable cutoff wall constructed	P1GDR/ P1GER	2-26/2-7	--	--
12.8 to 14.5	1990	Yuba City installed shallow seepage interceptor system along southern portion of site and additional relief wells	P1GER	2-7	--	--
N/A	1957	Emergency levee repairs, relief trench drain installed	P1GDR	2-26	4-4-437	2302
14 to 15.5	1956	Emergency levee repairs	P1GDR	2-26	4-4-431	2238
14 to 15.5	1960	Levee stabilization, 600 lineal feet of cutoff trench installed	P1GDR	2-26&53	4-4-508	2655
14 to 15.5	1986?	Yuba City constructed emergency landside toe berm	P1GDR	2-26	--	--
14 to 15.5	N/A	Emergency landside toe berm replaced with permanent seepage/stability berm from 5th St Bridge to 2,500 ft N of 10th Street Bridge	P1GDR	2-26	--	--
14 to 15.5	1998	Rock slope protection installed	P1GDR	2-26	--	--
From midway between 5th St & SR 20 to 4,000 ft north	N/A	Landside sloping drain and berm with toe trench	P1GDR	2-33	--	--
Mile 24.5	1966	Bank protection	144	N/A	50-4-4004	3154

Table I-1: Sutter County Levee Alterations/Modifications

Levee Mile or Location	Year Complete	Alteration/Modification	Document	Page	USACE Drawing	USACE Spec
Maintenance Area 03 (MA03)						
Sutter By-Pass to Nicolaus Bridge	1943	Enlarged levee	143	2	--	--
N/A	1952	Surfacing levee crown for patrol road purposes	143	2	--	--
N/A	1956	Emergency levee repairs	143	2A	4-4-417	2221
0 to 5.11	1963	Levee stabilization	P1GDR	2-24	4-4-531	2783
3.7	1997	Drainage ditch near levee toe converted to toe drain	P1GDR	2-25	--	--
3.7	1998	Seepage/stability berm constructed	P1GDR	2-25	--	--
Sutter Bypass, E Levee (SBP2)						
Sta. 0+66 to 16+50	1942	Levee enlarged to current dimensions	135	2 & 2A	50-4-1946-2	--
Sta. 1+62 to 484+00	1942	Levee enlarged to current dimensions	135	2	50-4-1945-2	--
Sta. 331+00 to 692+00	1942	Levee enlarged to current dimensions	135	3	50-4-2772	--
Sta. 800+00 to 1137+62	1942	Levee enlarged to current dimensions	135	2 & 2A	50-4-1946-2	--
Wadsworth Canal to Gilsizer Slough	1958	Emergency levee repair	135	3A	50-1-3531	2463
N/A	1968	Bank protection	135	3A	50-4-4393	3492
4.4 to 5.4	2001	12 foot wide pervious toe drain and seepage/stability berm	P1GDR	2-12	--	--
5.4 to 13	1957	Installation of exploration holes backfilled with sand (relief drains)	P1GDR	2-14	--	--
5.4 to 13	1958	Construction of 2 ft wide by 15 ft deep relief drain	P1GDR	2-14	--	--
7	1963	Levee repair, bank protection, channel rect.	135	3	4-4-536	
12.66	N/A	Pressure relief well at landside toe	P1GDR	2-14	--	--
12.7 to 14.6	1992	Construction of 10-ft high, 130-ft long rock relief toe drain and berm with 3-ft thick and 10-ft wide embankment berm	P1GDR	2-14	--	--
12.88	N/A	Pressure relief well at landside toe	P1GDR	2-14	--	--
16.6 to 16.78	N/A	Filled ditch on landside toe, constructed wide berm	P1GDR	2-14	--	--
17.6	2001	791-ft long, 2-ft wide, 5-ft deep relief toe trench/drain and overlying seepage/stability berm	P1GDR	2-14	--	--
19.42 to 19.5	N/A	Bow levee constructed around abandoned landside state pumping plant	P1GDR	2-15	--	--
21.88 to 22.07	2001?	1,000 foot long vertical drain in landside berm	P1GDR	2-14		
Near Nelson Bend	1971	Emergency repairs - 800 ft levee construction; 2,300 ft of bank protection	135	3A	4-4-588	3903

Table I-1: Sutter County Levee Alterations/Modifications

Levee Mile or Location	Year Complete	Alteration/Modification	Document	Page	USACE Drawing	USACE Spec
SBP2 and WAD1						
4.48 (SBP2) to 0.5 (WAD1)	2008	3,000 ft of soil-cement-bentonite cutoff wall to 40 to 61 foot depth, levee reconstruction near 0.4 (WAD1) due to slurry boil at waterside levee toe	135	3A and 3B	50-04-6235	1520
Wadsworth Canal – Unit 1, left bank (WAD1)						
N/A	1942	Enlarged levees to current configuration	135	3	50-4-1949-3	
1.0	2001	USACE constructed pervious toe drain	P1GDR	2-9		
Interceptor Canal – Unit 2, east canal (INT2)						
N/A	N/A	N/A	N/A	N/A	N/A	N/A

ENCLOSURE C

REPORT ON COMP STUDY VERTICAL DATUM CONVERSION

US Army Corps of Engineers, Sacramento District
American River Watershed Common Features, Control Survey
Contract No. W91238-07-D-0001, Task Order 0006 and 0007

Report for Task 5
July 01, 2010

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PACIFIC AERIAL SURVEYS

REPORT TITLE: Task 5 Report Summarizing Tasks 1 through 5 that have undergone ITR

SUBMITTED BY: HJW GeoSpatial, Inc, July 01, 2010

REPORT STATUS: For review and approval by USACE

PROJECT TITLE AND LOCATION: American River Watershed Common Features, Control Survey, Sacramento CA.

CONTRACT NO: W91238-07-D-0001 Task Order 0006 & 0007
The survey services performed for this project are described in the Statement of Work dated 5 June 2009 and revised 24 July 2009, together with the Supplemental Statement of Work dated 9 December 2009 and Revised 7 January 2010, issued as Task Orders 0006 & 0007 to USACE Contract No. W91238-07-D-0001

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1. Project Description

Background

During the late 1990's and early 2000's, the Sacramento District collected topographic and bathymetric survey data for the Sacramento River Bank Protection Project and Sacramento-San Joaquin River Basins Comprehensive Study. The data covered most of the Central Valley waterways. The mapping data is currently being used by multiple ongoing studies in the region. The primary submittals of the mapping data effort were Digital Terrain Model (DTM) surfaces and annotated contour and planimetric maps generated from the DTM surfaces. Cross sections were cut from the DTM surfaces for hydraulic models.

The comprehensive study mapping was performed by three vendors: Towill (Concord, CA), Andregg Geomatics (Auburn, CA) and Ayres (Sacramento, CA), under contract with the Corps of Engineers. Most of the comprehensive study mapping was collected to meet 1 inch = 200 feet, 2 foot contour interval map accuracy standards. The contract documents specified the mapping was to be based on NGVD29 vertical datum and NAD83 horizontal datum. Control surveys were tied to NGS benchmarks using static GPS network methods and Geoid 96. Most topographic data were collected using aerial photogrammetric methods. However, LiDAR was used for all of the Towill area and a portion of the Ayres/Andregg area. Bathymetric data for all areas were collected using post processed kinematic GPS for vertical and horizontal positioning of soundings. Bathymetric data were merged into the topographic data to create seamless data sets. Figure 1 illustrates the overall project area along with primary and secondary control locations.

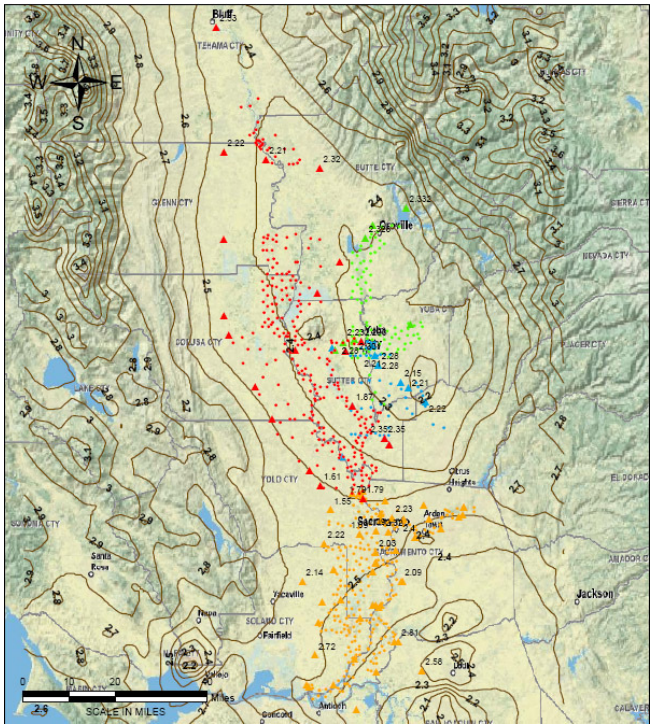

Figure 1- Map of project area and control network

Purpose

The NGS no longer provides elevations adjusted to the NGVD29 datum and recommends that NAVD88 be used for control. The U.S. Army Corps of Engineers, in cooperation with the National Geodetic Survey (NGS), has several engineering manuals including EM 1110-1-1005 Control and Topographic Surveying (Reference a) and EC 1110-2-6065 Comprehensive Evaluation of Project Datums (Reference b), that now mandate all such data and its many applications reference the North American Vertical Datum of 1988 (NAVD 1988). To make the comprehensive study mapping data compatible with recent data collected in the NAVD88 datum, the American River Common Features GRR Project has requested these data be accurately updated to the NAVD88 datum. The purpose of the five tasks described in this report is to develop a project-specific conversion surface to apply to the original mapping deliverables, to convert the datasets into NAVD88.

2. Task 1 Overview

Task Objective
Develop quality control plan and geospatial data management plan

Procedure
HJW developed a quality control plan which was signed and submitted by HJW on October 7th, 2009. This plan illustrates the following elements:

- HJW Quality Statement
- Management approach to quality control
- Project delivery team
- Quality control procedures
- Project milestone quality control timeline
- Independent technical review

On October 8th, 2009, HJW provided the geospatial data management plan, which integrates geospatial data management into project management business process, facilitating the implementation of enterprise data management.

Conclusion
HJW's quality control plan and geospatial data management plans were approved by the USACE, and the project team proceeded to Task 2.

3. Task 2 Overview

Task Objective
Review comprehensive study mapping control

Procedure
Task 2 as listed in the Statement of Work involved the review of the comprehensive study mapping control and GPS network files for the four separate networks. A subset of stations from the four networks was selected to be included in our survey, subject to recovery efforts, and criteria for selecting alternate stations were identified.

As part of Task 2, a technical memorandum was prepared describing the selection of stations for survey, the planned survey method and control. A draft report was prepared in accordance with the original Statement of Work which described a static GPS survey network to be surveyed according to NGS58/59 specifications. Interpretation of these specifications, particularly in regards to station spacing and minimum observation times, revealed that following the strictest interpretation would be unnecessarily prohibitive for this project given the accuracy requirements, and this led to discussion of alternate methods. Upon discussion with the USACE it was determined that network RTK would meet the project needs and the scope was modified by the issuing of a supplemental Statement of Work (dated December 9, 2009 and Revised January 7, 2010) before the control survey had commenced.

Conclusion
A final technical memorandum, dated March, 10 2010, describing the proposed survey was subsequently accepted by the USACE and is included in this submittal as Task 2/Appendix A. Filename: "Appendix A - 100310 Control Memo.pdf".

4. Task 3 Overview

Task Objective
Control survey to achieve the following objectives:

1) Provide adequate NAVD88 vertical constraints to readjust four legacy static GPS networks to the NAVD88 datum. (Upper Feather River, Lower Feather River, Lower Sacramento & Upper Sacramento networks)
2) Resurvey a selection of points from all four legacy GPS networks to establish check points for validation of a conversion surface to be created from the readjusted legacy networks. These points will not be used in developing the conversion surface
3) Establish accurate NAVD88 benchmark elevations at approximately 30 State of California Department of Water Resources (DWR) stream gauging stations, and level elevations to additional marks and features at each site.
4) Establish accurate NAVD88 elevations on approximately 20 existing USED benchmarks
5) Establish accurate NAVD88 elevations on control points used in topographic mapping of five weirs specified by the USACE, to facilitate conversion of the mapping to the NAVD88 datum

Methodology for the control survey is described in the final technical memorandum, submitted as the Task 2 deliverable for the project.

4.1. Schedule

The three main components of the control survey were performed through the following dates:

1) **Control Station Recovery**: Most Stations were recovered between November 23, 2009 and December 17, 2009. Additional recovery efforts for USED Benchmark and stream gage reference marks took place in January through April of 2010.

2) **GPS Surveying:** GPS observations for control stations and Comprehensive Study Mapping control stations were performed between late January 2010 and early March 2010. Additional observations at USED benchmarks, stream gages, and reoccupation of stations with poor repeat precision were performed throughout May and April of 2010.

3) **Leveling:** Most leveling was performed during the second half of March 2010, with some additional leveling performed in April 2010

4.2. Control Station Recovery

Stations were searched for and recovered using handheld GPS receivers (Trimble Juno SB) and ArcPad 8.0 software. Recovered stations were photographed using the onboard camera, and basic recovery information (date, condition, party chief) was stored. An ESRI ArcGIS shapefile was created including all collected information and links to photographs. Photos taken using the Trimble Juno SB hardware were also geotagged if the GPS receiver had a positional fix at the time the photo was taken. Photos and GIS data are delivered with this submission in the folder: Task 3/Monument Photos and GIS Data.

An evenly distributed selection of stations from each of the comprehensive study GPS networks was identified as part of Task 2, and the field staff was instructed to search for these stations. If the selected station was not found or found disturbed, the crews searched for nearby stations until one in good condition was recovered. NAVD88 control stations were also recovered at this time.

4.3. RTK GPS Survey

Through coordination with the USACE it was determined that the best methodology to perform the survey within the time, budget & achieve the positional accuracy required would be to use RTK GPS in conjunction with a Real-Time Network (RTN). To maximize the accuracy of the RTK survey, all stations were observed for a minimum of 5 minutes (300 epochs), and all stations were observed at least twice, with observations a minimum of 3 hours apart in order to obtain significantly different satellite geometry. The two observed heights were then averaged to obtain a final result.

Statistical review of the data obtained in the first few weeks of surveying showed that for repeat observations, the 95% confidence interval for the height component was approximately +/- 0.20 feet between observations. This value was then used as a basis to determine which stations would need to be observed a third time. Any stations for which the two observed heights did not agree within 0.20' were observed a third time and the results were re-evaluated. If two of the heights were in relative agreement and the third was an obvious outlier, then the outlier was discarded and the average of the remaining two was taken. If the third observed height was midway between the first two observed heights, then an average of all three was taken.

Our assessment of the accuracy of the NAVD88 elevations obtained by RTK methods is based on a number of components. Evaluation of repeat observations showed the vertical accuracy of any given measurement to be +/- 0.2 feet at 95% confidence. Derived heights were based on a GPS site calibration to control stations with inherent uncertainty (typically height modernization stations published +/-0.10 foot vertical accuracy), and observations on the control stations have the same uncertainty as all other RTK observations. There is also inherent uncertainty in the Geoid model. We estimate that the overall vertical accuracy of surveyed stations relative to the National Spatial Reference System (NSRS) and NAVD88 will be better than +/-0.33 feet at 95% confidence.

The identical survey methodology was used for all stations observed as part of this survey regardless of purpose, including the comprehensive study mapping control, NAVD88 calibration points, USED benchmarks and stream gage benchmarks. All RTK survey data is included in the "RTK Survey Data" folder in the Task 3 submittal folder.

4.3.1. Equipment

Two of Bestor's RTK rovers were configured to work with either RTN, and two survey parties were dispatched to survey simultaneously. Equipment used consisted of the following:

Rover #1:
Trimble 5800 GPS Receiver / integrated GPS antenna
Trimble TSC-2 Data Collector with Survey Controller Software (v. 12.45)
Verizon MiFi 2200 mobile WiFi data link with Verizon Wireless 3G data service
Fixed-height GPS rover rod with clamp-on tripod.

Rover #2:
Trimble 5700 GPS Receiver
Trimble Zephyr Geodetic GPS Antenna
Trimble TSC-2 Data Collector with Survey Controller Software (v. 12.46)
Motorola Cellular phone with Verizon 3G data service & Bluetooth Dial-up Networking
Fixed-height GPS rover rod with clamp-on tripod.

4.3.2. Real-Time Networks

Two separate Real Time Networks (RTN's) were utilized to perform the RTK survey, maintained by two separate survey equipment vendors. Each network has unique characteristics. It was necessary to use both to networks achieve complete coverage of the project area.

Our primary deciding factor in deciding which to utilize was network coverage. Topcon California's network includes a higher density of stations near the southern end of the project, while the network operated by California Survey and Drafting Supply has coverage that extends further north.

Topcon California RTN:

Bestor is partnered with Topcon California to host a network station from their RTN on our building. This provides us with one user account to use the network, and it was used as the primary network for our survey. A second subscription was purchased in order to allow us to survey with two receivers simultaneously. Coverage for Topcon California's RTN does not extend to the northernmost extents of the project, however, so we used an alternate RTN to survey the northerly stations.

Topcon California's network includes options for network or single-base solutions. Network solutions were used exclusively for this project. While the RTN supports GLONASS observations, our rovers used only GPS for this project.

Real-time corrections for the Topcon California RTN were delivered via the RTCM broadcast format. This format did not allow positions to be store as vectors using our field equipment, therefore all observations were stored as positions.

California Survey and Drafting Supply (Trimble) RTN:

Corrections for the California Survey and Drafting Supply RTN are delivered via the CMR Broadcast format, and using this format we were able to choose to store our observations as vectors. All stored positions were based on a network solution based on the surrounding reference stations, however storing the observations as vectors from the nearest physical reference station can allow additional functionality using Trimble software. While the RTN supports GLONASS observations, our rovers used only GPS for this project.

4.3.3. GPS Site Calibrations

Three separate GPS site calibrations were performed, the results of which are include as GPS Site Calibrations Reports in Appendices B, C & D in the Task 3 submission folder.

As two different RTNs were used to cover different Geographic areas, each needed to include observations on a sufficient number and distribution of control stations to calibrate the given RTN to desired coordinate system and datum. Stations used in the calibrations are identified in the attached GPS Site Calibration Reports.

In addition to the two separate calibrations required by the use of two separate RTNs, the Lower Sacramento mapping area was calibrated to a different set of control stations than the rest of the project, which required a separate site calibration. All observations in the Lower Sacramento area used Topcon California's RTN, so there was no separate calibration of the CSDS RTN to the Lower Sacramento control.

Our survey was designed to include calibration points at approximately a 20 km spacing throughout the project, which we generally accomplished, however not all of the control stations we searched for were recovered which resulted in greater spacing in certain areas.

While performing the site calibrations, stations with high residuals were carefully reviewed, and in some cases obvious outliers were removed from the calibration.

GPS Site Calibrations were based on the following sets of control stations:

Lower Sacramento Mapping Area:

In the Lower Sacramento Mapping area, the Topcon California RTN was calibrated to stations from Delta Height Modernization survey, as published by the NGS. NGS published heights for these stations are derived using GEOID03, and are published with orthometric heights to the 0.1 foot. No surveying was performed in the Lower Sacramento mapping area using the California Survey and Drafting Supply RTN. Please refer to Appendix B in the Task 3 submission folder.

Upper Sacramento, Lower Feather & Upper Feather Mapping Areas:

In all other mapping areas, two separate site calibrations were performed to derived orthometric heights obtained by applying the GEOID09 separation to the unpublished Sacramento Valley Height Modernization Project (SVHMP) ellipsoid heights, as delivered by the USACE. Please refer to Appendix C and D in the Task 3 submission folder.

4.4. Leveling

Leveling was performed at various locations for specific purposes identified in the Statement of Work. Most of the leveling required was to establish elevations on various reference marks at stream gages.

Additional leveling was required for certain USED benchmarks. Where a USED benchmark was recovered but was not in a GPS-suitable location, a temporary benchmark was established nearby and leveling was performed from the temporary benchmark to the USED benchmark.

Equipment used for leveling consisted of Leica NA2 auto levels. All elevations determined through leveling were part of a closed loop.

All leveling was performed using closed loops, and all loop closures were less than 0.02 feet. Local accuracy between stations within one level loop is +/- 0.02 feet.

4.4.1. Stream Gages

The locations of stream gage reference marks were provided by the USACE, who obtained them from the operating agency (California Department of Water Resources or U.S. Geological Survey). At each gage site, our crews attempted to recover the reference marks indicated.

If a reference mark was found in a GPS-suitable location, an elevation was established by GPS methods (described above), and a leveling crew later returned to the gage site to level from the GPS-established benchmark elevation to additional reference marks and the water surface. If no recovered reference marks were GPS-suitable, then a temporary benchmark was established at the site using GPS methods for use as a local benchmark.

Our office prepared a custom form specific for leveling at the stream gage locations, and our leveling crews completed a leveling form for each stream gage. Scans of the completed stream gage leveling forms are attached as Appendix E in the Task 3 submission folder.

The GPS-established reference mark at each stream gage was determined through RTK GPS methods described in Section 4.3. Estimated accuracies for the reference marks with respect to the National Spatial Reference System (NSRS) and NAVD88 are +/-0.33 feet as described above. All leveling at each gage site was performed as part of a closed loop, and all loop closures were less than 0.02 feet. The local accuracy between leveled marks at each gage site is +/- 0.02 feet.

4.4.2. USED Benchmarks

Leveling was performed at certain USED benchmarks, in cases where the recovered benchmark was found in a location not suitable for GPS. The table below summarizes the results of our survey of USED benchmarks. Some of the elevations shown were established by leveling from a temporary benchmark, while others were surveyed directly with GPS methods.

In six locations, no benchmark was recovered after searching for all of the alternates identified on the spreadsheet provided by the USACE. In the general area identified as Tisdale Weir, none of the identified benchmarks were recovered; however we leveled to a USED Brass Disc that we

found in the North End of Weir with the stamping illegible. Some additional "USED" stamped monuments not identified in the table below were also surveyed as reference marks at stream gage locations. Elevations for these monuments can be found on the stream gage leveling forms.

Area ID	General Area	Station ID	Benchmark NAVD88 Elevation (U.S. FT)	NAVD88 Survey Date	Notes
1	Collinsville	USGS BM 1906 5B	8.33	26-Jan-10	
2	Rio Vista	USC & GS BM D-585-JS1797	20.19	25-Jan-10	
3	Isleton	Bm # 15	22.59	27-Jan-10	
4	Walnut Grove	USED # 26 (marked #50)	26.82	27-Jan-10	
	Courtland	USED 61	25.17	2-Feb-10	
5	Courtland		27.14	28-Jan-10	No Requested Stations Found - Surveyed "USE64" in Same Vicinity
6	Freeport	USED 81	28.80	2-Feb-10	
7	Sacramento 1	Tidal 3 -JS2309	34.44	3-Feb-10	
	Sacramento 2	Weir # 1	44.64	3-Feb-10	AKA "SAI-179"
8	Sacramento 2	Weir # 2	44.50	3-Feb-10	AKA "SA-178"
9	Sacramento 3	USGS 21 B	23.68	15-Apr-10	
10	Knights Landing	USED 1001	43.65	3-Mar-10	
11	Tisdale Wier		44.22	3-Mar-10	No Requested Stations Found - Surveyed USED Brass Disc in North End of Weir, stamping illegible
	Middle of Upper Sac	USED 1259 Moulton Weir	84.41	16-Feb-10	
14	Middle of Upper Sac	USED 1257	84.43	16-Feb-10	
18	Yuba/Marysville	USED 3111	73.28	14-Apr-10	
12	Butte		No Benchmarks Recovered		
13	Colusa		No Benchmarks Recovered		
15	Upper/middle sac		No Benchmarks Recovered		
16	Upper Sac River		No Benchmarks Recovered		
17	Lower Feather		No Benchmarks Recovered		
19	Upper Feather		No Benchmarks Recovered		

Table 1: Summary of USED Benchmarks

4.4.3. Weir Surveys

A small amount of leveling was also performed at various weir survey locations for the purpose of establishing NAVD88 elevations on hard features identified in topographic survey drawings. These will be used as reference points to convert these drawings to the NAVD88 datum. Conversion will be done as part of Task 6.

The tables below show comparisons between the surveyed NAVD88 elevations and the NGVD29 elevation of certain benchmarks and features shown on CAD drawings provided by the USACE. At each weir site an average difference has been calculated for use in converting NGVD29 elevations shown on the drawing to NAVD88.

All elevations at any one weir site were determined through differential leveling from a single GPS-established reference mark, with the exception of the Fremont Weir, where a reference mark was established by GPS methods at each end of the weir. Estimated accuracies are +/- 0.02 feet within each closed level loop, and +/- 0.33 feet relative to the National Spatial Reference System (NSRS) and NAVD88.

Moulton Weir				
Point	**NGVD29 Elevation (m)**	**NGVD29 Elevation (USFT)**	**NAVD88 Elevation (USFT)**	**Difference (USFT)**
South Headwall / USED 1257	25.15	82.51	84.43	1.92
North Headwall / USED 1259	25.19	82.64	84.41	1.77
Weir Crest - South End	22.49	73.79	75.87	2.08
Weir Crest - Midpoint	22.55	73.98	75.92	1.94
Weir Crest - North End	22.56	74.02	75.99	1.97
			Average Difference:	**1.94**

Table 2- Elevations for Moulton Weir

Fremont Weir				
Point	**NGVD29 Elevation (m)**	**NGVD29 Elevation (USFT)**	**NAVD88 Elevation (USFT)**	**Difference (USFT)**
East Headwall / "Fremont"	11.84	38.85	41.11	2.26
Weir Crest - East End	9.25	30.35	32.67	2.32
Weir Crest - West End	9.21	30.22	32.42	2.20
		0.00	**Average Difference:**	**2.26**

Table 3- Elevations for Fremont Weir

Colusa Weir				
Point	**NGVD29 Elevation (m)**	**NGVD29 Elevation (USFT)**	**NAVD88 Elevation (USFT)**	**Difference (USFT)**
North End Weir @ Centerline	17.94	58.86	60.77	1.91
North End Weir @ West Edge	17.86	58.60	60.62	2.02
North End Weir @ East Edge	17.86	58.60	60.58	1.98
			Average Difference:	**1.97**

Table 4- Elevations for Colusa Weir

Tisdale Weir				
Point	**NGVD29 Elevation (m)**	**NGVD29 Elevation (USFT)**	**NAVD88 Elevation (USFT)**	**Difference (USFT)**
Weir Crest - North End / USED 1129	12.82	42.06	44.22	2.16
North Headwall / "RP#1"	14.69	48.20	50.33	2.13
			Average Difference:	**2.15**

Table 5- Elevations for Tisdale Weir

Sacramento Weir				
Point	**NGVD29 Elevation (m)**	**NGVD29 Elevation (USFT)**	**NAVD88 Elevation (USFT)**	**Difference (USFT)**
F9 01	11.90	39.04	41.28	2.24
SA1-229	12.44	40.81	43.09	2.28
Conc Wall NE Corner Weir / SA-178	12.89	42.29	44.50	2.21
Weir Crest - North End	6.28	20.60	22.87	2.27
Weir Crest - South End	6.39	20.96	22.91	1.95
			Average Difference:	**2.26**

Table 6- Elevations for Sacramento Weir

5. Task 4 Summary

Task Objective

Readjust Comprehensive Study GPS Network Files into NAVD88.

5.1. Lower Sacramento

The readjustment of the Lower Sacramento Comprehensive Study GPS Network was performed by a third party contracted directly by the USACE. The readjustment was based on stations surveyed by Bestor and provided to the USACE.

The original Lower Sacramento Comprehensive Study network adjustment was performed using a software package that our office was unable to work with (Geolab). Also, digital files containing the original GPS data or processed vectors were not available. Data available from the network consisted of only scanned printouts of the adjusted coordinate listing, and some of the adjustment results.

The USACE contacted the vendor of the Geolab software, Bitwise Solutions, and arranged to transpose the scanned adjustment reports and have Bitwise readjust the network using a current software release. A report documenting the readjustment was prepared by Bitwise Solutions and is included in this submittal in the Task 4 folder, in the "Bitwise Readjustment" subdirectory.

Bestor's involvement was limited to providing surveyed NAVD88 elevations for a sufficient number of stations to facilitate the readjustment, and reviewing the comparison of checkpoint elevations to elevations derived using a surface created from the readjusted elevations.

5.2. Lower Feather River

The comprehensive study GPS network files for the Lower Feather River mapping area were delivered to us by the USACE in Trimble Geomatics Office format, the format generally used by our office for GPS processing.

The project was opened and converted to our current software version (ver. 1.63) and all NGVD29 control elevations were discarded. Our resurveyed NAVD88 elevations were added as constraints, and a least-squares network adjustment was performed. GEOID09 was used in the readjustment.

A horizontal and vertical adjustment was performed, however only the readjusted heights were used in the development of the conversion surface.

A network adjustment report is included in the Task 4 submittal folder, as Appendix F.

5.3. Upper Feather River

HJW arranged to purchase the comprehensive study GPS network files for the Upper Feather River area from the original surveyor, Andregg Geomatics, which were delivered to Bestor on 28 September 2010.

Files were delivered in a Trimble .A1 archive format, which we were able to import into our Trimble Geomatis Office software ver. 1.63. All NGVD29 control point elevations were discarded, and a least-squares network adjustment was performed constraining the NAVD88 resurveyed elevations. GEOID09 was used in the readjustment.

A horizontal and vertical adjustment was performed, however only the readjusted heights were used in the development of the conversion surface.

A network adjustment report is included in the Task 4 submittal folder, as Appendix G, along with the adjustment data, in the "Trimble Geomatics Office" directory.

5.4. Upper Sacramento

The comprehensive study GPS network files for the USACE were provided to us by the USACE in an Ashtech format that is no longer supported. We were therefore not able to open the network files directly with software available to us, however we were able to import the processed vectors into Magellan's GNSS Solutions software, version 3.10.10, which we obtained specifically to work with this data.
s
The Upper Sacramento network files consisted of five separate Ashtech projects, and were readjusted as five separate projects in GNSS Solutions, named "CHICO", "DAVIS", "SCID", "YUBANRTH" & "YUBASTH"

Elevations and coordinates of resurveyed stations were added to the respective projects as constraints, and a least-squares adjustment was performed using the Fillnet component of the GNSS Solutions software. Since the purpose of the readjustment was to establish NAVD88 heights, no attempt was made to perform a precise horizontal readjustment, or to resolve horizontal misclosures.

Survey reports including adjustment reports generated using GNSS Solutions software are included as Appendices H through L, in the Task 4 submittal folder. The network adjustment data is also contained within the "GNSS Solutions" folder in the Task 4 submittal folder.

5.5 Checkpoint Evaluation of Readjusted Networks

For each of the four readjusted Comprehensive Study GPS Networks, the readjusted elevations of a selection of stations were compared to newly surveyed checkpoint elevations of the same stations. Checkpoint elevations were determined by the use of the network RTK methodology described in Section 4.3. The surveyed checkpoint elevations were for evaluation purposes only and were not used in the network readjustments. This comparison provides a measure of how well the readjusted elevations can be expected to represent resurveyed elevations. This is strictly an evaluation of the network readjustments, and is completely independent of the development of the conversion surface (Task 5). Tables and statistics for the checkpoint evaluation of each of the four readjusted networks are shown below. All units shown are U.S. Survey Feet.

Upper Sacramento Readjustment	
RMS Error	0.152
Mean	-0.063
Median	-0.056
Mode	#N/A
Standard Deviation	0.14208
Sample Variance	0.02019
Kurtosis	0.92899
Skewness	-0.61053
Range	0.594
Minimum	-0.404
Maximum	0.19
Sum	-1.131
Count	18

Table 7- Checkpoint analysis of Upper Sacramento readjusted network

One checkpoint, point # 388, was rejected and not used in the RMS calculation for the Upper Sacramento region. The point was a statistical outlier for the dataset, outside the 95% confidence interval (1.96 sigma). The large observed difference between the readjusted elevation and surveyed elevation is likely indicative that the monument has been disturbed since the time of the original Comprehensive Study survey.

Upper Feather Readjustment	
RMS Error	0.049
Mean	-0.015
Median	-0.017
Mode	#N/A
Standard Deviation	0.04922466
Sample Variance	0.00242307
Kurtosis	-1.1690365
Skewness	-0.0034134
Range	0.146
Minimum	-0.087
Maximum	0.059
Sum	-0.152
Count	10

Table 8- Checkpoint analysis of Upper Feather readjusted network

Lower Feather Readjustment	
RMS Error	0.066
Mean	-0.035
Median	-0.026
Mode	#N/A
Standard Deviation	0.059122
Sample Variance	0.003495
Kurtosis	1.771227
Skewness	-0.86275
Range	0.198
Minimum	-0.158
Maximum	0.04
Sum	-0.314
Count	9

Table 9- Checkpoint analysis of Lower Feather readjusted network

Lower Sacramento Readjustment	
RMS Error	0.196
Mean	-0.095
Median	-0.091
Mode	#N/A
Standard Deviation	0.185508
Sample Variance	0.034413
Kurtosis	1.979844
Skewness	1.232794
Range	0.556
Minimum	-0.292
Maximum	0.264
Sum	-0.662
Count	7

Table 10- Checkpoint analysis of the Lower Sacramento readjusted network

One checkpoint, Point # 108, was rejected and not used in the RMS calculation for the Lower Sacramento region. The point was a statistical outlier for the dataset, outside the 95% confidence interval (1.96 sigma). The large observed difference between the readjusted elevation and surveyed elevation is likely indicative that the monument has been disturbed since the time of the original Comprehensive Study survey. Additionally two points, #86 and # 159, were surveyed for checkpoint purposes; however no readjusted elevations were provided for these stations so no comparison could be made.

Conclusion

RMS vertical errors for the four network readjustments range between 0.05' and 0.20' based on our checkpoint evaluation. This is consistent with our expected vertical accuracy of our survey methods used to resurvey the control stations and checkpoints, demonstrating that all four readjustments were successful. The readjusted coordinates represent accurate NAVD88 elevations, and are suitable for use in development of the conversion surface.

6. Task 5 Summary

Task Objective
Develop conversion surface which will be used to convert Comprehensive Study DTM data from original datum into NAVD88.

6.1 Methodology

The Comprehensive Study DTM data was tied into multiple unreliable control networks referencing NGVD29. Because of this lack of reliability, Vertcon alone does not provide an adequate conversion to NAVD88. Therefore, in addition to the Vertcon correction, we also model the "Vertcon error", which we define as the difference between the Vertcon correction and the measured correction at known points. The "Vertcon error" for this network of points acts as the conversion surface; an enhancement to the transformation from NGVD29 to NAVD88 that is applicable only to this dataset- the Comprehensive Study DTM. For clarity, it is important to note that our use of the term "Vertcon error" does not imply that there is error in Vertcon, but rather it describes the error that remains for this particular dataset after applying the Vertcon transformation.

The following steps were taken to develop the conversion surface:

1. For each surveyed point in the control network, we determined the difference between NGVD29 and NAVD88 using Vertcon.
2. We subtracted the Vertcon-derived value of NAVD88 from the newly-surveyed, adjusted value
3. A TIN was created of these differences, which we call the "Vertcon error"
4. The TIN was converted into a DEM at 1,000' point posting
5. CORPSCON was used to determine Vertcon correction values, based upon the horizontal position of each DEM point
6. At each DEM point, the "Vertcon error" is added to the Vertcon value. These are the final correction values that can be applied to the Comprehensive Study DTM in order to convert into NAVD88.
7. The DEM was then represented as a TIN for subsequent contour generation (at 0.1' interval) and utilization as a conversion surface.

Input data used in the development of the conversion surface was provided by Bestor Engineers, as a result of their completion of Task 4. All primary and secondary control points that were surveyed had the following information provided as input to the conversion surface computation:

a. Station Name
b. Horizontal position (Northing and Easting in SPCS NAD 83 Zone II – US Foot)
c. Height in NGVD29
d. Height in NAVD88 – resulting from field survey (primary points), or as a result of network adjustment (secondary points)
e. Vertical differences between NAVD88 and NGVD29 at these locations.

Initially, the team had planned to generate each of the four conversion surfaces independently of each other; that is to say that there will be one conversion surface for Upper Feather, Lower Feather, Upper Sacramento and Lower Sacramento, and each surface will utilize only control

points (primary / secondary) that were part of each region's original survey. This approach was modified after determining that the control networks as planned did not provide suitable geometry for circumscribing the respective mapping areas for interpolation. The solution to this was to create two (rather than four) conversion surfaces.

1. Conversion surface 1 ("CSurface 1"): Lower Feather River Area
2. Conversion surface 2 ("CSurface 2): Lower Sacramento, Upper Sacramento, Upper Feather Areas.

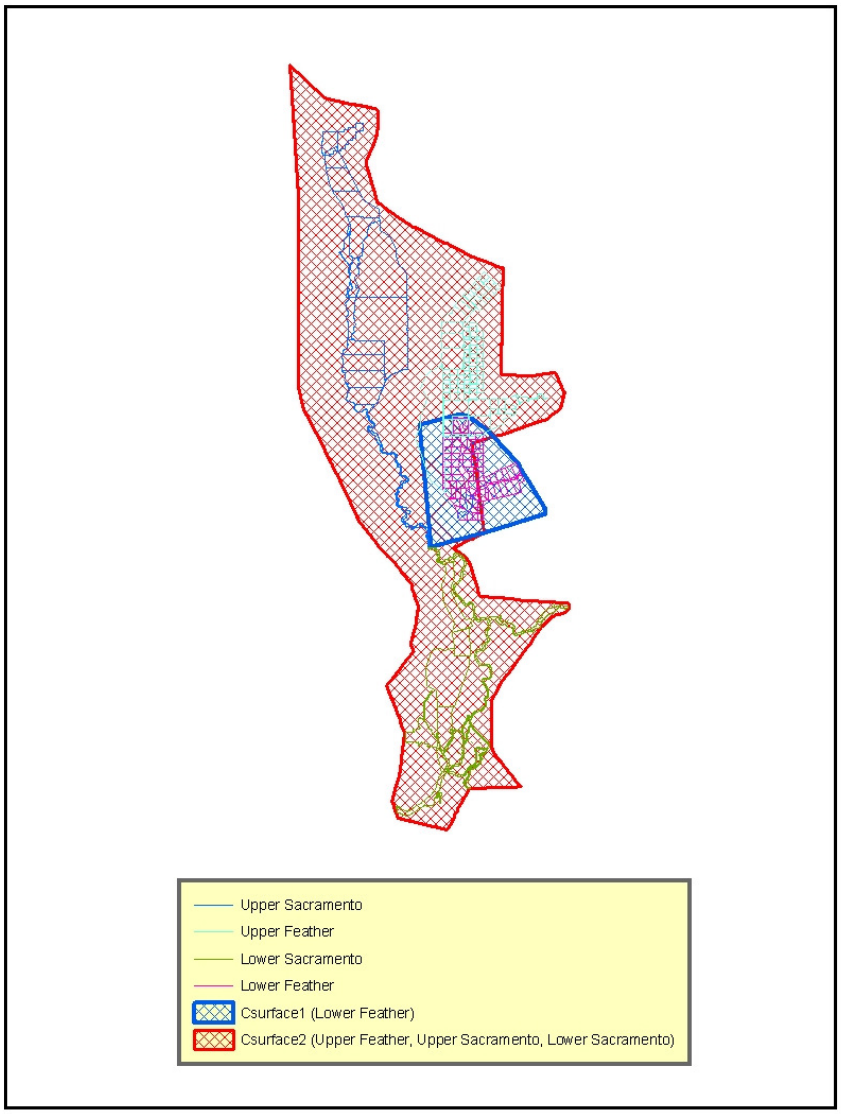

Figure 2: Conversion surface 1 in blue, conversion surface 2 in red

6.1.1 Conversion Surface 1- Lower Feather River Area

For the Lower Feather River area, it was determined that due to the control distribution, another control point external to the planned network was necessary for proper interpolation of the conversion surface. The USACE provided an additional point- NGS station Q213 (see table below) to use for this purpose. All data in the following table is with respect to State Plane Coordinates, Zone 2, NAD83, USFT.

PT	N	E	EL29	EL88	EL_DIFF	VERTCON	VCON_ERROR
Q 213	2229142.12	6816654.03	1814.763	1817.221	2.458	2.451	0.007

PT = Station Name
N = Northing
E = Easting
EL29 = Elevation in NGVD 29
EL88 = Elevation in NAVD 88
EL_DIFF = Elevation difference EL88 – EL29
VERTCON = Vertcon value
VCON_ERROR = Vertcon error values

Table 11- NGS point provided by USACE to complete conversion surface 1 TIN

Conversion Surface 1 covers 403 square miles and utilizes 57 surveyed points. One point was omitted from the surface computation after it was determined to be in error, as it was exhibiting a spike in the surface. Nine checkpoints were tested for this conversion surface.

6.1.2 Conversion Surface 2- Lower Sacramento, Upper Sacramento and Upper Feather River Areas

In Conversion Surface 2, there were four points common to the Upper Sacramento and Lower Sacramento areas that Bestor had surveyed and which were also computed independently by adjustment of an existing dataset. In the conversion surface, we used only the surveyed points in this case. The four points and surveyed coordinates are listed in the table below.

PT	N	E	EL29	EL88	EL_DIFF	VERTCON	VCON_ERROR
AYRES 494	2013742.95	6654790.27	47.621	49.474	1.852	2.661	0.809
AYRES 500	2014208.17	6663022.65	38.520	40.318	1.798	2.694	0.896
DUFOUR RM 2	2039908.19	6606054.47	64.370	66.054	1.684	2.772	1.088
Q858	2069993.26	6697206.30	44.560	46.228	1.667	2.516	0.849

Table 12- Surveyed points used in Upper Sacramento area conversion surface

It was necessary to add three more control points in order to have proper TIN interpolation of the conversion surface. The USACE provided HJW with three additional NGS points, as listed in the table below.

PT	N	E	EL29	EL88	EL_DIFF	VERTCON	VCON_ERROR
S 138	2585481.44	6736182.87	4850.200	4853.616	3.416	3.428	-0.012
Q 213	2229142.12	6816654.03	1814.763	1817.221	2.458	2.451	0.007
G 900	2341925.07	6669223.60	320.925	323.306	2.381	2.375	0.006

Table 13- Additional NGS points provided by USACE for Conversion Surface 2

Conversion Surface 2 covers 3,567 square miles and utilizes 612 surveyed points. Three points were classified as blunders and omitted from the surface computation as they were showing spikes in the conversion surface. 36 checkpoints were used in this conversion surface. Section 6.3 lists the supporting data files and deliverables applicable to this conversion surface.

6.2 Checkpoint Comparison & Conversion Surface QA/QC

Based on the readjusted elevations from the Comprehensive Study GPS networks, two NGVD29 to NAVD88 conversion surfaces were developed for use in converting the mapping to the NAVD88 datum. Methodology for the development of the conversion surfaces was determined by coordination between HJW and the USACE, with minimal involvement from Bestor.

Bestor's role in the QA/QC of the conversion surfaces was primarily the comparison of the elevations of surveyed checkpoints to elevations derived using the conversion surface.

Some outlier checkpoints with excessively high residuals were rejected, and review of the locations of the surveyed monuments found that most of these were in locations that were likely to have been disturbed. In all cases any rejected checkpoints were statistical outliers that were outside the 95% confidence interval (1.96 sigma) for the data set.

A comparison of nine checkpoints to elevations derived using the conversion surface yields the following statistics for the residuals (units are U.S. Survey Feet):

Lower Feather	
RMSE	0.077
Mean	0.005
Median	-0.006
Standard Deviation	0.081
Sample Variance	0.007
Range	0.313
Minimum	-0.124
Maximum	0.189
Sum	0.048
Count	9

Table 14- Checkpoints results for conversion surface 1- Lower Feather River Area

A similar comparison using 36 checkpoints from the remaining three areas (and rejecting points # 388 & 504) gives the following:

Lower / Upper Sacto & Upper Feather	
RMSE	0.133
Mean	-0.032
Median	-0.044
Standard Deviation	0.131
Sample Variance	0.017
Range	0.573
Minimum	-0.296
Maximum	0.277
Sum	-1.144
Count	36

Table 15- Checkpoint results for conversion surface 2- Lower and Upper Sacramento, Upper Feather River Areas

The calculated RMSEz for the two sets of checkpoints indicate that the conversion surfaces should be effective in accurately converting the comprehensive study mapping files to the NAVD88 datum, as the accuracy of surveyed checkpoints will exceed most all map accuracy standards used for aerial mapping that may have been used in the development of the comprehensive study mapping.

6.3 Conclusion

Two conversion surfaces were generated for the four mapping areas (upper and lower Feather, and upper and lower Sacramento River areas) by incorporating measurements of height differences between NGVD29 and NAVD88 at known primary survey points and secondary points determined through network readjustments. This allows for the determination of errors that remain after the Vertcon transformation between datums. Checkpoint analysis of the conversion surface indicates accuracies that are well within mapping specifications for the Comprehensive Study DTM.

Conversion Surface 1

- Applicable area: Lower Feather River mapping area
- Based upon checkpoint comparisons, the RMSE of 0.077' indicates that tested points are well within the requirements of converting the Comprehensive Study DTM data.

Conversion Surface 2

- Applicable areas: Lower Sacramento, Upper Sacramento, Upper Feather River mapping areas.
- Based upon checkpoint comparisons, the RMSE of 0.133' indicates that tested points are well within the requirements for converting the Comprehensive Study DTM data.

Instructions for use of the Conversion Surfaces
Both conversion surfaces area applicable only to the Comprehensive Study DTM data, which was collected in the late 1990's and early 2000's, by three vendors, as illustrated in the introduction to this report. The conversion surface is used to convert elevations from the instance of NGVD29 used in the Comprehensive Study project, into NAVD88. Task 6 is dedicated to the application of this conversion surface to the DTM files.

6.4 Listing of Task 5 Deliverables and Data Directory Index

1. Report summarizing Tasks 1-5, after having undergone independent technical review, including assessment of uncertainty based upon values at checkpoints. Final report in digital and three paper hardcopies.

2. ESRI TIN of conversion surface
    a. Conversion Surface/CSurface1/ESRI/TIN/
        i. CSurf1_vconer
        ii. CSurface1
    b. Conversion Surface/CSurface2/ESRI/TIN/
        i. CSurf2_vconer
        ii. CSurface2

3. Contour map of conversion surface in shapefile format
    a. Conversion Surface\CSurface1\ESRI\Shp\Csurface1_contourlines.shp
    b. Conversion Surface\CSurface2\ESRI\Shp\Csurface2_contourlines.shp

4. Shapefile of final control points- NGVD29 and new values
    a. Conversion Surface/CSurface1/ESRI/Shp/
        i. Csurface1_points_primary.shp
        ii. Csurface1_points_secondary.shp
    b. Conversion Surface/CSurface2/ESRI/Shp/
        i. Csurface2_points_primary.shp
        ii. Csurface2_points_secondary.shp

5. Approval of conversion surface by PLS
    a. Attached: "100526 Conversion Surface Certification.pdf"

6. Map of checkpoints and uncertainties
    a. Conversion Surface\CSurface1\PDF\ CSurface1_CheckpointandUncertaintiesMap.pdf
    b. Conversion Surface\CSurface2\PDF\ CSurface2_CheckpointandUncertaintiesMap.pdf

7. Conversion surface in shapefile format
    a. See item 4- shapefile of final control points. This contains the conversion surface points as well.

8. Conversion surface in Arc Generate ASCII format
    a. Conversion Surface\CSurface1\ESRI\ArcGenerate
    b. Conversion Surface\CSurface2\ESRI\ArcGenerate

9. Conversion surface in InRoads V8 format
    a. Conversion Surface\CSurface1\Bentley\InRoads
    b. Conversion Surface\CSurface2\Bentley\InRoads

10. Conversion surface and contours in DGN format
    a. Conversion Surface\CSurface1\Bentley\Microstation
    b. Conversion Surface\CSurface2\Bentley\Microstation

11. Conversion surface and contours in Microstation V8 ASCII InRoads format
    a. Conversion Surface\CSurface1\Bentley\InRoads
        i. CSurface1_r.dat
        ii. CSurface1_e.dat
    b. Conversion Surface\CSurface2\Bentley\InRoads
        i. CSurface2_r.dat
        ii. CSurface2_e.dat

12. Paper map of conversion surface (22" X 34")
    a. Conversion Surface\CSurface1\PDF\CSurface1_ConversionSurfaceMap.pdf
    b. Conversion Surface\CSurface2\PDF\CSurface2_ConversionSurfaceMap.pdf

13. Quality control certification
    a. Considered complete per PLS approval document "100526 Conversion Surface Certification.pdf"

14. Raw GPS files
    a. All GPS data that was collected for this project is within the RTK Survey Data\ directory.

15. Trimble Geomatics office project
    a. See item 17 "Machine-readable unadjusted and adjusted network files"

16. GPS log sheets and field notes (digital version)
    a. Field notes: Stream Gage Level Data\Stream Gage Benchmark Forms.pdf
    b. USED Benchmarks\Surveyed USED Benchmarks.xls
    c. RTK Survey Data\
        i. 671305 - Lower Sac RTK
        ii. 671305 - Upper Sac RTK – CSDS
        iii. 671305 - Upper Sac RTK – Topnet
    d. Monument Photos & GIS Data\

17. Machine-readable unadjusted and adjusted network files
    a. Network Readjustment Files\
        i. Bitwise (Lower Sacramento Area)
        ii. GNSS Solutions
        iii. Trimble Geomatics Office
            1. Andregg Upper Feather
            2. Towill Feather River

18. Survey results at stream gages
    a. Field notes: Stream Gage Level Data\Stream Gage Benchmark Forms.pdf

Converted DTM Data- Two tiles in the “Converted Tiles” directory.

1. Microstation DGN V8, contours [planimetrics and DTM not converted for these two tiles; not present in input data]
2. Microstation DTM files
3. Microstation DTM files in ASCII format
4. Metadata
5. ESRI DTM files
6. ESRI shapefiles of contours, breaklines, planimetrics, exterior boundaries, etc.
7. ESRI DTM ArcGenerate ASCII files (interior, exterior, etc.)
8. DWG files contours [planimetrics and DTM not converted for these two tiles; not present in input data].

ENCLOSURE D

GEOMORPHOLOGY ASSESSMENTS

WILLIAM LETTIS & ASSOCIATES, INC.
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tel (925) 256-6070 fax (925) 256-6076

September 8, 2009

Mr. Juan Vargas
URS Corporation
2870 Gateway Oaks Drive, Suite 150
Sacramento, CA 95833

RE: Surficial geologic mapping and geomorphic assessment, California Department of Water Resources Urban Levees, Wadsworth Canal, Sutter County, California

Dear Mr. Vargas:

This memorandum presents the surficial geologic mapping and preliminary geomorphic assessment of the Wadsworth Canal area, for the California Department of Water Resources (DWR) Urban Project Levees geotechnical characterization. The goal of this mapping and geomorphic assessment is to provide information on the type and distribution of surface and shallow subsurface deposits that likely underlie the project levees along the canal, with respect to potential levee underseepage. This letter presents the technical approach, surficial geologic map, conceptual geomorphic model, and initial results based on map analysis and preliminary review of Phase 1 geotechnical data.

We appreciated the opportunity to provide these geomorphic and geologic data and preliminary interpretations of the shallow stratigraphic conditions in the Wadsworth Canal study area. Please do not hesitate to call either of the undersigned if there are any questions or comments.

Respectfully,

WILLIAM LETTIS & ASSOCIATES, INC.

Justin Pearce, C.E.G. 2421
Senior Project Geologist
(925) 395-2035

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(925) 395-2032

1.0 Approach

The approach to developing a surficial geologic map of the Wadsworth Canal area (Figure 1, Plate 1) consisted of analysis of the following data: Aerial photography (black and white stereo-pairs taken in 1937, ~1:20,000-scale); early topographic maps (USGS, 1911); published surficial geologic maps (Helley and Harwood, 1985); early and modern soil survey maps (Strahorn et al., 1911; Lytle, et al., 1988); field reconnaissance visit on June, 22, 2007, and other maps and documents (i.e., Chambers, 2002). Synthesis of these data allow for the development of a detailed surficial geologic map that provides an initial understanding of primary geomorphic processes that have acted in the study area during recent geologic and historical time. Through this mapping, primary geomorphic features and associated surficial geologic deposits are identified, such as abandoned paleochannels, marsh and basin deposits, and other features commonly associated with flood basins adjacent to large, active river systems.

The surficial geologic map was developed at the nominal scale of the aerial photography (1:20,000). This scale establishes the resolution of the map (Plate 1). The map unit contacts shown on the surficial geologic map should be considered approximate, and accurate to no more than about 30 feet on either side of the line shown on the map. The 1937 aerial photographs are the primary data set for interpreting the surficial geologic deposits because: (1) they are the oldest high-quality images available and pre-date much of the cultivation and landscape alteration within present-day Sutter County (Figure 2); and, (2) because these data represent a close approximation to the surficial deposits that were likely present at the ground surface prior to construction of the levees. The 1937 photographs generally were taken in later summer or early autumn (i.e., August). By 1937, the area had experienced moderate cultivation that locally obscures geomorphic conditions. However, integration of data from the 1937 photographs, old and recent topography, existing geologic maps, existing soil surveys and historical documents provides sufficient information to delineate many of the pre-historical and historical surficial deposits in detail. Taken together, these data provide key insights to the geomorphic processes and resulting deposits that may affect levee underseepage.

Additional floodplain deposition may have occurred after 1937, due to flood overflows, levee overtopping, or localized levee failure. A time series analysis that interprets successive aerial photographs taken after major flood events (i.e., 1955) or known local levee failures (i.e., 1986) may reveal additional information on surficial deposits in the Wadsworth Canal area. However, such analyses are beyond the scope of this project. The data and interpretations presented herein address the primary goal of characterizing the type and distribution of deposits likely present directly beneath the project levees.

1.1 Report Preparation Quality Control

The surficial geologic map data and geomorphic interpretations presented in this memorandum were subject to quality control and quality assurance procedures as required by the Levee Geotechnical Evaluation Project Management Plan (PMP). The surficial geologic map data developed by this study were reviewed for accuracy and completeness through an internal review and an independent technical review by Dr. Janet Sowers of WLA. Results of QA/QC

review were documented using PMP Exhibit 2.2-3 (Independent Technical Review Report) and are kept on file according filing control plan. Subsurface data shown on diagrams were provided as draft information, and were not verified for accuracy or completeness by this study.

2.0 Geologic Setting

The Wadsworth Canal (WC) study area is southeast of the Sutter Buttes, a presently in-active and dissected rhyolitic and andesitic volcanic neck, and between the Sacrametno River to the west and the Feather River to the east (Figure 1). The WC levee addressed in this study borders the southeastern side of Wadsworth Canal from just north of Butte House Road to the eastern Sutter Bypass levee. The WC levee trends northeast-southwest, and ties in to the eastern Sutter Bypass levee (Figure 1).

The WC levee lies northeast of Sutter Basin, a low-lying area east of the Sacramento River where overflow and floodwaters produce a seasonally marshy area. Except for the Sutter Buttes, the land regional surface is nearly flat, and along the WC area gently slopes southwest at an elevation of about 40 to 50 feet. Construction of the WC levee was completed by 1924, and was subsequently enlarged in 1942 (DWR, 1976). Prior to cultural modification, surface water runoff in the WC area was delivered to the Sutter Basin via intermittent, meandering creeks and sloughs from the northern Central Valley, including: Snake River, Snake Slough, Little Blue Creek, and ephemeral channels emanating from the eastern side of Sutter Buttes. Presently, many of the natural drainages and channels have been replaced by linear ditches, agricultural drains, and canals (Figure 2).

3.0 Surficial Geologic Mapping

Published surficial geologic maps within the WC study area generalized the surficial deposits primarily as Quaternary basin deposits, with localized units of Quaternary alluvium (map unit Qa) and Quaternary Modesto Formation (lower member, map unit Qml) (Helley and Harwood, 1985). These map units were delineated by Helley and Harwood (1985) at a regional scale (i.e., 1:62,500). The current analysis of the WC uses this existing geologic framework as a basis for more detailed mapping of late Holocene alluvium and geomorphic features (Plate 1). The surficial geologic map units in the Wadsworth Canal study area are described below, in order from oldest to youngest.

The oldest map unit exposed in the study area is the Pliocene-Pleistocene tuff breccia (map unit QTm). This rock primarily comprises a peripheral topographic ring around the relatively high relief Sutter Buttes, and consists of consolidated coarse material derived from the volcanic rocks of the Buttes. This bedrock is exposed in the northwest corner of the WC map area (plate 1).

The Quaternary Riverbank Formation (lower and upper members) is exposed at the ground surface adjacent to the tuff breccia (map unit Qrl and Qru, Plate 1). This map unit does not directly underlie the project levees in this study area, but is present in the shallow subsurface as

alluvial-fan deposits derived from the Sutter Buttes during the middle Pleistocene (about 400,000 to 200,000 years ago). The Riverbank Formation is semi-consolidated, and the top of the formation is marked by a hardpan (or, duripan) layer that is a product of soil-forming processes over substantial geologic time. This hardpan layer reflects an ancient land surface that is now buried by younger deposits. In WC area, the upper Riverbank formation is associated with the Sutter clay (Strahorn, et al., 1911), and Marcum clay loam with "siltstone" hardpan (Lytle, 1988).

The late Pleistocene Modesto Formation is exposed at the surface as alluvial-fan deposits emanating from southwestern Sutter Buttes, and is younger than, and inset into, the Riverbank Formation (Plate 1). This unit is divided into two members, a lower (older) unit that is about 42,000 to 29,000 years old (map unit Qml), and an upper member that is about 24,000 to 12,000 years old (map unit Qmu) (Helley and Harwood, 1985). The upper member in the map area is associated with sub-linear low ridges to the east of the WC that have not been completely covered by basin deposits. The Modesto Formation is locally associated with the Sutter sandy loam (Strahorn, et al., 1911), and the Olashes sandy loam (Lytle, et al., 1988); the sand consisting of volcanic lithologies indicating derivation from Sutter Buttes parent material. The latest Pleistocene Modesto Formation, in general, consists of unconsolidated sand, silt, and clay, and is associated with a moderate amount of secondary (pedogenic) clay accumulation that may form laterally continuous zones of low hydraulic conductivity.

Holocene deposits (less than 11,000 years old) in the WC map area consist of basin and alluvial deposits (Qb of Helley and Harwood [1985]; map unit Qn, Plate 1). These widespread basin deposits, about 4 to 8 feet thick, overlie the Modesto Formation. The soils developed on the basin deposits are generally the Gridley clay loam and Oswald clay (Stahorn et al., 1911; Lytle, et al., 1988), immature soils with fine-grained textures. Undifferentiated Quaternary alluvium (map unit Qa) is present near the western margin of the map area, deposited by pre-historic Butte Creek. Holocene alluvium is mapped at the surface as alluvial-fan deposits emanating from southwestern Sutter Buttes, and is younger than, and locally overlies the upper Modesto Formation. These deposits likely consist of poorly sorted mixtures of fine gravel, sand, and silt derived from the volcanic rocks of the Buttes. The Quaternary marsh deposits (map unit Qs, Plate 1) are present between the levees of the Sutter Bypass, and consist of fine grained deposits that are differentiated from basin deposits by generally being underwater or having standing water at the time when the 1937 photographs were taken.

Holocene alluvial channels (map unit Hch, Plate 1) are mapped as a network of moderately sinuous channels with southwesterly orientations. These channels appear to be mostly filled in with sediment on the 1937 photographs, and are not expressed as strong topographic lows in the ground surface. Many of these channels extend beyond, and therefore cross beneath, the eastern Sutter Bypass levee and WC levee (Plate 1). The infilling material in the basal portions of the channel consists of relatively loose, coarse material (i.e., sand), which fines upward into fine-grained, silt and clay. The channel deposits are tentatively associated with the Liveoak series, sandy clay loam soil (Lytle, et al., 1988).

Localized deposits related to the Holocene alluvial channels are in-stream bars (map unit Hb) that typically occur in the medial portions of the channels, and distributary fans (map unit Hdf)

that occur where the channel morphology tapers out and the channel has deposited sediment on the basin floor. These two types of deposits are uncommon in the study area, and have been mapped only distant from the WC levee.

Historical alluvial channels (map unit Rch, Plate 1) also are mapped as a network of moderately sinuous channels that have southwesterly orientations toward Sutter Basin. The term "historical" is applied to deposits that are estimated to be less than 150 years old. The historical channels are differentiated from the slightly older Holocene channels on the basis of cross-cutting relationships, relative degree of geomorphic expression, and correlation with mapped creek positions on the 1911 USGS topographic map. The Wadsworth Canal levee overlies the former locations of these alluvial channels in several locations throughout its length (Plate 1).

4.0 Conceptual Geomorphic Model

Based on synthesis of surficial geologic mapping, early topographic maps, soil surveys, geologic maps, and review of readily available subsurface geotechnical information, this section presents a preliminary conceptual model describing general relationships among surface and subsurface deposits in the Wadsworth Canal area. This conceptual model provides a consistent basis for understanding the type and distribution of surficial geologic deposits, primary geomorphic processes, and shallow subsurface stratigraphy in the area.

The geologic deposits present at the surface and in the shallow subsurface are derived from three general source areas: (1) material eroded from the Sutter Buttes and transported to the adjacent low-lying basin floor forming modest alluvial fans (i.e. Riverbank and Modesto Formations); (2) material deposited on the basin floor as fine silt and clay settled from standing or slow moving floodwaters of large rivers (i.e., basin deposits); and, (3) material transported to the basin by the ephemeral creeks and sloughs that traversed the valley floor prior to present day modification (i.e., channel fill).

The WC project levee trends southwest, and is primarily underlain by clayey basin deposits with some silt and sand (Plate 1, Figure 3). The basin deposits rest directly on the upper Modesto Formation, the upper boundary of which is characterized by a clay hardpan horizon associated with a buried soil. The hard pan layer is generally observed as a very stiff to hard, lean to fat clay, 10YR ¾ colors (Munsell color notation) associated with locally increased density (i.e., blow counts, CPT tip resistance), and likely very low permeability. Thus, the upper Modesto Formation mapped in northwest potion of the map area extends below ground, and dips southeasterly beneath the project levee in the shallow subsurface.

Fine-grained basin deposits overlie the upper Modesto Formation near the WC levees (Figure 3). These deposits accumulated on the valley floor over geologic time resulting from flooding of the major rivers (i.e., Sacramento and/or Feather Rivers), tributaries draining Sutter Buttes, and sheetwash from the generally flat valley floor. This resulted in inundation of the basin with standing water, and subsequent settlement of silt and clay from suspension. The thickness of the basin deposits is about 4 to 8 feet, but locally may be thicker. Review of available Phase 1 and other existing geotechnical data (i.e., Chambers 2002) indicate medium stiff to very stiff

relative density of the basin deposits. However, there is a substantial lateral and vertical variability in the hardness properties of the basin deposits.

Laterally cross-cutting, and vertically inset into the basin deposits, are the Holocene and Historical channel deposits (map units Hch and Rch, Plate 1). These southwest-trending alluvial channel deposits locally underlie the WC levee, and thus result in local differences in material textures beneath the levee (Figure 3). Field reconnaissance on June 22, 2007 reveals that the topographic expression of these channels has been obliterated by cultivation. However, sub-linear to curvilinear differences in ground color (i.e., darker strips) were observed in the cultivated fields in areas that potentially correlate with mapped channels, suggesting a contrast in materials in the shallow subsurface. Review of subsurface geotechnical data indicate that the channel fill deposits include a lower channel fill consisting of relatively loose, coarser material (i.e., sand), fining upward and grading into fine-grained silt and clay. Many of these channels extend across, and therefore continue beneath, the WC levees (Plate 1, Figure 3).

Figure 3 illustrates the relationships between the surficial channels, basin deposits, and shallow stratigraphy that underlie the WC project levee, wherein dense, semi-consolidated Pleistocene deposits are overlain by a layer of fine-grained basin deposits, locally cut by alluvial channel deposits.

5.0 Applications to the Urban Levee Project

Based on synthesis of the surficial geologic map with preliminary Phase 1 boring and cone penetrometer (CPT) data, and historical geotechnical subsurface exploration data (i.e., Chambers, 2002), the WC levee is underlain by relatively young fine-grained clay and sandy clay deposits that are laterally interrupted by local coarser channel fill deposits (Figure 3). Mud rotary borehole WSEWWC-002B penetrates a mapped surficial channel unit (Figure 3, Plate 1), and indicates the channel fill is silty sand that grades upward into clay, with an uncorrected SPT blow count of 5 blows per foot. This suggests locally loose and unconsolidated, and therefore likely permeable, material in the shallow subsurface. Initial review of subsurface boring profiles completed along the eastern landside of the Wadsworth Canal near the tie-in to the Sutter Bypass levee (Chambers, 2002) also shows relatively loose and soft sandy deposits (i.e., blow counts of 0 to 5) that are overlain by a layer of medium stiff clay-rich material.

Synthesis of the surficial mapping and geotechnical data indicate that subsurface stratigraphy the WC area locally may be conducive to levee underseepage. Shallow strata typically include denser and probably semi-cemented material (i.e., Modesto Formation) that likely contains a low-permeability hardpan horizon. The hardpan may or may not be laterally continuous, depending on post-depositional soil formation and erosional processes. The Modesto formation is overlain by about 4 to 6 feet of medium stiff to stiff clay (i.e., basin deposits). Surficial mapping indicates that the basin materials locally are cross-cut by relatively loose, sandy channel deposits; subsurface geotechnical data show lateral and vertical variations in texture and density that are probably related to buried channel deposits. Therefore, this shallow subsurface stratigraphy may promote levee underseepage along certain areas of the WC project

levees where geologically young, loose, sandy channel material lies between the dense Pleistocene deposits and relatively stiff, low-permeability clay-rich surface “blanket” layer.

Lateral and vertical variability in the shallow subsurface deposits has resulted from past geomorphic processes. The conceptual subsurface stratigraphic framework suggests that stratigraphic relationships may promote localized levee underseepage, given certain hydraulic conditions. Further spatial analyses of the surficial geologic mapping and subsurface geotechnical exploration data are needed to better constrain and characterize areas that are most susceptible to underseepage in the study area.

6.0 Limitations

This geomorphic assessment and associated data interpretation have been performed in accordance with the standard of care commonly used as the state-of-practice in the geologic engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this geographic area performing the same services under similar circumstances during the same time period.

Discussions of surface and subsurface conditions summarized in this technical memorandum are based on geologic interpretations of subsurface soil data at limited exploration locations available to this assessment through July of 2007. Variations in subsurface conditions may exist between exploration locations, and the project team may not be able to identify all adverse conditions in the levee and its foundation. This memorandum is for the use and benefit of DWR. Use by any other party is at their own discretion and risk.

7.0 References

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Strahorn, A.T., Mackie, W.W., Holmes, L.C., Westover, H.L., Van Duyne, C., 1911, Soil Survey of the Marysville Area, California; 1:62,500, USDA Bureau of Soils

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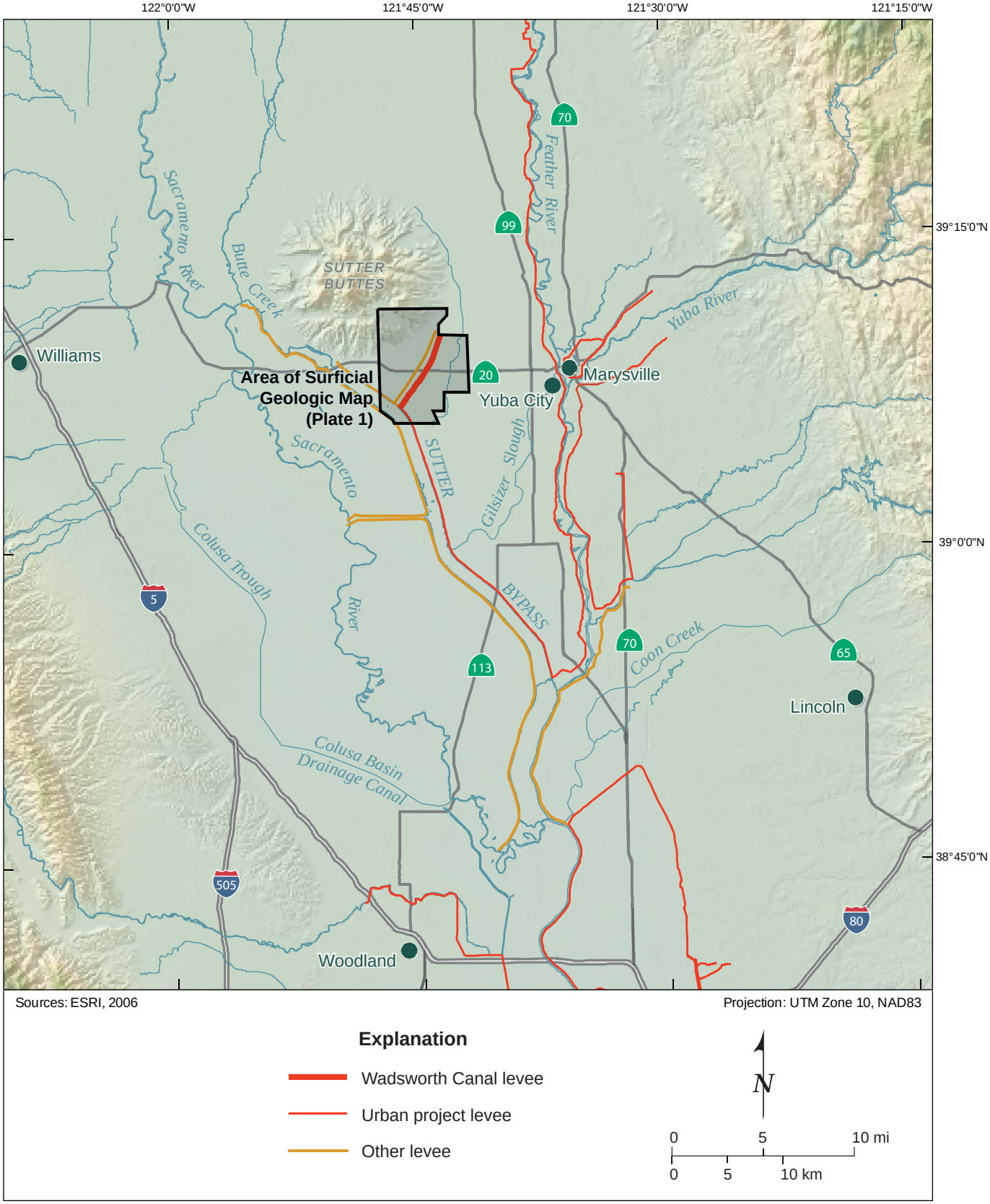


WLA

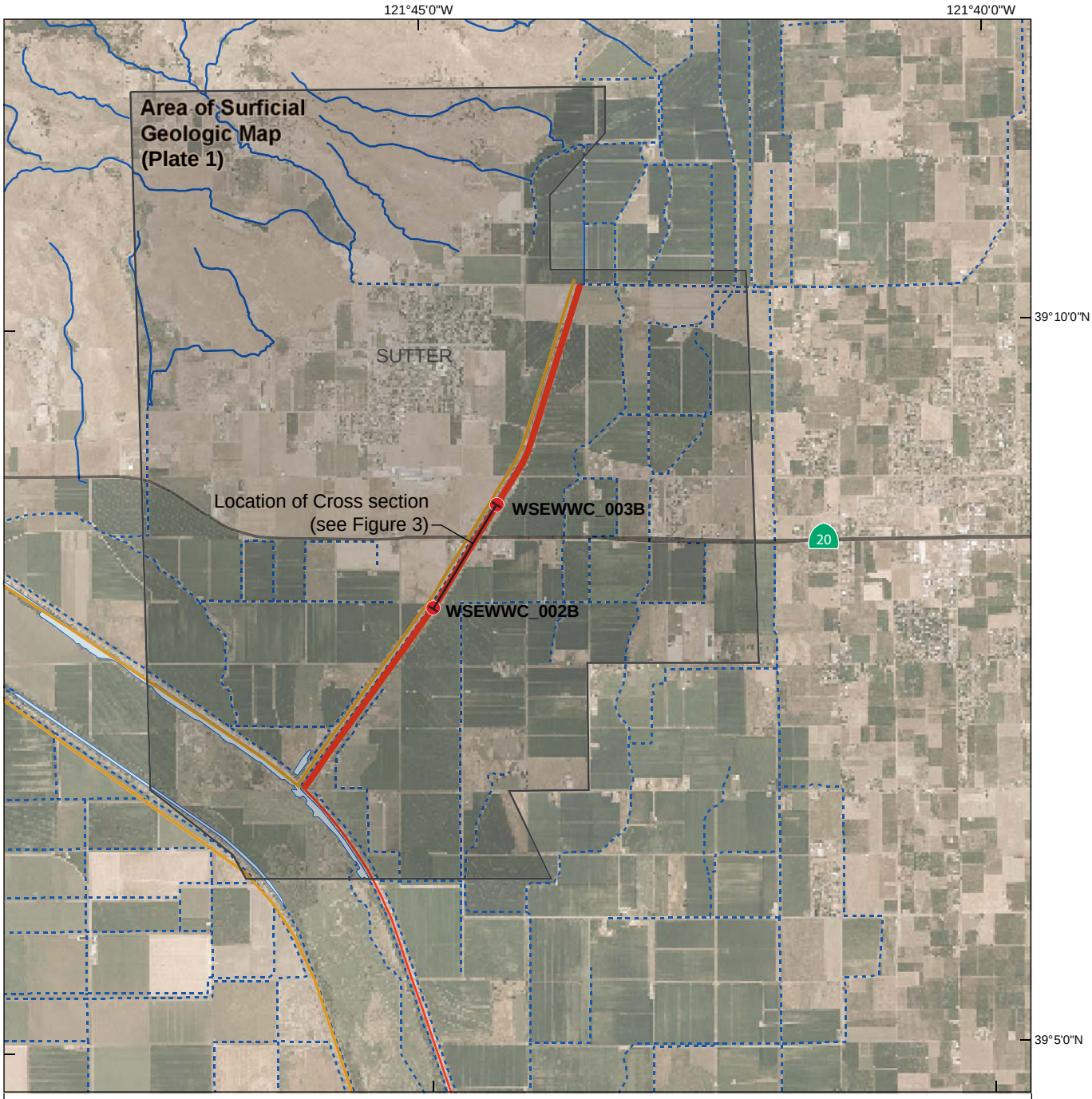
Map of Northern Central Valley, California

DWR URBAN LEVEE PROJECT

Figure 1

1881 Wadsworth Canal

Modified 09.03.09



Sources: ESRI, 2006

Projection: UTM Zone 10, NAD83

Explanation

- Creek, slough
- Canal, drain
- Wadsworth Canal Urban Project levee
- Other Urban Project levee
- Other levee

N

0 1 2 mi

0 1 2 km

WADSWORTH CANAL

Looking Northwest

S36°W

Southwest

Northeast

Approximate levee crest

WSEWWC 002B | WSEWWC 015C | WSEWWC 016C | WSEWWC 017C | WSEWWC 018C | WSEWWC 003B

Holocene channel, surficial map unit Hch, (Plate 1)

Levee fill (AF)

Stiff clay and hard silt (Quaternary Basin Deposits, Qn)

Stiff clay with layers of stiff silt and silty sand (Upper Modesto Formation, Qmu)

Stiff clay with layers of medium dense silty sand and very stiff silt (Lower Modesto Formation, Qml)

Hard sandy clay interbedded with medium dense silty sand (Upper Riverbank Formation, Qru)

Very dense sand interbedded with stiff clay and silt (Lower Riverbank Formation, Qrl)

B.O.H. 65 ft.

B.O.H. 60 ft.

B.O.H. 60 ft.

B.O.H. 60 ft.

B.O.H. 140 ft. below ground surface

B.O.H. 140 ft. below ground surface

Elevation (feet, NAVD 88): 70, 50, 30, 10, 0, -10, -30, -50, -70, -90

Log description from borehole WSEWWC 002B

44.0 to 42.5 feet. Lean CLAY (CL) stiff; dark brown (10YR 3/3); moist; 90% medium plasticity; 10% fine sand

42.5 to 41.0 feet. SILT with SAND (ML) loose, dark yellowish brown (10YR 3/4); moist; 15% fine sand

41.0 to 39.0 feet. SILTY SAND (SM) medium dense; dark yellowish brown (10YR 3/4); moist; 75% fine to medium sand; 25% fines

42.5 to 41.5 SPT = 5 blows/foot

Explanation

- Channel identified on surficial geologic map or as fining upward sequence of sediments in boreholes
- Localized sand and gravel; possible channel; interpreted from suburface borehole data
- Moderate paleosol (hardpan)
- Strong paleosol (hardpan)

Notes:
1. Borehole ground elevation values from Engeo, Inc. draft borehole logs as estimated from map (NAVD 88). Absolute elevations of geologic contacts could change if reported ground elevations of boreholes are revised.
2. CPT borehole surface elevations are approximate, placed on projected ground surface between continuous boreholes WSEWWC-002B and 003B.
3. All depths (vertical axis) shown as elevation values (NAVD88), as shown on Engeo, Inc. borehole logs.
4. Bottom of hole (B.O.H.) values shown as total depth below ground surface.
5. Borehole names and and horizontal distance shown above (from Engeo logs and location maps). Geologic relations could change if borehole locations are revised.
6. Drilling method indicated as last letter in borehole name:
   B = Mud Rotary borehole with SPT
   C = Cone Penetrometer Test
7. See Figure 2 for location of cross section.

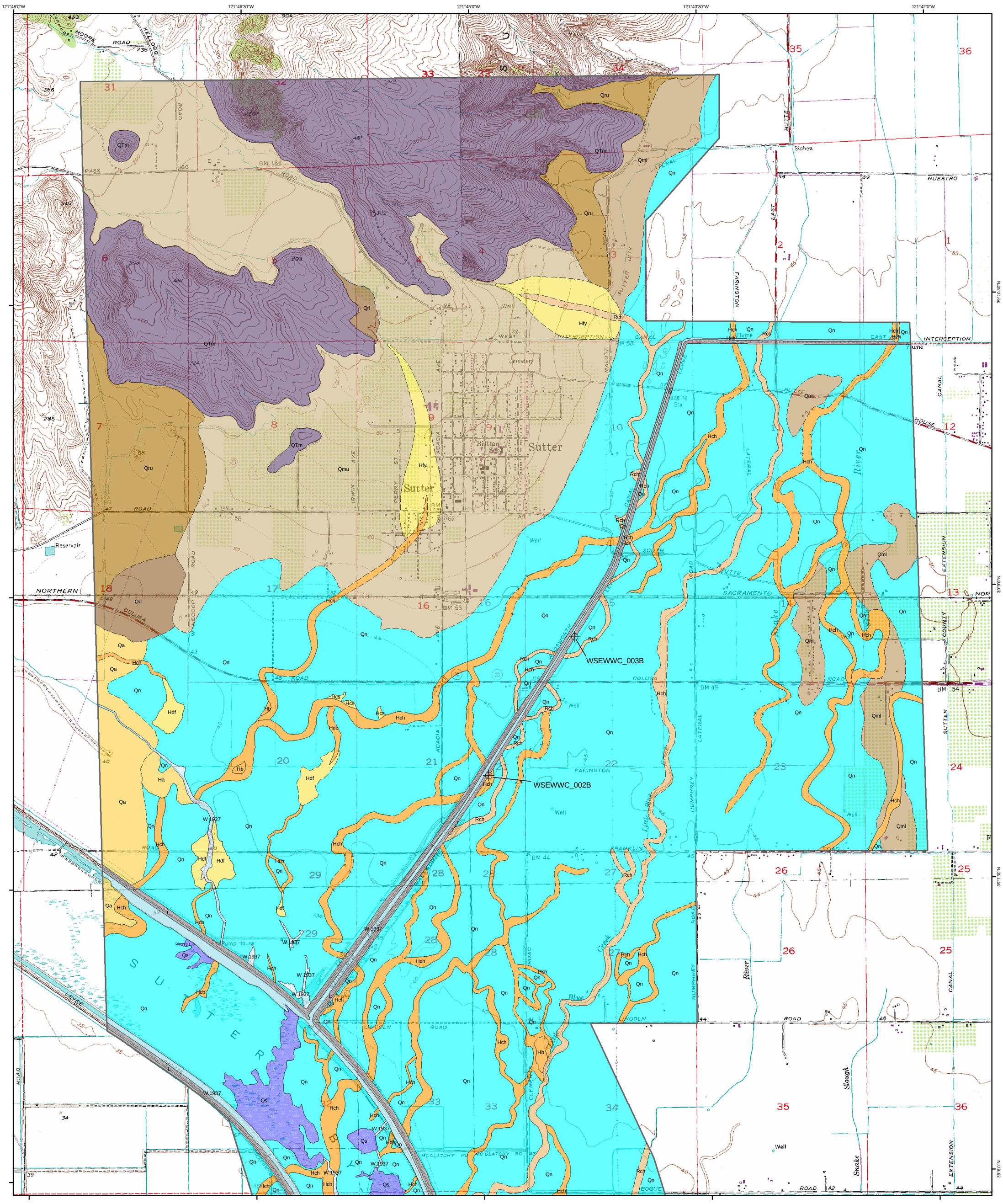
20 feet

0

0 — 1000 feet

Scale

Vertical exaggeration 50X



Explanation

Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain; solid contacts have a resolution no better than about 30'.

WSEWWC_003B — Geotechnical borehole, approximately located.

W — Water visible on 1937 aerial photography.

Geologic Units

HISTORICAL

- AF — Artificial fill; visible on 1937 aerial photography.
- Rch — Channel deposits; sorted sands and silty sand; fining upward.

HOLOCENE

- Hcs — Crevasse splay deposits; fine to coarse sand, silt and clay.
- Hdc — Distributary channels, sand, silt, and clay.
- Hdf — Distributary fan deposits; sand, silt and clay.
- Ha — Alluvial deposits; undifferentiated; sand, silt, and minor lenses of gravel; under cultivation in 1937.
- Hch — Channel deposits; sorted sands and silts; fining upward.
- Hb — Channel bar deposits; fine sand, and silt deposited in or along channel lateral margins.
- Hfy — Alluvial fan deposits, well graded gravel, sand, silt and clay; volcanic lithologies.
- Qa — Alluvial deposits, undifferentiated; sand, silt, and minor lenses of gravel; under cultivation in 1937.
- Qn — Basin deposits; fine sand, silt and clay, dark yellow to dark yellowish brown, under cultivation in 1937.
- Qs — Marsh deposits; silt and clay, likely organic-rich; perennially or seasonally submerged on 1937 photography.

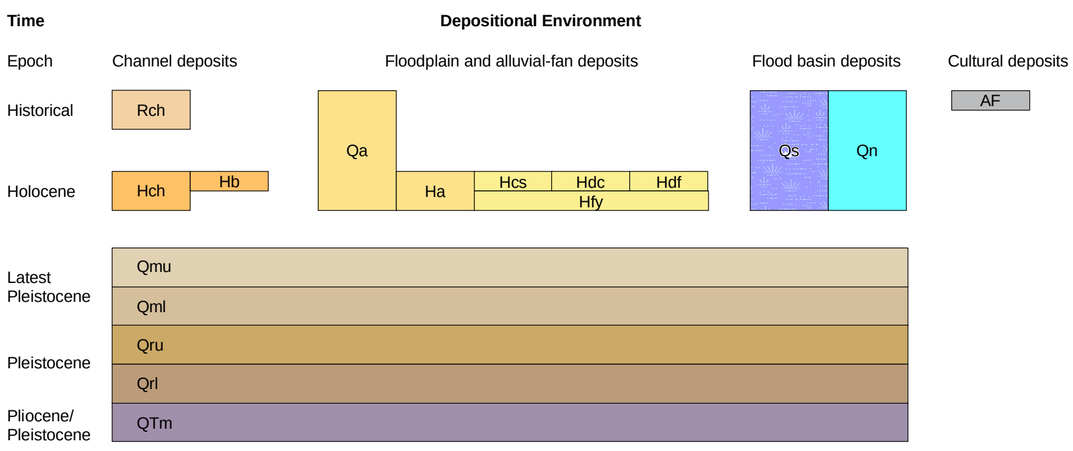
PLEISTOCENE

- Qmu — Modesto Formation; upper member; unconsolidated to semi-consolidated gravel, sand, silt, and clay.
- Qml — Modesto Formation; lower member; unconsolidated gravel, sand, silt and clay.
- Qru — Riverbank Formation; upper member, semi-consolidated to consolidated gravel, sand, silt and minor clay.
- Qrl — Riverbank Formation; lower member; consolidated gravel, sand, silt, and clay, generally associated with strong duripan horizon.

PLIOCENE / PLEISTOCENE

- QTm — Tuff Breccia; Volcanic tuff breccia (andesitic and rhyolitic) from Sutter Buttes, latest Pliocene.

Stratigraphic Correlation Chart



1:20,000

N

0 0.5 1 Miles

0 0.5 1 Kilometers

Map projection: UTM NAD83 Zone 10N
Topo base USGS quadrangles.

Plate 1 - Surficial Geologic Map of the Wadsworth Canal Area

WILLIAM LETTIS & ASSOCIATES, INC.
Walnut Creek, CA

Sutter_MGT_Plate1_Wadsworth.mxd 09/04/2009

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September 8, 2009

Mr. Juan Vargas
URS Corporation
2870 Gateway Oaks Drive, Suite 150
Sacramento, CA 95833

RE: Surficial geologic mapping and geomorphic assessment, California Department of Water Resources Urban Levees Project, Sutter Bypass, Sutter County, California

Dear Mr. Vargas:

This memorandum presents the surficial geologic mapping and preliminary geomorphic assessment of the eastern Sutter Bypass area, for the California Department of Water Resources (DWR) Urban Levees Project geotechnical characterization. The goal of this mapping and geomorphic assessment is to provide information on the type and distribution of surface and shallow subsurface deposits that likely underlie the project levees along the eastern part of the bypass. The purpose of this study is to develop spatially-continuous geologic data and a conceptual model that allows reasonable stratigraphic interpretations between widely-spaced subsurface explorations, with respect to potential levee underseepage (i.e., Llopis et al., 2007). This letter presents the technical approach, surficial geologic map, conceptual geomorphic model, and initial results based on map analysis and preliminary review of available Phase 1 geotechnical data.

We appreciate the opportunity to provide these geomorphic and geologic data and preliminary interpretations of the shallow stratigraphic conditions in the Sutter Bypass study area. Please do not hesitate to call either of the undersigned if there are any questions or comments.

Respectfully,

WILLIAM LETTIS & ASSOCIATES, INC.

Justin Pearce, C.E.G. 2421
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(925) 256-6070

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1.0 Approach

The approach to developing a surficial geologic map of the Sutter Bypass area (Figure 1, Plate 1) consisted of analysis of the following data: Aerial photography (black and white stereo-pairs taken in 1937, ~1:20,000-scale); early USGS topographic maps (i.e., 1911); published surficial geologic maps (Helley and Harwood, 1985); early and modern soil survey maps (Strahorn et al., 1911; Lytle, et al., 1988); field reconnaissance visit on June 22, 2007; and other maps and documents. Synthesis of these data allow for the development of a detailed surficial geologic map that provides an initial understanding of primary geomorphic processes that have acted in the study area during recent and historical geologic time. Through this mapping, we identify primary geomorphic features and associated surficial geologic deposits, such as abandoned paleochannels, marsh and basin deposits, flood-basin deposits, and other features commonly associated with flood-basins adjacent to large, active river systems. Knowledge of fluvial processes and the ability to recognize depositional environments in the geologic record are key to identifying locations along levees where underseepage is most likely to occur (Llopis, 2007).

The surficial geologic map was developed at the nominal scale of the aerial photography (1:20,000). This scale establishes the resolution of the map (Plate 1). The map unit contacts shown on the surficial geologic map should be considered approximate, and accurate to no more than about 30 feet on either side of the line shown on the map. The 1937 aerial photographs are the primary data set for interpreting the surficial geologic deposits because: (1) they are the oldest high-quality images that pre-date much of the urbanization and landscape alteration within present-day Sutter County (Figure 2); and, (2) these data represent a close approximation to the surficial deposits that were likely present at the ground surface prior to the construction of the levees. The 1937 photographs generally were taken in late summer or early autumn (i.e., August). By 1937, the area had experienced moderate cultivation that locally obscures geomorphic conditions. However, integration of data from the 1937 photography, old and recent topographic maps, geologic maps, soil surveys and historical documents provides sufficient information to delineate many of the pre-historic and historic surficial deposits in detail. Taken together, these data provide key insights to the geomorphic processes and resulting deposits that may affect levee underseepage.

Additional flood-basin or floodplain deposition may have occurred after 1937, due to flood overflows, levee overtopping, or localized levee failure. A time series analysis that interprets successive aerial photographs taken after major flood events (i.e., 1955) or known local levee failures (i.e., 1986) may reveal additional information on surficial deposits in the Sutter Bypass area. Such analyses are beyond the scope of this study. The data and interpretations presented herein address the primary goal of characterizing the type and distribution of deposits likely present directly beneath the project levees.

1.1 Report Preparation Quality Control

The surficial geologic map data and geomorphic interpretations presented in this memorandum were subject to quality control and quality assurance procedures as required by the Levee

Geotechnical Evaluation Project Management Plan (PMP). The surficial geologic map data developed by this study were reviewed for accuracy and completeness through an internal review and an independent technical review by Dr. Janet Sowers of WLA. Results of QA/QC review were documented using PMP Exhibit 2.2-3 (Independent Technical Review Report) and are kept on file according filing control plan. Subsurface data shown on diagrams were provided as draft information, and were not verified for accuracy or completeness by this study.

2.0 Geologic Setting

The Sutter Bypass (Bypass) study area lies southeast of the volcanic Sutter Buttes, between the Sacramento and Feather Rivers. The project levee addressed in this study borders the eastern side of the Sutter Bypass, extending from the Wadsworth Canal southeast to the Feather River (Figure 1). The Bypass levee generally trends northwest-southeast, and ties in to the Feather River west bank levee.

The Bypass levee lies northeast of Sutter Basin, a low-lying area east of the Sacramento River and west of the Feather River, where overflow and floodwaters from Butte Basin (located northwest of the Sutter Buttes), the Sacramento River, and the Feather River produced a seasonally marshy area. Except for the Sutter Buttes area, the regional land surface is nearly flat, and along the Bypass area gently slopes southwest at an elevation of about 30 to 40 feet. Construction of the Sutter Bypass was completed in 1924 to serve as an overflow for Sacramento River floods in the winter, and a source of irrigation in the summer (DWR, 1976). The eastern levee was enlarged in 1942 (Corps of Engineers, 1953). Prior to cultural modification, surface water runoff in the Bypass area was delivered to the Sutter Basin via intermittent, meandering creeks and sloughs from the northern Central Valley, including: Snake River, Snake Slough, Gilsizer Slough, Nelson Slough, and flood overflow channels emanating from the western side of the Feather River. The construction of the Bypass levee blocks water from the east that normally drains to the Sutter Basin and Sacramento River (DWR, 1976). Presently, many of the natural drainages and channels have been replaced by linear ditches, agricultural drains, and canals (Figure 2).

3.0 Surficial Geologic Mapping

Published surficial geologic maps of the Sutter Bypass study area generalized the surficial deposits primarily as late Quaternary basin (map unit Qb) deposits, with localized units of late Quaternary alluvium, Quaternary Modesto Formation (lower member), and Quaternary Riverbank Formation (lower member) (Helley and Harwood, 1985). These map units were delineated at a regional scale (i.e., 1:62,500). The current analysis of the Bypass uses this geologic framework as a basis for more detailed mapping of late Holocene alluvium and geomorphic features (Plate 1). The surficial geologic map units within the Sutter Bypass study area are described below, in order from oldest to youngest.

The oldest map unit exposed in the study area is the late Quaternary Riverbank Formation (lower member), and is mapped in the south portion of the study area east of Nelson Slough,

where it likely directly underlies the project levee near the latitude of Laurel Avenue (Plate 1). This formation (map unit Qrl) is present in the shallow subsurface beneath much of the bypass area, and consists of alluvial-fan deposits derived from the Sierra Nevada during the middle Pleistocene (about 400,000 to 200,000 years ago). The Riverbank Formation is semi-consolidated, and is associated with the presence of a well-developed hardpan (or, duripan) layer that is a product of soil-forming processes over substantial geologic time. This hardpan layer reflects an ancient land surface that locally is buried by younger deposits. Soils developed on the Riverbank Formation in the Bypass area include the San Joaquin loam of Strahorn et al. (1911) and the Yuvas loam (Lytle et al., 1988), both of which document a strongly cemented hardpan at depths of about 1.5 to 3 feet below ground surface.

The late Pleistocene Modesto Formation is younger than the Riverbank Formation and is present in the map area primarily along the margin of Gilsizer Slough and directly east of Highway 113 (Plate 1). This unit is divided into two members, a lower (older) unit that is about about 42,000 to 29,000 years old (Qml), and an upper member that is about 24,000 to 12,000 years old (Qmu) (Helley and Harwood, 1985). The Modesto Formation, in general, consists of unconsolidated sand, silt, and clay, and is associated with a moderate amount of secondary (pedogenic) clay accumulation. This clay-rich horizon may form laterally continuous zones of low hydraulic conductivity. These soil horizons may extend across boundaries between coarse and fine-grained strata within the latest Pleistocene alluvium, and may form relatively continuous zones of low vertical hydraulic conductivity within the Modesto Formation. Soils developed on the Modesto Formation include the Gridley loam of Strahorn et al. (1911) and the Marcum clay loam with “siltstone” hardpan (Lytle, 1988).

Younger surficial deposits overlying the Riverbank and Modesto Formation include late Quaternary marsh, basin, and alluvial deposits (map units Qs, Qn, and Qa, respectively), which are considered Holocene age (i.e., less than 11,000 years old). The widespread basin deposits are about 4 to 8 feet thick and bury the gently southwest dipping Modesto Formation (Figure 3). The thickness of the basin deposits increases to the southwest, in the direction of Sutter Basin (Figure 3). The soils developed on the basin deposits generally are associated with the Stockton clay adobe and Marcuse clay of Strahorn et al. (1911) and the Oswald clay (Lytle et al., 1988), and thus represent immature soils with overall fine-grained textures. Undifferentiated alluvial deposits (map Qa, Plate 1) are present along Gilsizer Slough, and are inset (i.e., topographically lower) into the adjacent Modesto Formation. The Quaternary marsh deposits (map unit Qs, Plate 1) are present between the Sutter Bypass levees northwest of Gilsizer Slough, and are also fine-grained deposits that are differentiated from basin deposits by usually being underwater or having standing water at the time when the 1937 photographs were taken (usually late summer to early autumn).

Inset into the units described above are deposits of Holocene alluvial channels (map unit Hch, Plate 1), which are a network of moderately sinuous channels with southwesterly orientations. These channels appear to be mostly filled with sediment by the time of 1937 photographs, and are expressed only locally as subtle topographic lows in the ground surface. Many of these channels extend west of, and therefore cross beneath, the eastern Sutter Bypass levee (Plate 1). The alluvial channels west of Gilsizer Slough start on the alluvial plain as intermittent creeks, and are not directly connected to the Feather River (USGS Tisdale Weir quadrangle, 1911).

The channel deposits are tentatively associated with the Liveoak series, sandy clay loam soil (Lytle et al., 1988), and consist of a lower, sandy unit that fines-upward into an upper, silt and clay layer.

Subdivisions of the Holocene channels include sloughs (map unit Hsl, Plate 1), distributary channels (map unit Hdc), and overflow channels (map unit Hofc). These deposits, in general, also consist of a fining-upward sequence of sand, silt, and clay. The sloughs are present primarily east of Highway 113 (Plate 1) and have southwesterly orientations. The sloughs are ephemeral channels that drain the alluvial plain between Gilsizer Slough and the Feather River. The term "slough" in this study does not mean tidally-influenced channels, but instead channels that likely conveyed relatively slow-moving water from direct precipitation and sheet-flow runoff. The overflow channels convey flood flows that overtop the banks of the Feather River onto the floodplain, and are interpreted as higher-energy channel systems relative to the sloughs. The distributary channels route flow from and sediment onto the floodplain, and end at distributary-fan deposits. The overflow and distributary channel deposits are present in the southeastern portion of the Bypass area, south of the latitude of Laurel Avenue (Plate 1).

Localized deposits related to the Holocene alluvial channels are bars (map unit Hb) that typically occur in the medial and lateral portions of the channels, and distributary fan deposits (map unit Hdf) that occur where the channel becomes unconfined and has deposited sediment on the basin floor. Channel bars are relatively uncommon in the Sutter Bypass study area. Distributary fans are common in the southeast portion of the Bypass area, south of the latitude of Sacramento Avenue (Plate 1). The distributary-fan deposits likely consist of unconsolidated fine sand and silt (i.e., Strahorn et al., 1911).

Historical geologic deposits are present along the length of the Bypass study area (i.e., map unit Rch, map unit Rdf). The term "historical" is applied to deposits that are estimated to be less than 150 years old. These deposits share the same genetic origin as the Holocene deposits described above. The historical channel deposits are differentiated from the Holocene channel deposits on the basis of cross-cutting relationships with other map units, relative degree of geomorphic expression and/or dissection, and correlation with land surface expression on the early and modern topographic maps. The Bypass eastern levee overlies the former locations of Holocene and historical alluvial channels in several locations throughout its length (Plate 1).

Undifferentiated Holocene and historical alluvium (map units Ha and Ra) is mapped in the southeastern Bypass area, near the confluence of the Sutter Bypass and the Feather River, generally east of Sawtelle Road (Plate 1). The undifferentiated map unit is delineated where the morphology of these deposits is indistinguishable on 1937 photographs as a result of cultural modifications (i.e., agriculture). The soils developed on the undifferentiated historical alluvium generally correspond with the Sacramento series fine sandy loam and silt loam of Strahorn et al. (1911) and the Shanghai silt loam (Lytle et al., 1988). There is no hardpan layer associated with these soils, supporting the interpretation of geologically young deposits.

4.0 Conceptual Geomorphic Model

Based on synthesis of surficial geologic mapping, topographic maps, soil surveys, geologic maps, and review of readily available subsurface geotechnical information, we present a preliminary conceptual geomorphic model describing general relationships among surface and subsurface deposits along the Sutter Bypass study area. This conceptual model provides a consistent basis for understanding the type and distribution of surficial geologic deposits, primary geomorphic processes, and shallow subsurface stratigraphy in the area. Identification of subsurface stratigraphic formations is challenging, primarily because of a lack of distinctive and laterally extensive stratigraphic marker beds within late Quaternary deposits of the northern Central Valley (i.e., Page, 1986), and because there is little apparent difference in lithology between the late Quaternary formations (i.e., Helley and Harwood, 1985). This study relies heavily on the identification and local correlation of hardpan horizons and deposit color and density changes to delineate subsurface formations.

In a general sense, the Sutter Bypass levees traverse across the distal portions of ancient alluvial-fan deposits that were derived from the Sierra Nevada, and prograded westward onto the valley floor (i.e., Riverbank and Modesto Formations). These Pleistocene deposits are exposed at the ground surface northeast of the Bypass study area (Helley and Harwood, 1985; Page, 1986), dip to the southwest and are mantled by younger fine-grained basin deposits (Figure 3). In contrast, the Modesto Formation is exposed at the ground surface along Gilsizer Slough and directly east of Highway 113 (Plate 1). The surficial map pattern of the Modesto deposits in these locations suggests depositional lobes from an ancestral Gilsizer Slough. These deposits may have been related to discharges and sediment loads that were higher than present-day conditions. These deposits may, perhaps, represent an ancestral Feather River channel location that occupied the present-day Gilsizer Slough during the latest Pleistocene and was subsequently abandoned.

The surficial geologic mapping (Plate 1) shows differences in deposit type and distribution from northwest to southeast along the Bypass, which are associated with changes in watershed production of water and sediment, related geomorphic processes, soil profile development, and the underlying subsurface hardpan layer. These differences illustrate the diversity of past geomorphic processes along and near the Bypass and, as a consequence, the type of geologic deposits at and near the ground surface. The surficial geologic map allows the interpretation of "reaches" along the Bypass within which geomorphic processes and their associated deposits are likely to be relatively consistent. The Bypass study area consists of four general reaches, from northwest to southeast, each having characteristic deposit types and distributions (Plate 1).

The westernmost reach of the Bypass study area extends from the junction with the Wadsworth Canal to directly south of the Tisdale Weir ("Reach I", Plate 1). The levee along this reach, about 8.1 miles long, primarily overlies fine grained basin deposits accumulated on the valley floor over geologic time. This deposition resulted from flooding of the Sacramento and Feather Rivers, tributaries draining Sutter Buttes, and sheet flow from the generally flat valley floor. Holocene and historical channel deposits (map units Hch and Rch, Plate 1) are inset into the basin deposits. These southwest-trending alluvial channel deposits locally underlie the Bypass

levee, and result in local differences in material textures beneath the levee (Figure 4). About 27 abandoned channels traverse the levee along this reach (approximately 3 channels per levee mile). The channels are about 250 feet wide, but range from about 100 to 300 feet wide (Plate 1). In this area, the channels are about 6 to 8 feet deep, and are typically filled with sand, silt, and clay in a fining-upward sequence, i.e., coarser-grained sand overlain by about one to two feet of silt and clay. This sedimentary sequence may be conducive to seepage where relatively more-permeable channel sands are overlain by a relatively thin, fine-grained "blanket" layer.

The second reach along the Bypass, about 1.1 miles long, extends across Gilsizer Slough ("Reach II", Plate 1), where Modesto Formation deposits are present at the ground surface. Undifferentiated alluvium (map unit Qa, Plate 1) is present along the historically-active Gilsizer channel floor, and is inset to the Modesto Formation (Figure 5). The Gilsizer Slough alluvium extends beneath the eastern and western Bypass levee, and thus represents the progradation of younger deposits with respect to the Modesto Formation. Along this reach, the Bypass levee is underlain by younger Gilsizer Slough alluvium flanked by the relatively denser, semi-consolidated late Pleistocene Modesto deposits (Figure 5). Areas where the levee directly overlies the Modesto Formation may be relatively less conducive to underseepage, as the associated hardpan layer may form locally continuous zones of low hydraulic conductivity.

The third reach along the Bypass extends from the Gilsizer Slough to the latitude directly south of Laurel Avenue, and is about 6.6 miles long ("Reach III", Plate 1). This reach is generally similar to Reach I, except Reach III has Pleistocene deposits (i.e., lower Modesto and Riverbank Formations) exposed at or very near the ground surface, and has a sparser channel density (about 2 channels per levee mile) compared to Reach I. About 14 southerly-oriented sloughs are mapped across this reach and locally underlie the Bypass levee (Plate 1). The sloughs originate from the Feather River, near Star Bend and Shanghai Bend, extending southward toward the Bypass. The sloughs along Reach III are about 250 feet wide, but range from about 100 to 300 feet wide, similar to Reach I (Plate 1). In this area, the channels are also probably about 6 to 8 feet deep, and probably filled with sand fining-upward to silt and clay. These channel deposits may be conducive to underseepage because of the deposit stratigraphy that has coarser-grained sand overlain by about one to two feet of silt and clay. Late Quaternary Riverbank Formation is at the ground surface along the southwestern end of Reach III (Plate 1), and likely is not conducive to seepage due to the dense and strongly-developed hardpan clay layer that is usually at about 1.5 to 4 feet depth below ground surface.

The fourth reach along the Bypass extends from directly south of the latitude of Laurel Avenue to the confluence with the Feather River west bank levee ("Reach IV", Plate 1). Reach IV, about 1.9 miles long, has Holocene and historical alluvium at the ground surface along this reach of the Bypass, primarily because of the proximity to the Feather and Bear Rivers (Plate 1). About 8 distributary channels, usually 90 feet wide but ranging from 45 to 190 feet wide, cross the floodplain in southwesterly orientations, leading to geologically young distributary-fan sediments. These sediments, primarily consisting of fine to coarse sand and silt, probably were deposited as a result of increased sediment and water input contributed to the Feather River from the Bear River; the confluence located directly upstream from this reach of the Bypass (Figure 1). Historically, the Feather River and the Bear River have aggraded from substantial mining debris input, thus reducing channel cross sectional area (i.e., James, 1999).

This reduction of cross section area, coupled with the trajectory of floodflow from the Bear River watershed, resulted in water overtopping the Feather River channel banks, and depositing sediment onto the western floodplain where the Bypass levee is located (Plate 1).

5.0 Applications to the Urban Levee Project

Based on synthesis of the surficial geologic map with preliminary Phase 1 borehole and cone penetrometer (CPT) data, the Bypass levee generally is underlain by relatively young fine-grained clay and sandy clay deposits that are laterally interrupted by local coarser channel fill deposits (i.e., Figures 3, 4, 5, and 6).

The northernmost reach of the Bypass levee ("Reach I") is predominantly underlain in the shallow subsurface by relatively young fine-grained clay and sandy clay deposits. These basin deposits are laterally interrupted by coarser-grained deposits filling abandoned channels that are about 250 wide (Plate 1, Figure 4). Mud rotary borehole WSESBP_011B, which penetrated channel unit Rch norths of Gilsizer Slough (Plate 1), indicates the channel deposit is about four-feet thick, consisting of about 60% fine to coarse sand (medium dense) with clayey sand. The clayey sand grades upward into clay, of about 45% sand fraction. This suggests locally coarse and unconsolidated, and therefore likely permeable, material in the channel fill. Based on review of adjacent borehole data, the basin deposits (Figure 4) generally consist of stiff clay, with less than 10% fine sand. It is likely that most or all of the small channels mapped herein as unit Rch are similar in textural characteristics and depths, because of similar genetic origin and geomorphic process of channel development and infilling. These deposits underlie Reach I in at least 27 places between Wadsworth Canal and Gilsizer Slough (Plate 1).

Reach II crosses late Pleistocene and Holocene geologic deposits associated with Gilsizer Slough (Plate 1). Review of subsurface borehole and CPT data indicate that the basin deposits north of the slough consist of medium stiff to stiff clays (Figure 5). The channel fill deposits within Gilsizer Slough (map unit Qa, Plate 1) consist of alternating beds of sandy gravel and clay. These channel deposits are inset into the lower Modesto Formation which, in this area, consists of very stiff sandy clay interbedded with silty sand and localized dense sand. Directly south of Gilsizer Slough, the lower Modesto Formation is at the ground surface (Plate 1). Subsurface data suggest that a hardpan horizon is encountered at about 3 to 4 feet below the ground surface. The uppermost deposit above the hardpan consists of sand and silty sand, and probably is weathered and/or culturally re-worked materials of the lower Modesto Formation. Thus, north of Gilsizer Slough, potentially low-permeability basin materials blanket the Modesto, and are locally cut by channel deposits, whereas at and south of Gilsizer Slough the local channel deposits are inset directly into the dense Modesto Formation. Where the Bypass levee rests on the unconsolidated Qa deposits within Gilsizer Slough, these coarse deposits may be associated with higher probabilities of levee underseepage. In constrast, the sections of the levee underlain directly by the Modesto Formation containing consolidated (hardpan) horizons are much less likely to experience underseepage.

Reach III is similar in geomorphic nature to Reach I, except it has a lower frequency of channels as compared to Reach I (Plate 1). It is probable that the composition of these deposits

generally will be consistent with those along Reach I (i.e., coarse-grained channel fill with upper fine-grained layers). These channels are more likely to promote seepage beneath the levee compared to the basin deposits. Additionally, the Pleistocene materials that likely directly underlie the project levees along this reach (Plate 1) are relatively dense and the associated hardpan layer may form a relatively continuous zone of lower hydraulic conductivity. Where the levee directly overlies Modesto formation (NW ¼, Section 20; southeast of the Sutter Causeway), there is a lower likelihood of underseepage. There is also a lower likelihood of underseepage where the levee rests on the Riverbank Formation in lower length of Reach III (SW ½, Section 34).

Along Reach IV, geologically young Holocene and historical alluvium is beneath the Bypass levee (Plate 1). This uppermost layer, about five-feet thick, is locally cross-cut by channel deposits that also consist of silt and sand (Figure 6). Quaternary basin deposits do not directly underlie the Bypass levee along this reach. Review of Phase 1 subsurface geotechnical data indicates that these alluvial deposits consist of silty sand and sandy silt textures. Based on review of Phase 1 data in other Project areas (i.e., Marysville), the uppermost alluvium generally has low densities (i.e. loose to medium dense), and consequently relatively high permeability. The surficial mapping indicates that essentially all of this reach of the levee (about1.9 miles) is underlain by loose, unconsolidated sandy alluvium, which may be susceptible to substantial underseepage. The local recent channels (map units Ra and Rdc; Plate 1) may contain coarser deposits and may be more susceptible to underseepage.

Synthesis of the surficial mapping and geotechnical data indicate that subsurface stratigraphy along the Sutter Bypass area locally may be conducive to levee underseepage. Shallow strata typically include denser and probably semi-consolidated material (i.e., Modesto Formation) that likely contains a moderately developed low-permeability hardpan horizon. The hardpan may or may not be laterally continuous, depending on post-depositional soil formation and erosional processes. Along Reach I and III, the Modesto formation is overlain by about 4 to 6 feet of medium stiff to stiff clay (i.e., basin deposits). The basin materials locally are cross-cut by relatively loose, sandy channel deposits that have a thin fine-grained upper “blanket” layer. Therefore, this shallow subsurface stratigraphy may promote levee underseepage along certain areas of the Bypass project levees that overlie geologically young, loose, sandy channel material lies between the dense Pleistocene deposits and relatively thin, low-permeability clay-rich “blanket” layer. Along Reach IV, a layer Holocene and historical alluvium from the Feather River mantles the Modesto Formation, and also may promote levee underseepage.

Lateral and vertical variability in the shallow subsurface deposits has resulted from past geomorphic processes. The conceptual subsurface stratigraphic framework suggests that stratigraphic relationships may promote localized levee underseepage, given certain hydraulic conditions. Further spatial analyses of the surficial geologic mapping and subsurface geotechnical exploration data are needed to better constrain and characterize areas that are most susceptible to underseepage in the study area.

6.0 Limitations

This geomorphic assessment and associated data interpretation have been performed in accordance with the standard of care commonly used as the state-of-practice in the geologic engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this geographic area performing the same services under similar circumstances during the same time period.

Discussions of surface and subsurface conditions summarized in this technical memorandum are based on geologic interpretations of subsurface soil data at limited exploration locations available to this assessment through August of 2007. Variations in subsurface conditions may exist between exploration locations, and the project team may not be able to identify all adverse conditions in the levee and its foundation. This memorandum is for the use and benefit of DWR. Use by any other party is at their own discretion and risk.

7.0 References

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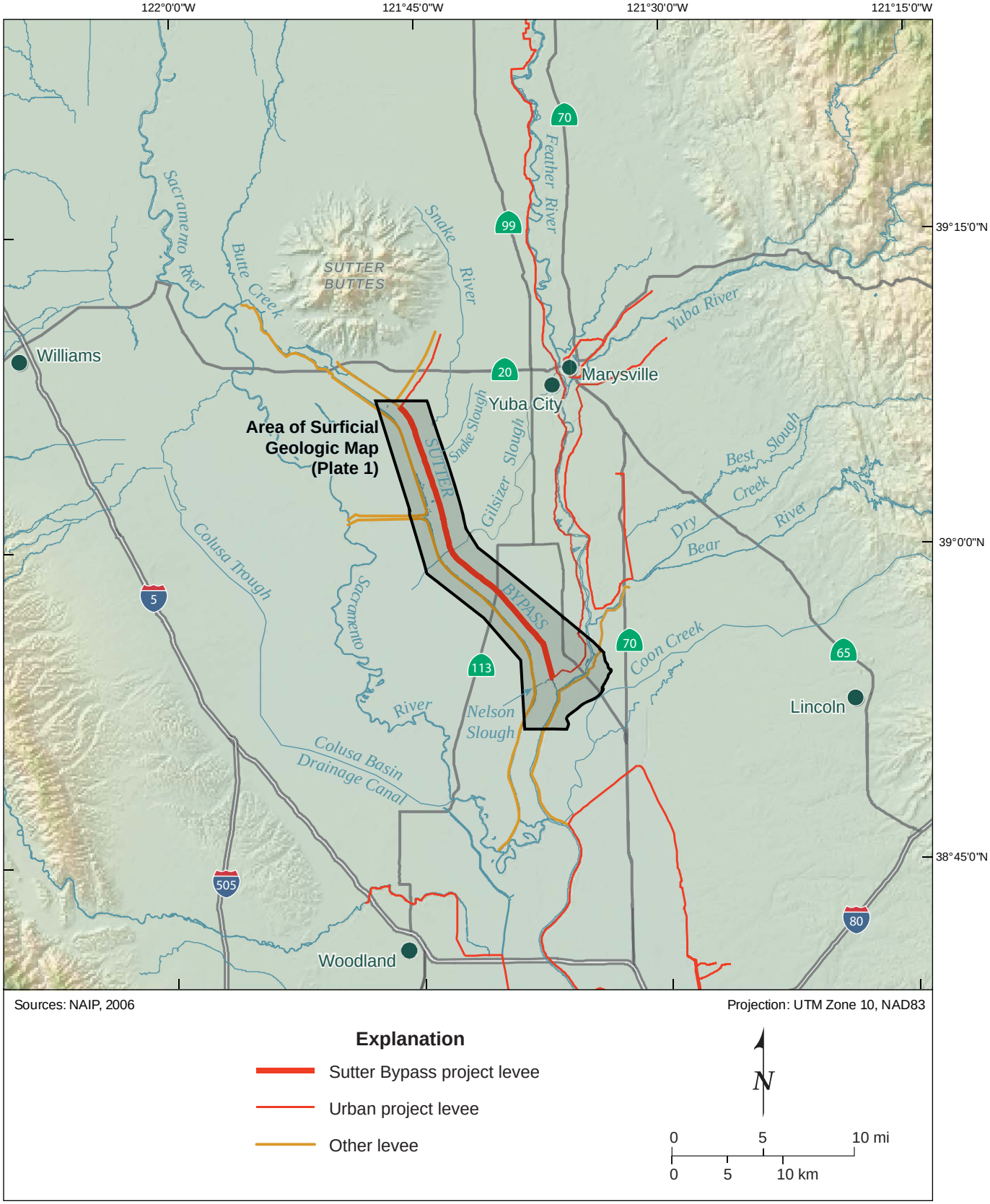
USGS, Marcuse topographic quadrangle, surveyed 1909, published 1911; map scale 1:31,680, five foot contour interval.

USGS, Nicolaus topographic quadrangle, surveyed 1908, published 1910; map scale 1:31,680, five foot contour interval.

USGS, Tisdale Weir topographic quadrangle, surveyed 1909, published 1911; map scale 1:31,680, five foot contour interval.



WLA

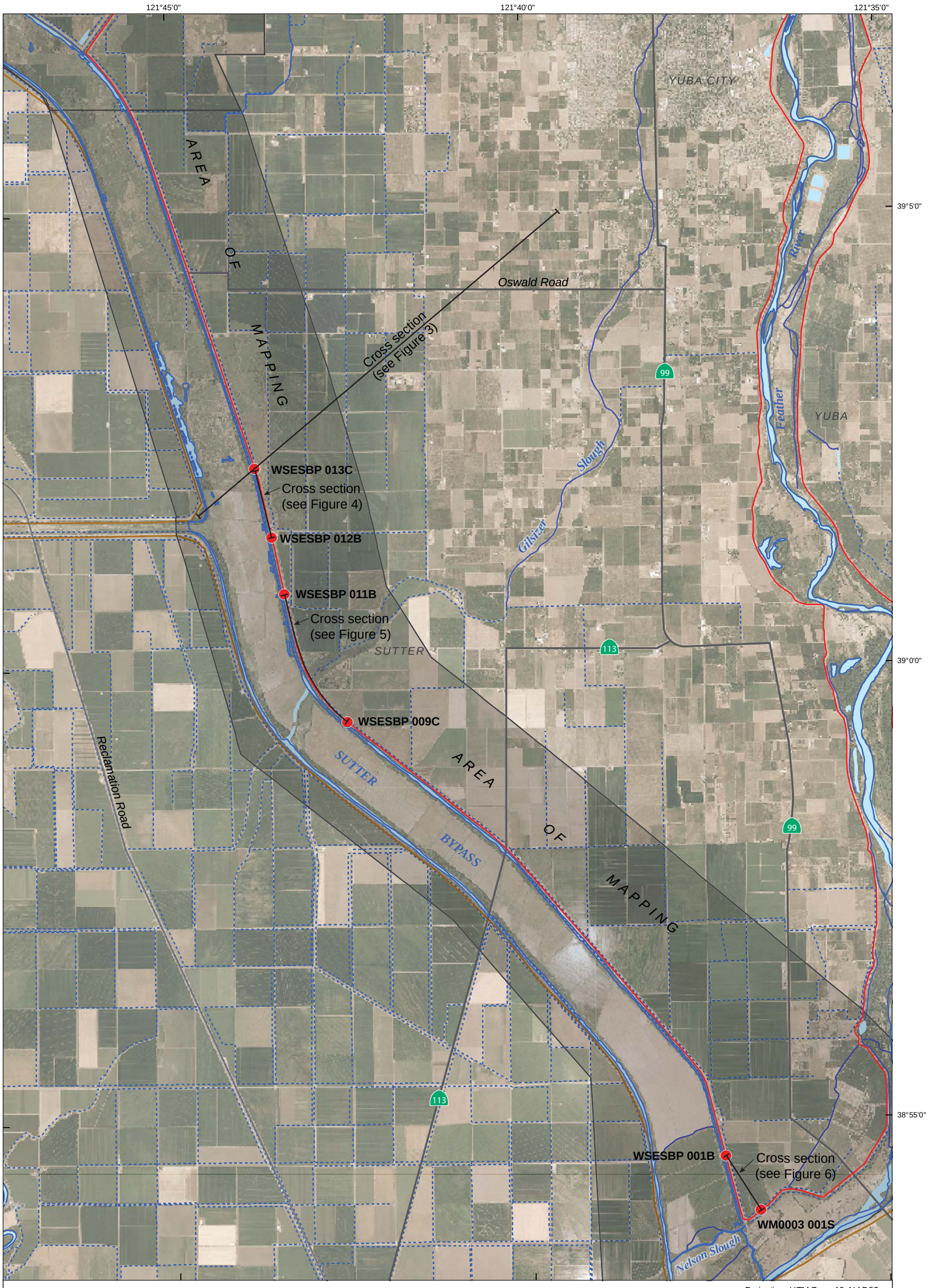
Map of Northern Central Valley, California

DWR URBAN LEVEE PROJECT

Figure 1

1881 Sutter Bypass

Modified 09.03.09



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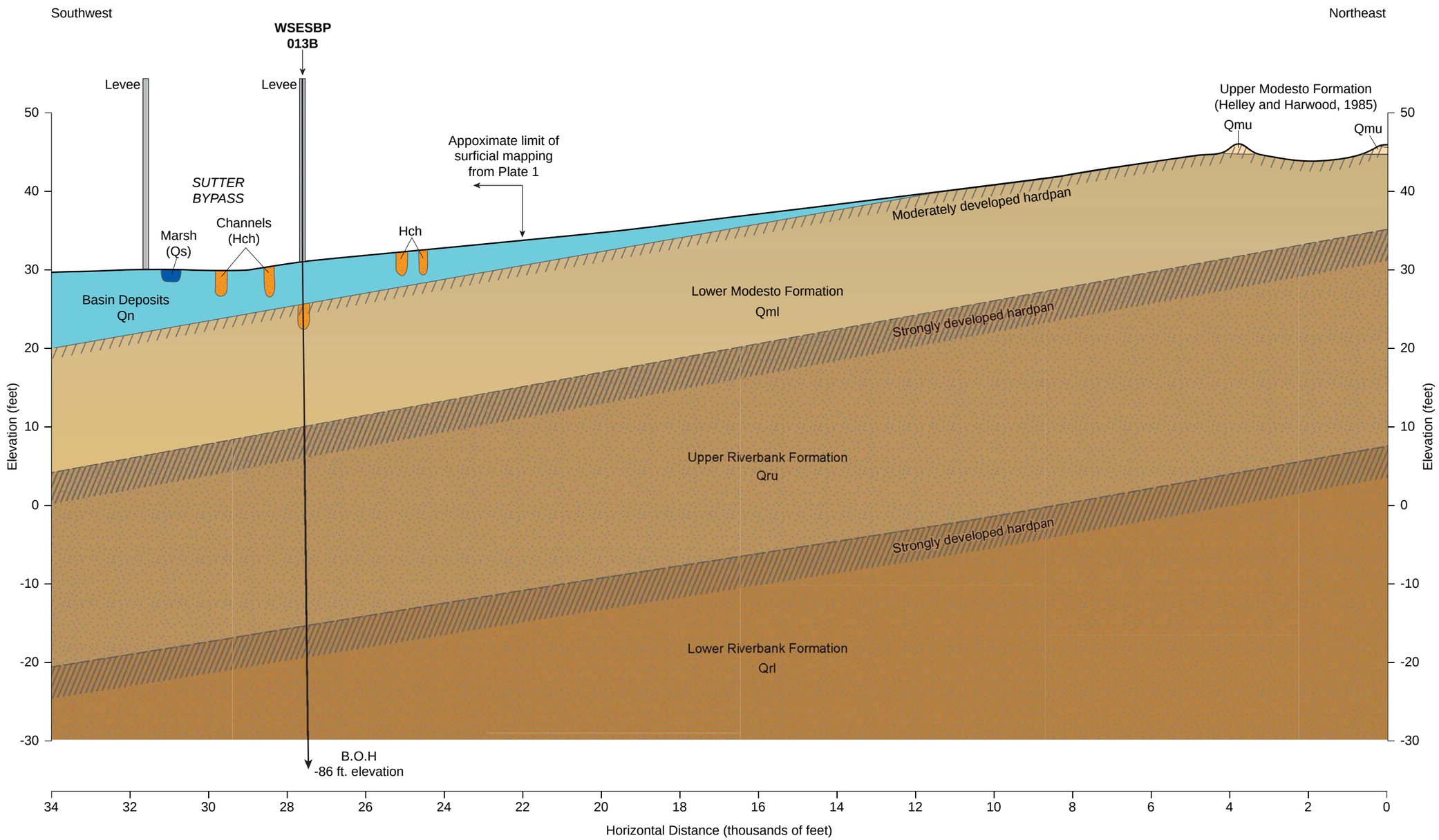
Sutter Bypass

DWR URBAN LEVEE PROJECT

Figure 2

1881 Sutter Bypass

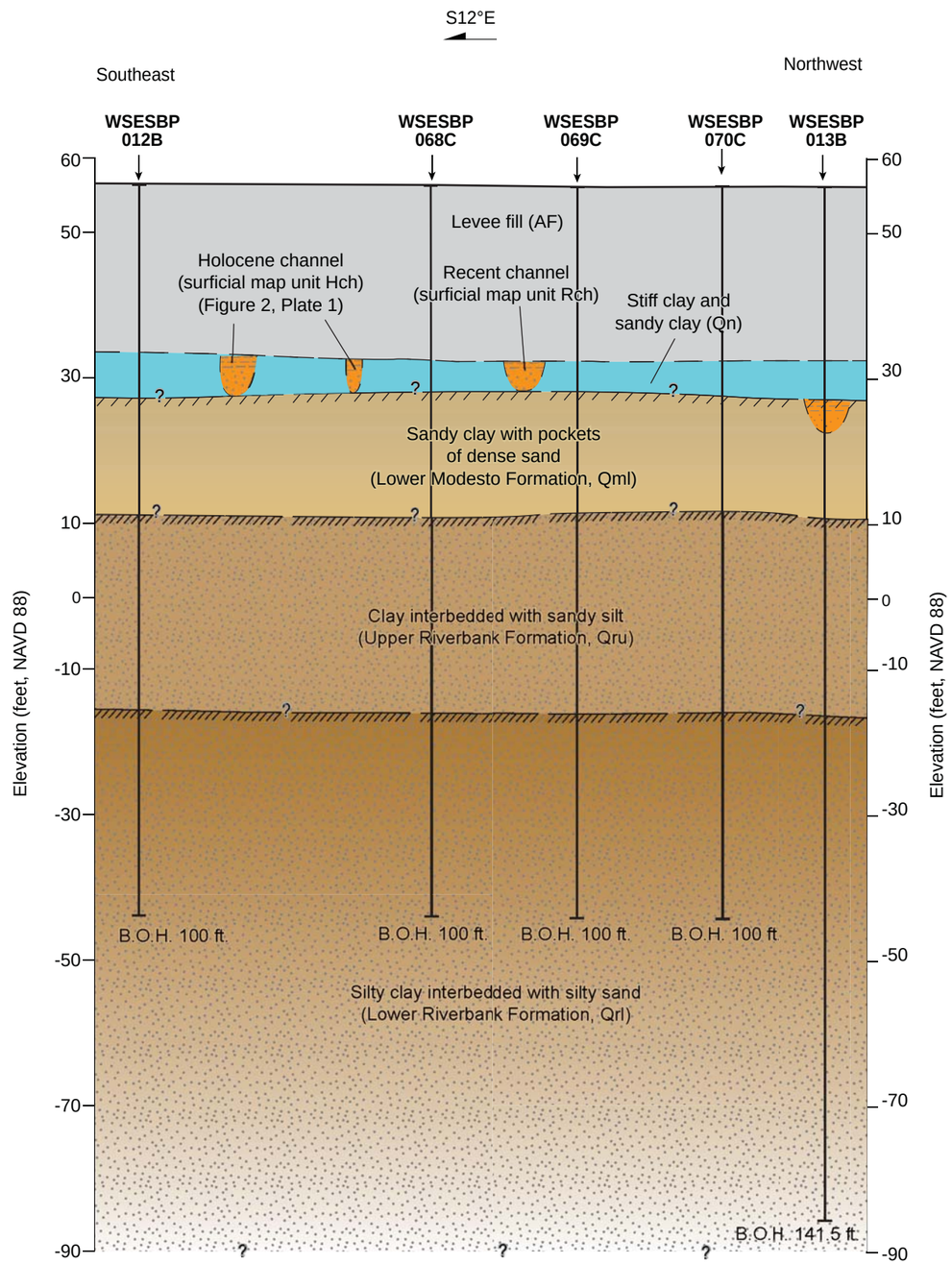
Modified 09.03.09



Notes: 1. See Figure 2 for location of cross section.
2. Surficial geologic units and contacts from this study and Helley and Harwood (1985).
3. Ground surface elevation from USGS Gilsizer Slough topographic map, 5-foot contour interval.

Conceptual Cross Section Transverse to Sutter Bypass

TISDALE WEIR



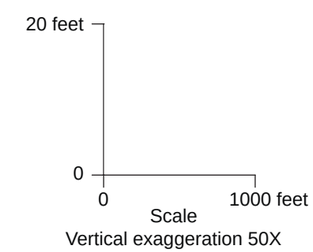
Explanation

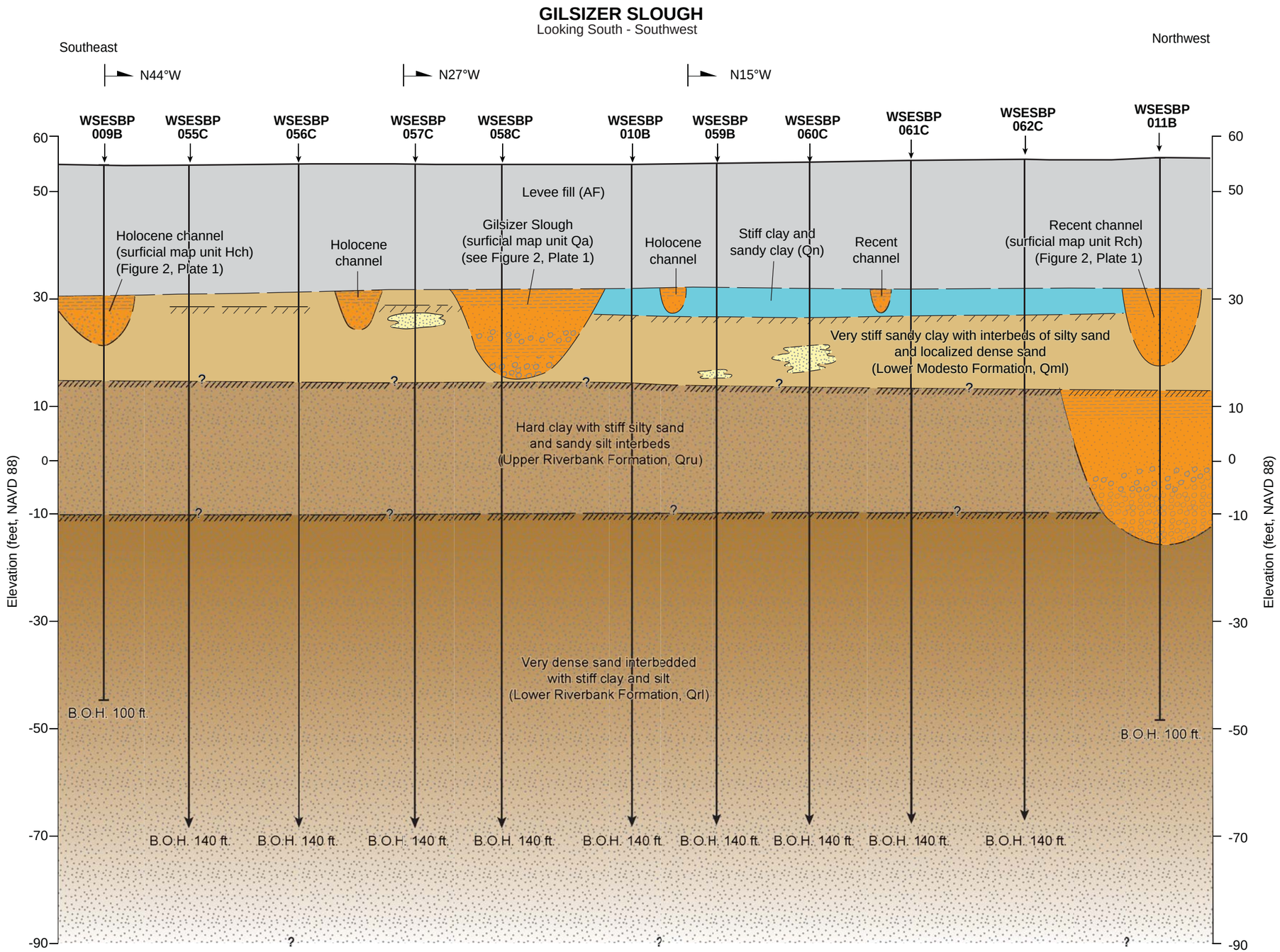
Channel identified on surficial geologic map or as fining upward sequence of sediments in boreholes

Moderate paleosol (hardpan)

Strong paleosol (hardpan)

Notes:
1. Borehole ground elevation values from URS Corp., and reported in the Boring Location Survey, DWR task #10. (NAVD 88).
2. CPT borehole surface elevations are approximate, placed on projected ground surface between boreholes WSESBP_012B and WSESBP_013B.
3. Bottom of hole (B.O.H.) values shown as total depth below ground surface.
4. Borehole names and horizontal distance shown above from draft URS logs and location maps. Geologic relations could change if borehole locations are revised.
5. Drilling method indicated as last letter in borehole names.
   B = Mud Rotary unit with SPT
   C = Cone Penetrometer Test.





Explanation

- Channel identified on surficial geologic map or as fining upward sequence of sediments in boreholes
- Localized sand and gravel; possible channel interpreted from borehole logs
- Moderate paleosol (hardpan)
- Strong paleosol (hardpan)
- Bend in levee
- N16°W Azimuth of levee segment

Notes:
1. Borehole ground elevation values from URS Corp., and reported in the Boring Location Survey, DWR task #10.(NAVD 88).
2. CPT borehole surface elevations are approximate, placed on projected ground surface between continuous boreholes WSESBP-009B, WSESBP-010B, and WSESBP-011B.
3. Bottom of hole (B.O.H.) values shown as total depth below ground surface.
4. Borehole names and horizontal distance shown above (from draft URS logs and location maps). Geologic relations could change if borehole locations are revised.
5. Drilling method indicated as last letter in borehole names.
   B = Mud Rotary unit with SPT
   C = Cone Penetrometer

20 feet
0
0 1000 feet
Scale
Vertical exaggeration 50X

WLA

Conceptual Subsurface Diagram across Eastern Levee Crest at Gilsizer Slough

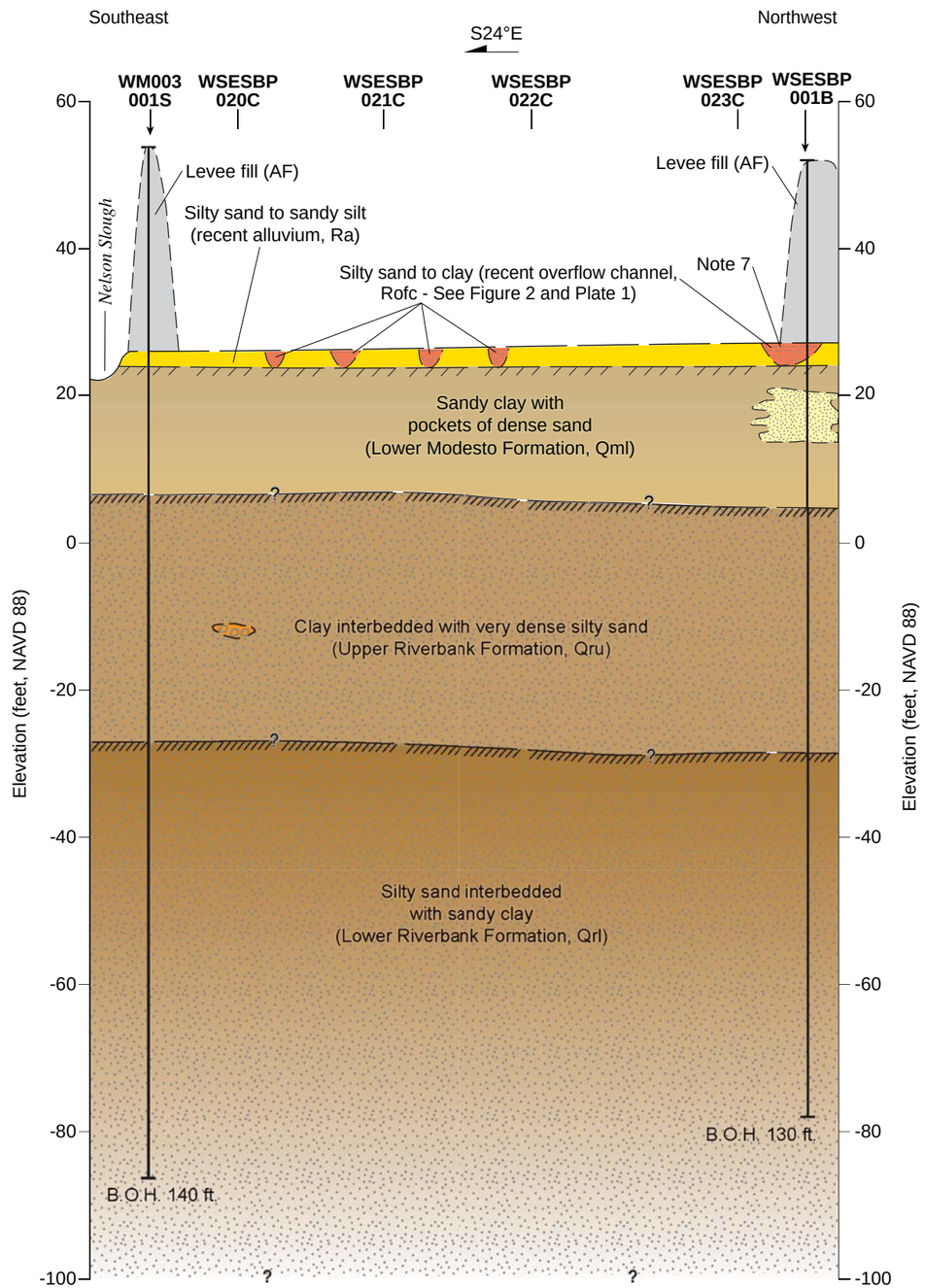
DWR URBAN LEVEE PROJECT
Figure 5

1881 Sutter Bypass

Modified 09.03.09

SOUTHERN SUTTER BYPASS

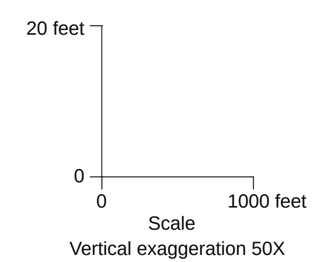
Looking Southwest

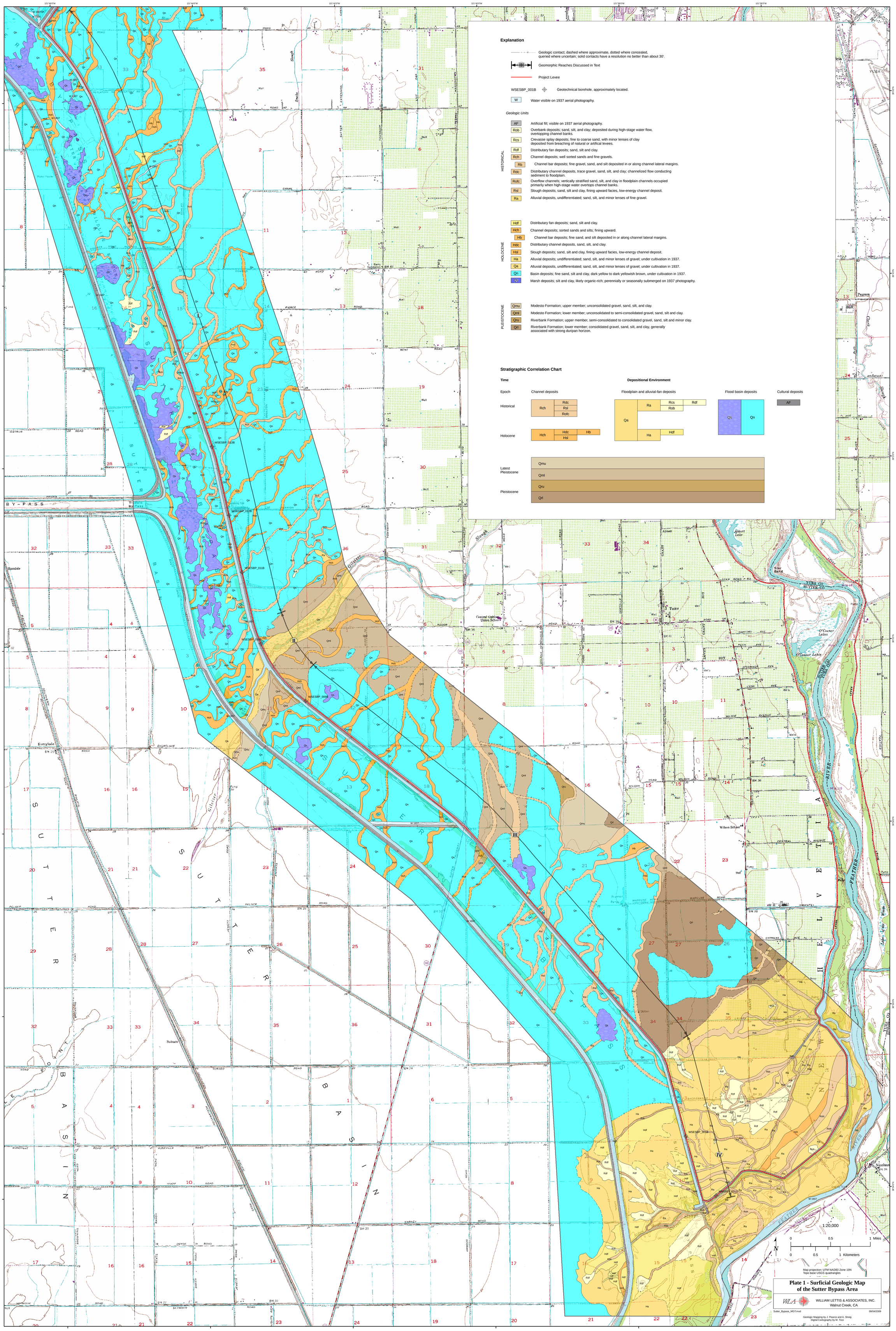


Explanation

- Channel identified on surficial geologic map or as fining upward sequence of sediments in boreholes
- Localized sand and gravel; possible channel interpreted from borehole logs
- Moderate paleosol (hardpan)
- Strong paleosol (hardpan)
- Levee widths and side slopes are schematically shown

Notes:
1. Borehole ground elevation values from URS Corp., and reported in the Boring Location Survey, DWR task #10. (NAVD 88).
2. CPT borehole surface elevations are approximate, placed on projected ground surface between boreholes WM00_001S and WSESBP_001B.
3. Bottom of hole (B.O.H.) values shown as total depth below ground surface.
4. Borehole names and horizontal distance shown above from draft URS logs and location maps. Geologic relations could change if borehole locations are revised.
5. Drilling method indicated as last letter in borehole names.
   - B = Mud Rotary unit with SPT
   - S = Sonic vibracore
   - C = Cone Penetrometer Test.
6. Cone penetrometer borehole locations projected to the trend of this cross section.
7. Recent over flow channel shown beneath the northwestern levee intersects the levee at a sub-orthogonal angle. This conceptual cross section intersects the levee and the over flow channel at an oblique angle, as shown in the channel asymmetry.




Explanation
Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain; solid contacts have a resolution no better than about 30'.
Geomorphic Reaches Discussed in Text
Project Levee
WSESBP_001B
Geotechnical borehole, approximately located.
W
Water visible on 1937 aerial photography.
Geologic Units
HISTORICAL
AF
Artificial fill; visible on 1937 aerial photography.
Rob
Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overtopping channel banks.
Rcs
Crevasse splay deposits; fine to coarse sand, with minor lenses of clay deposited from breaching of natural or artifical levees.
Rdf
Distributary fan deposits; sand, silt and clay.
Rch
Channel deposits; well sorted sands and fine gravels.
Rb
Channel bar deposits; fine gravel, sand, and silt deposited in or along channel lateral margins.
Rdc
Distributary channel deposits, trace gravel, sand, silt, and clay; channelized flow conducting sediment to floodplain.
Rofc
Overflow channels; vertically stratified sand, silt, and clay in floodplain channels occupied primarily when high-stage water overtops channel banks.
Rsl
Slough deposits; sand, silt and clay, fining upward facies, low-energy channel deposit.
Ra
Alluvial deposits, undifferentiated; sand, silt, and minor lenses of fine gravel.
HOLOCENE
Hdf
Distributary fan deposits; sand, silt and clay.
Hch
Channel deposits; sorted sands and silts; fining upward.
Hb
Channel bar deposits; fine sand, and silt deposited in or along channel lateral margins.
Hdc
Distributary channel deposits, sand, silt, and clay.
Hsl
Slough deposits; sand, silt and clay, fining upward facies, low-energy channel deposit.
Ha
Alluvial deposits; undifferentiated; sand, silt, and minor lenses of gravel; under cultivation in 1937.
Qa
Alluvial deposits, undifferentiated; sand, silt, and minor lenses of gravel; under cultivation in 1937.
Qn
Basin deposits; fine sand, silt and clay, dark yellow to dark yellowish brown, under cultivation in 1937.
Qs
Marsh deposits; silt and clay, likely organic-rich; perennially or seasonally submerged on 1937 photography.
PLEISTOCENE
Qmu
Modesto Formation; upper member; unconsolidated gravel, sand, silt, and clay.
Qml
Modesto Formation; lower member; unconsolidated to semi-consolidated gravel, sand, silt and clay.
Qru
Riverbank Formation; upper member, semi-consolidated to consolidated gravel, sand, silt and minor clay.
Qrl
Riverbank Formation; lower member; consolidated gravel, sand, silt, and clay, generally associated with strong duripan horizon.
Stratigraphic Correlation Chart
Time
Depositional Environment
Epoch
Channel deposits
Floodplain and alluvial-fan deposits
Flood basin deposits
Cultural deposits
Historical
Rch
Rdc
Rsl
Rofc
Ra
Rcs
Rdf
Rob
Qa
Qs
Qn
AF
Holocene
Hch
Hdc
Hsl
Hb
Ha
Hdf
Latest Pleistocene
Pleistocene
Qmu
Qml
Qru
Qrl
1:20,000
0
0.5
1 Miles
0
0.5
1 Kilometers
N
Map projection: UTM NAD83 Zone 10N
Topo base USGS quadrangles
Plate 1 - Surficial Geologic Map of the Sutter Bypass Area
WILLIAM LETTIS & ASSOCIATES, INC.
Walnut Creek, CA
Sutter_Bypass_MGT.mxd
09/04/2009
Geologic Mapping by J. Pearce and A. Streig
Digital Cartography by M. Ticci

WILLIAM LETTIS & ASSOCIATES, INC.
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September 8, 2009

Mr. Juan Vargas
URS Corporation
2870 Gateway Oaks Drive, Suite 150
Sacramento, CA 95833

RE: Surficial geologic mapping and geomorphic assessment, California Department of Water Resources Urban Levees Project, Southern Feather River, Sutter County, California

Dear Mr. Vargas:

This memorandum presents the surficial geologic mapping and preliminary geomorphic assessment of the southern Feather River study area, for the California Department of Water Resources (DWR) Urban Levees Project geotechnical characterization. The goal of this mapping and geomorphic assessment is to provide information on the type and distribution of surface and shallow subsurface deposits that likely underlie the project levees along the western bank of the Feather River. The purpose of this study is to develop spatially-continuous geologic data and a conceptual model that provides a framework for stratigraphic interpretations between widely-spaced subsurface explorations. A primary goal is to provide a geologic framework for the geotechnical assessment of potential levee underseepage. This memo presents the technical approach, surficial geologic map, conceptual geomorphic model, and initial results based on map analysis and preliminary review of Phase 1 geotechnical data.

We appreciated the opportunity to provide these geomorphic and geologic data and preliminary interpretations of the shallow stratigraphic conditions in the southern Feather River study area. Please do not hesitate to call either of the undersigned if there are any questions or comments.

Respectfully,

WILLIAM LETTIS & ASSOCIATES, INC.

Justin Pearce, C.E.G. 2421
Senior Geologist

Ashley Streig
Senior Staff Geologist

Keith Kelson, C.E.G. 1610
Principal Geologist

1.0 Approach

The approach to developing a surficial geologic map of the southern Feather River project area (Figure 1, Plate 1) consisted of analysis of the following data: Aerial photography (black and white stereo-pairs taken in 1937, ~1:20,000-scale); early USGS topographic maps (i.e., 1911); published surficial geologic maps (Helley and Harwood, 1985); early and modern soil survey maps (Strahorn et al., 1909; Lytle, et al., 1988); and other maps and documents (Busacca et al., 1989). Synthesis of these data allow for the development of a detailed surficial geologic map that provides an initial understanding of primary geomorphic processes that have acted in the study area during recent and historical geologic time. Through this mapping, primary geomorphic features and associated surficial geologic deposits are identified, such as abandoned paleochannels, channel deposits, floodplain deposits, basin deposits and other features commonly associated with surficial deposits with large active river systems. Knowledge of fluvial processes and the ability to recognize depositional environments in the geologic record are key to identifying locations along levees where underseepage is most likely to occur (Llopis
et al., 2007).

The surficial geologic map was developed at the nominal scale of the aerial photography (1:20,000). This scale establishes the resolution of the map (Plate 1), such that analysis of the map data at a more detailed scale than 1:20,000 may introduce uncertainties beyond the original resolution of the data. The map unit boundaries shown on the surficial geologic map should be considered approximate, and accurate within 30 feet on either side of the line shown on the map. The 1937 aerial photographs are the primary data set for interpreting the surficial geologic deposits because: (1) they are the oldest high-quality images that pre-date much of the urbanization and landscape alteration within present-day Sutter County (i.e. Figure 2); and, (2) these data represent a close approximation to the surficial deposits that were likely present at the ground surface prior to the construction of the levees. The 1937 photographs generally were taken in late summer or early autumn (i.e., August). By 1937, the area had experienced moderate cultivation that locally obscures geomorphic conditions. However, integration of data from the 1937 photography, old and recent topographic maps, geologic maps, soil surveys and historical documents provides sufficient information to delineate many of the pre-historical and historical surficial deposits in detail. Taken together, these data provide key insights to the characteristics of shallow deposits beneath the levees, as well as the geomorphic processes responsible for their distribution.

Additional floodplain deposition may have occurred after 1937, due to flood overflows, levee overtopping, or localized levee failure. A time series analysis that interprets successive aerial photographs taken after major flood events (i.e., USDA, black and white stereo-pairs taken in 1958, ~1:20,000-scale) or known local levee failures (i.e., 1986) may reveal additional information on surficial deposits in the southern Feather River area. Such analyses are beyond the scope of this study. The data and interpretations presented herein address the primary goal of characterizing the type and distribution of deposits likely present directly beneath the project levees.

1.1 Report Preparation Quality Control

The surficial geologic map data and geomorphic interpretations presented in this memorandum were subject to quality control and quality assurance procedures as required by the Levee Geotechnical Evaluation Project Management Plan (PMP). The surficial geologic map data developed by this study were reviewed for accuracy and completeness through an internal review and an independent technical review by Dr. Janet Sowers of WLA. Results of QA/QC review were documented using PMP Exhibit 2.2-3 (Independent Technical Review Report) and are kept on file according filing control plan. Subsurface data shown on diagrams were provided as draft information, and were not verified for accuracy or completeness by this study.

2.0 Geologic Setting

The southern Feather River study area lies in the Central Sacramento Valley, between the Coast Ranges to the west and the Sierra Nevada foothills to the east. Feather River drains the western slope of the Sierra Nevada, and emerges from the mountains south of the Thermalito Afterbay (Figure 1). The river flows southward from the Thermalito Afterbay, over middle-to late Pleistocene dissected alluvium derived from the Sierra Nevada. The regional land surface is nearly flat, with a gentle west-southwest slope that flattens out south of the Sutter Buttes, in Sutter Basin. The Feather River is entrenched into middle to late Pleistocene semi-consolidated sediments. Holocene alluvium deposited by the Feather River is present between the present-day levees, inset to the older formations, as well as on the western floodplain as subdued natural levees. The river trends roughly south until its confluence with the Bear River, where it curves
to the southwest (Figure 1). The Feather River lies east of, and is a tributary to the Sacramento River, converging near the town of Nicolaus (Figure 1). A primary influence on the historic processes in the river system was the hydraulic mining that began in the 1850's. Mining occurred through the early 1900's in the Feather, Yuba and Bear River watersheds, and abruptly introduced large quantities of sediment, drastically changing the geomorphic characteristics of these river systems (DWR, 2004; Ellis, 1939). Aggradation within the stream channel was a primary response to the introduction of substantial mining debris (James, 1999), consequently young alluvial deposits are common throughout the study area.

3.0 Surficial Geologic Mapping

Previous geologic mapping in the study area along the Feather River and surrounding areas generalize the surficial deposits as: Quaternary Alluvium (Qa) and Quaternary stream channel deposits (Qsc) within and proximal to the modern Feather River channel, (Helley and Harwood, 1985). These map units are considered Holocene age (less than 11,000 years old). Late Quaternary Modesto Formation (Qmu, Qml) is mapped along the western margin of the floodplain. These map units were delineated by Helley and Harwood (1985) at a regional scale (i.e., 1:62,500). The current analysis of the Feather River uses this geologic framework as a basis for more detailed mapping of late Holocene alluvium and geomorphic features (Plate 1).

The surficial geologic map units within the southern Feather River study area are described below, in order from oldest to youngest. Surficial geologic mapping for this study subdivides these map units and delineates individual deposits based on relative age and depositional process or environment (Plate 1). The map units depicted on Plate 1 are based primarily on analysis of 1937-vintage photography, and thus the map essentially is a "snapshot" of geologic conditions at this time.

The oldest unit exposed along the Feather River is the lower member of the Riverbank Formation (Qrl) of Helley and Harwood (1985). This unit is a highly dissected alluvial surface with textures of weathered gravel, sand and silt with strong soil-profile development. The Riverbank Formation is semi-consolidated, and is associated with the presence of a well-developed hardpan (or, duripan) layer that is a product of soil-forming processes over substantial geologic time. This hardpan layer reflects an ancient land surface that locally is buried by younger deposits. The Riverbank Formation is late to middle Pleistocene in age, and is estimated to be 130,000 to 450,000 yrs old (Helley and Harwood, 1985). The upper member is unconsolidated dark brown to red alluvium consisting of gravel, sand, silt and minor clay (Busacca et al., 1989, Helley and Harwood, 1985).

The Modesto Formation is divided into two members, a lower (older) unit that is latest Pleistocene in age (about 29,000 to 49,000 years old), and consists of unconsolidated slightly weathered gravel, sand, silt and clay. The upper member, a younger unit, is latest Pleistocene age (circa 12,000 to 26,000 years old) (Helley and Harwood, 1985). This unit (Qmu) is composed of sand, silt, and some gravel, comprising river channel and floodplain deposits, and is associated with a moderate amount of secondary (pedogenic) clay accumulation. This clay-rich horizon may form laterally continuous zones of low hydraulic conductivity, and may extend across boundaries between coarse and fine-grained strata within the latest Pleistocene alluvium. Soils on the Modesto Formation deposits include the Gridley loam of Strahorn et al. (1909) and the Conejo complex of Lytle et al. (1988).

Latest Holocene deposits overlie or are inset into the Modesto Formation, and are categorized as channel, floodplain, and basin deposits (Plate 1). Channel deposits include Holocene channels (Hch), distributary channels (Hdc), overflow channels (Hofc), sloughs (Hsl), in-stream or lateral bars (Hb), and meander scrolls (Hms). These deposits likely consist of fine to coarse sand, silty sand, and clayey sand, with trace fine gravel. Holocene channel deposits (Hch), which are present along Gilsizer Slough and the western floodplain as secondary channels, contain fining-upward sequences of sand, silt and clay. Overflow channels (Hofc) transport water across the land surface during high flow stages toward Sutter Basin. Networks of sloughs wander across the distal floodplain, and are likely filled with a fining-upward sequence of silt and clay (map unit Hsl). These deposits are associated with former channels, and generally are present landside (outboard) of the present-day human-made levees.

Holocene floodplain deposits include crevasse splays (Hcs), distributary fans (Hdf), and overbank deposits (Hob). Crevasse splays (Hcs) are sandy deposits that form from breaching of river banks or natural levees. Distributary fan deposits (Hdf) occur when water and velocity within a distributary channel decreases, can no longer transport its sediment load, and sediment is laid down on the floodplain. Overbank sediments are formed by localized overtopping of

river banks or natural levees, subsequent deposition from shallow sheet flow or standing water. Basin deposits occur on the distal floodplain and include undifferentiated basin deposits (Qn), and marsh deposits (Qs). Basin and marsh deposits are present in the topographically low areas west of the present-day natural levees along the Feather River. These deposits consist of fine sand, silt, and clay laid down in a relatively low-energy depositional environment. Soils developed on these deposits are the Sacramento series silt loam, fine sandy loam, clay, Alamo clay loam adobe and Stockton clay adobe. Marsh deposits are generally saturated and are often underwater in the present-day environment. Undifferentiated Holocene and Quaternary alluvium (Ha and Qa, respectively) usually are proximal to the river channel, and this map unit is used in areas where geomorphic features are obscured or obliterated by historical (1937-era) agriculture or cultivation. The deposits within these agriculturally modified areas are assigned a relative age (Ha or Qa) based on overlapping and cross cutting relationships with the surrounding deposits as follows: Ha if the agriculture-modified area is mapped within or shown overlying Holocene deposits; or Qa where it is difficult to evaluate the surface age based on the nearby deposits. Soils associated with these, undifferentiated units (Qa) are the Sacramento silt loam and Sacramento fine sandy loam, (Strahorn et al., 1909), and the Columbia fine sandy loam of Lyle et al. (1988), which are weakly developed soils commonly developed on relatively young deposits.

Historical deposits mapped in the area include stream channel and floodplain deposits, as well as artificial fill deposits (L and SP) (Plate 1). Historical deposits are estimated to be less than 150 years old, dating from approximately 1800 to 1937. Historical stream channels (Rch), distributary channels (Rdc), and overflow channels (Rofc) within the floodplain are recently abandoned channels or reflect active channels with low water flow. Lateral bar deposits (Rb) and meander scrolls (Rms) are located adjacent to the present-day Feather River, and are generally present inboard (waterside) of the present-day Feather River levees. When the river overtops its banks, distributary channels (Rdc) and recent overflow channels (Rofc) transport water and sediment across the floodplain. These channel deposits likely consist of silt and sand with traces of gravel. The upper few feet of these deposits probably are filled with debris from upstream hydraulic mining activities. Historical sloughs transport low velocity water flow derived from distributary channels proximal to the Feather River onto the distal floodplain and into the Sutter Basin. Slough deposits (Rsl) likely consist of fining-upward silt and clay.

Historical flood plain deposits include crevasse splay (Rcs), distributary fan (Rdf), and overbank (Rob) deposits, which generally consist of a fining upward or episodic fining upward sequence of sand, silt, and clay. Historical overbank (Rob) deposits are slightly finer grained sand, silt, and clay deposited via sheet flow when the river is at flood-stage and overtops natural and artificial levees. These historical deposits are differentiated based on cross-cutting and superposition relationships relative to existing cultural deposits visible on the 1937 photographs. Historical alluvial deposits (Ra), generally located within the Feather River channel, consist of undifferentiated sand, silt, and minor lenses of gravel. Historical artificial fills (map units L and SP) are culturally-emplaced heterogeneous deposits, with varying amounts of clay, silt, sand, and gravel from local sources. These deposits include levee structures and canal levee systems (L), and some undifferentiated soil piles (SP), and are shown on the surficial geologic map where present and identifiable on the 1937 photography.

Mapping of historical and Holocene deposits shown on Plate 1 generally is consistent with early, less-detailed soil survey mapping along the western banks of the Feather River as areas of Gridley loam, Sacramento Series fine sand, sandy loam and silt loam soils (Strahorn et al., 1909). The Gridley loam occurs along the northern Feather River from Thermalito south to the confluence with the Bear River, and closely corresponds to the Modesto Formation of Helley and Harwood (1985). The relationship between the mapped surficial geologic units and the potential for underseepage is summarized below.

4.0 Geomorphic Conceptual Model

The preliminary conceptual model described here is based on general relationships among surface and subsurface geologic deposits along the Feather River, as described above and shown on Plate 1. This conceptual model provides a consistent basis for understanding the type and stratigraphy in the area.

Published geologic maps of the project area identify a complex series of westward aggrading alluvial fans and terraces derived from the Sierra Nevada, identified as the Riverbank and Modesto formations. The Riverbank Formation and Modesto Formation are semi-consolidated to unconsolidated deposits characterized by intraformational paleochannels and lateral and vertical stratigraphic complexity related to past fluvial processes and buried paleo-topography. The Riverbank Formation unconformably overlies the Laguna Formation, which is a deeply dissected alluvial surface (Busacca et al., 1989).

Subsurface deposits about 150 feet beneath the ground surface rest on a resistant volcanic tuff capped by interbedded alluvial gravel, sand and silt, interpreted as Pliocene-Pleistocene age Laguna Formation that represents a period of relatively stable landscape conditions (Helley and Harwood, 1985). The Laguna Formation is overlain by the Pleistocene Riverbank Formation, (very dense gravel deposits) that are, in turn, overlain by a medium dense sand and gravelly sand package of the latest Pleistocene Modesto Formation (Busacca et al., 1989). The upper member of the Modesto Formation is exposed at the ground surface adjacent to the western bank of the Feather River south of Marysville and Yuba City. The Modesto Formation is mantled by unconsolidated deposits of Holocene age that comprise most of the surficial geologic deposits along the western side of the Feather River (Plate 1).

Geomorphic evidence suggests that the Feather River system south of Yuba City may have been located west of its present course (Figure 3). The present-day Gilsizer Slough diverges from the modern Feather River directly north of Yuba City and trends southwestward toward the Sacramento River. Alluvial deposits of Gilsizer Slough are inset (i.e. incised) into the Modesto Formation from Yuba City southward. The ancestral Gilsizer Slough perhaps extended to as far as the Sacramento River (Figure 3), based on surficial mapping not included in this report, and inspection of topographic maps. The ancestral Gilsizer Slough deposits are related to discharges and sediment loads that were higher than present-day conditions, and perhaps is an ancestral course of the Feather River.

Surficial geologic deposits near the Yuba City airport indicate the Feather River occupied an intermediate position between ancestral and present locations. The river occupied an abandoned channel arm north of Shanghai Bend, located between Gilsizer Slough and the modern Feather River (Figure 3). From this point the river continued southward in nearly its present location. This paleochannel had a sharp, more exaggerated bend than the present-day channel at Shanghai Bend (Figure 2). The channel subsequently moved eastward, laterally backfilling and abandoning the meander above Shanghai Bend, and moved to the rivers' present location closer to Marysville. Today, Gilsizer Slough is a natural bypass for high water flow stages on the Feather River, in the area between Marysville and Yuba City (Ellis, 1939).

Surficial geologic mapping (Plate 1) shows differences in deposit type and distribution from north to south along the Feather River, which is associated with changes in watershed production of water and sediment, related geomorphic processes, soil profile development, and the underlying subsurface hardpan layer. These differences illustrate the diversity of past geomorphic processes along the river and, as a consequence, the type of geologic deposits at and near the ground surface. The surficial geologic map allows the delineation of reaches along the river within which geomorphic processes and their associated deposits appear to be relatively consistent.

Between Yuba City on the north to the confluence with the Sutter Bypass on the south, the southern Feather River consists of four major reaches, each having characteristic deposit types and distributions. The river reaches are numbered Southern Feather one through four (SF-I through SF-IV), sequentially from north to south (Plate 1, Figure 3). This report describes the surficial geologic characteristics of Reach SF-I, SF-II, SF-III and SF-IV of the southern part of the Feather River, extending from Yuba City, south to the confluence with the Sutter Bypass.

Reach SF-I, extends from the north end of Yuba City to the Yuba City airport, and is about 1.15 miles long (Plate 1, Figure 3). The Project levee along Reach SF-I trends roughly north-south, and overlies alluvial sediments deposited by the Feather River. In Yuba City the levee rests on Holocene deposits associated with Gilsizer Slough that are inset into the upper member of the Modesto Formation. The active Feather River channel is east of, and inset to these Holocene channel deposits (Figure 4).

The second reach of south Feather River project area, SF-II, extends from the Yuba City airport south to Shanghai Bend, and is about 2.9 miles long. Near the Yuba City airport, and south of the confluence of the Feather and Yuba Rivers, young channel deposits are inset against the Gilsizer Slough channel deposits (Plate 1). From the Yuba City airport, south to Epley Drive (about 1.5 miles), the levees overlie historical alluvium of mining debris origin, map unit Ra. From Epley Drive south to Shanghai Bend Road the levees (about 1.4 miles) overlie historical meander scrolls, map unit Rms, (Figure 2, Plate 1). The levee along this reach, SF-II, primarily overlies Holocene channel fill, historical alluvium and overbank deposits. These channels are likely filled with a fining-upward sequence of gravel, sand and silt, the upper few feet of these features are probably covered by a veneer of sediment derived from upstream hydraulic mining activities (Figure 4).

River Reach SF-III extends from Shanghai Bend on the north to just south of the confluence with Bear River, and is approximately 12 miles long (Plate 1). Along Reach SF-III, the active river floodplain is inset into the upper member of the Modesto Formation. Over geologic time, flooding has lead to the vertical accretion of overbank and crevasse splay deposits onto the Modesto Formation west of the Feather River. Overflow channels and related deposits (Rofc) are common along this reach of the river. Beginning at Shanghai Bend and continuing southward are seven overflow channels that range from approximately 100 to 200 feet wide. The Project levees overlie these channels in the area around Messick Road (Plate 1). A few overflow channels conduct water flow immediately landside of the levees, across a short distance between Shanghai Bend and Oswald Avenue, then converge with the Feather River. The overflow channels are slightly inset to the Modesto Formation, and based on borehole data from locations where these channels cross the Sutter Bypass, are probably 6 to 15 feet deep. These channels are likely filled with episodic fining upward sequences of silt, sand and gravel, representing multiple flood events on the Feather River. The upper few feet of these channels are probably filled with sediment from upstream historic hydraulic mining activities. The river channel widens considerably between Country Club Road (0.5 mile width) and Obanion Road (1 mile width), (Plate 1). Feather River meanders along the eastern edge of Abbott Lake, swings sharply southward into Star Bend, where the river is deflected eastward by a resistant knob of Modesto Formation (which forms Star Bend). Historical crevasse splay and overbank deposits overlie the Modesto Formation from Abbott Road to Star Bend Road, along the western edge of Abbot Lake (Figure 5). These crevasse splay deposits are likely filled with a fining-upward sequence of fine gravel, sand and silt, The upper few feet of these features are probably covered by a veneer of hydraulic mining sediment.

The southernmost reach, Reach SF-IV, extends from the area south of the confluence with the Bear River to the confluence of the Feather River and Sutter Bypass, and is roughly 4 miles long (Plate 1). The sediments underlying the levee along this reach are geomorphically complex, resulting from depositional convergence between the Feather River and Bear River. The Bear River channel deposits large amounts of sediment across the ground surface adjacent to the confluence. The Modesto and Riverbank Formations are exposed at the ground surface adjacent to natural levees immediately north of the Bear River confluence, and north of this reach (Plate 1). These formations are covered by historical alluvium, sourced from the Feather and Bear Rivers. Much of the historical activity along this reach is located near the levee at Laurel Avenue. Here, consisting eight distributary channels (Rdc), typically 90 feet wide but ranging from 45 to 190 feet wide, cross the floodplain in southwesterly orientations, terminating in geologically young distributary-fan sediments. These sediments, primarily consisting of fine to coarse sand and silt, probably were deposited as a result of increased sediment and water input contributed to the Feather River from the Bear River. Historically, the Feather River and the Bear River have aggraded from substantial mining debris input, thus reducing channel cross sectional area (i.e., James, 1999). This reduction of cross section area, coupled with the trajectory of flood flow from the Bear River watershed, resulted in water overtopping the Feather River channel banks, and depositing sediment onto the floodplain between the confluence of the Feather River and Sutter Bypass (Plate1).

5.0 Applications to the Urban Levee Project

Based on an initial analysis of surface geologic and geomorphic data, the levees bordering the western side of the Feather River from Yuba City to the Sutter Bypass, (Reaches SF-I, SF-II, SFIII and SF-IV) probably are underlain by a veneer of near-surface sandy deposits, or by buried channels that are inset into the Modesto Formation. The preliminary conceptual surface and subsurface geologic relationships as they relate to levee structures and potential underseepage along each reach of the river are described below. This study does not account for any existing seepage mitigation structures, i.e. slurry wall or cutoff wall, which may be present.

Reach SF-I contains the Gilsizer paleochannel deposits, this channel intersects the levees roughly 660 feet south of Lynn Way to Colusa Avenue (Plate 1). Along this length the levees are underlain by coarse channel deposits. These coarse grain deposits are likely laterally continuous and poorly consolidated and relatively highly permeable, and likely are susceptible to underseepage.

Levees along the reach SF-II are underlain by a Holocene paleochannel and historical meander scroll deposits (Figure 2, Plate 1). These deposits are coarse grained, laterally continuous and poorly consolidated, and likely are susceptible to underseepage. The presence of this paleochannel deposit suggests locally permeable material (channel fill) directly underlying the levees. Historical alluvium most likely of mining debris origin, blankets the Yuba City airport paleochannel and meander scroll deposits. The levees along this reach are underlain by a thick sequence of young, permeable alluvium of meander scroll deposits that are highly susceptible to seepage (Glynn and Kuszmaul, 2004).

Reach SF-III consists of coarse-grained avulsion deposits (overbank, crevasse splay and overflow channel deposits) overlying the Modesto Formation. Overflow channels (Rofc) are common along this reach, are relatively thin, slightly inset to the Modesto Formation and are filled with poorly consolidated sediments that may provide local pathways for underseepage. Individual shallow coarse deposits may be laterally discontinuous and may be separated by clayey interbeds (i.e. thin blankets). Local coarse deposits may be associated with higher likelihoods of levee underseepage. Deeper deposits probably consist of consolidated Modesto Formation with occasional small, but unconsolidated, overflow channel deposits incised into resistant strata.

Along Reach SF-IV the levee is underlain by laterally-continuous sandy deposits formed by distributary overbank fans and by the south flowing ancestral Feather River (Gilsizer Slough). These coarse-grained deposits likely are permeable and susceptible to underseepage. Near Laurel Avenue distributary channel deposits underlie the levees and may be relatively coarser than the surrounding alluvium.

6.0 Summary

Lateral and vertical variability in the shallow subsurface deposits has resulted from past geomorphic processes. Surficial geologic mapping along the south Feather River allows reach classifications within which conditions may be relatively consistent. The conceptual subsurface stratigraphic framework suggests that stratigraphic relationships may promote localized levee underseepage, given certain hydraulic conditions, particularly along reach SF-I and II. Further spatial analyses of the surficial geologic mapping and subsurface geotechnical exploration data are needed to better constrain and characterize areas that are most susceptible to underseepage in the study area.

7.0 Limitations

This geomorphic assessment and associated data interpretation have been performed in accordance with the standard of care commonly used as the state-of-practice in the geologic engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this geographic area performing the same services under similar circumstances during the same time period.

Discussions of surface and subsurface conditions summarized in this technical memorandum are based on geologic interpretations of subsurface soil data at limited exploration locations available to this assessment through August of 2007. Variations in subsurface conditions may exist between exploration locations, and the project team may not be able to identify all adverse conditions in the levee and its foundation. This memorandum is for the use and benefit of DWR. Use by any other party is at their own discretion and risk.

8.0 References

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USGS, Gilsizer Slough topographic quadrangle, surveyed 1909, published 1911; map scale 1:31,680, five foot contour interval.

USGS, Marcuse topographic quadrangle, surveyed 1906, published 1910; map scale 1:31,680, five foot contour interval.

USGS, Nicolaus topographic quadrangle, surveyed 1908, published 1910; map scale 1:31,680, five foot contour interval.

USGS, Ostrom topographic quadrangle, surveyed 1909, published 1911; map scale 1:31,680, five foot contour interval.

USGS, Sutter topographic quadrangle, surveyed 1909, published 1911; map scale 1:31,680, five foot contour interval.

USGS, Yuba City topographic quadrangle, surveyed 1909, published 1911; map scale 1:31,680, five foot contour interval.

USGS, Gilsizer Slough topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.

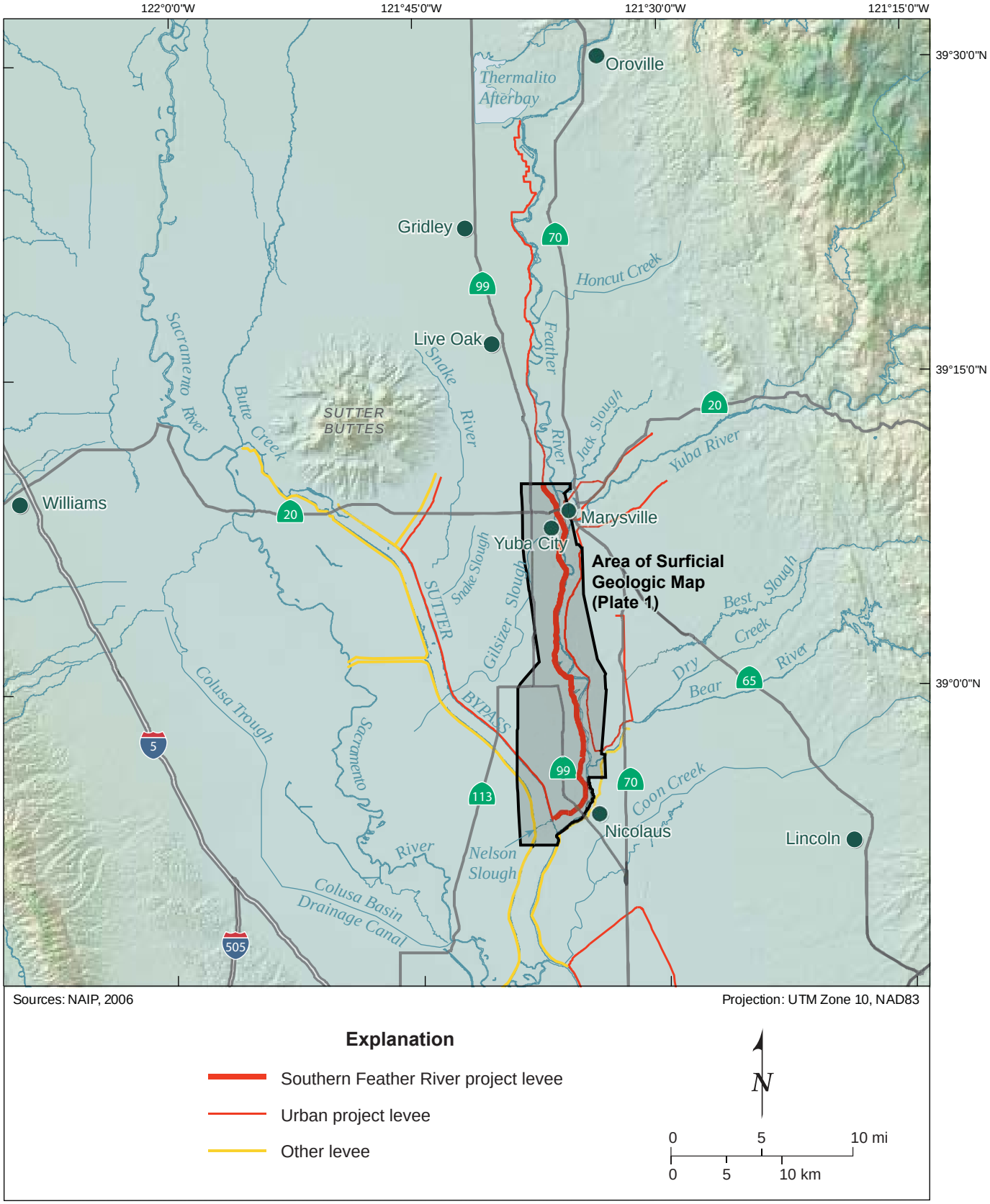
USGS, Nicolaus topographic quadrangle, published 1952, remapped 1992; map scale 1:24,000, five foot contour interval.

USGS, Olivehurst topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.

USGS, Sutter topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.

USGS, Sutter Causeway topographic quadrangle published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.

USGS, Yuba City topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.



WLA

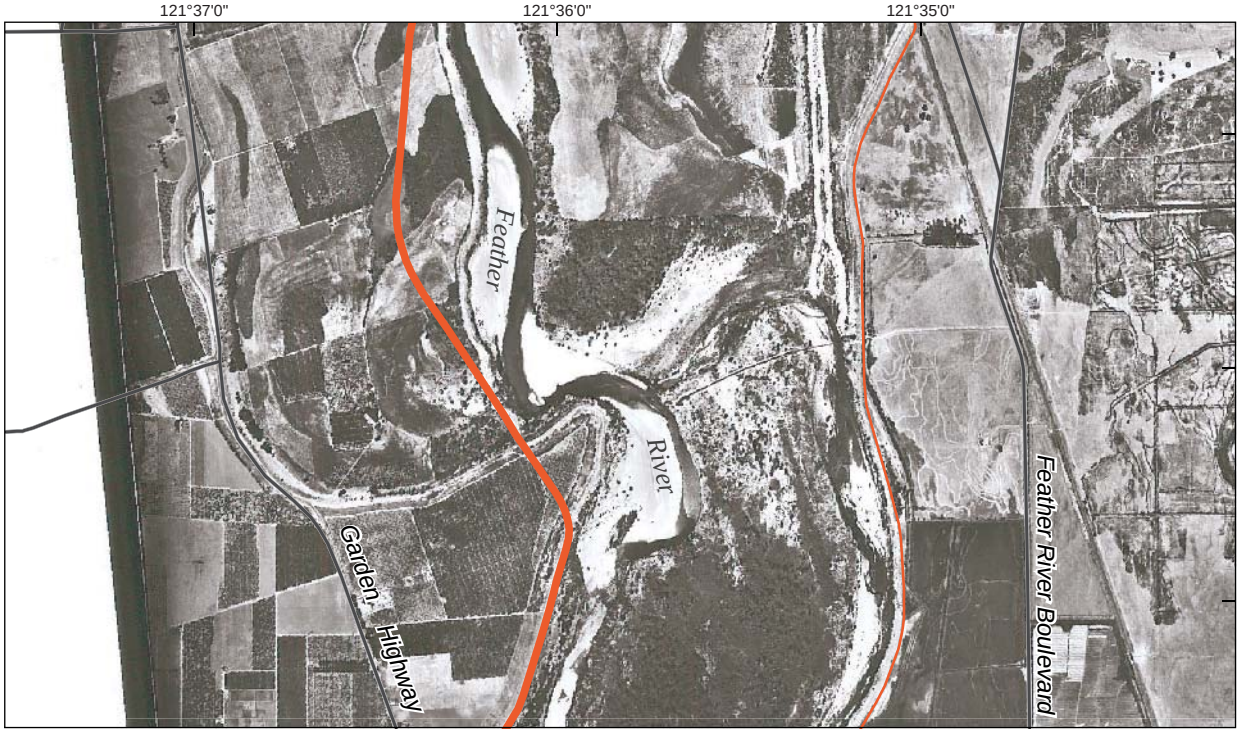
Map of Central Valley near Sutter Buttes, California

DWR URBAN LEVEE PROJECT

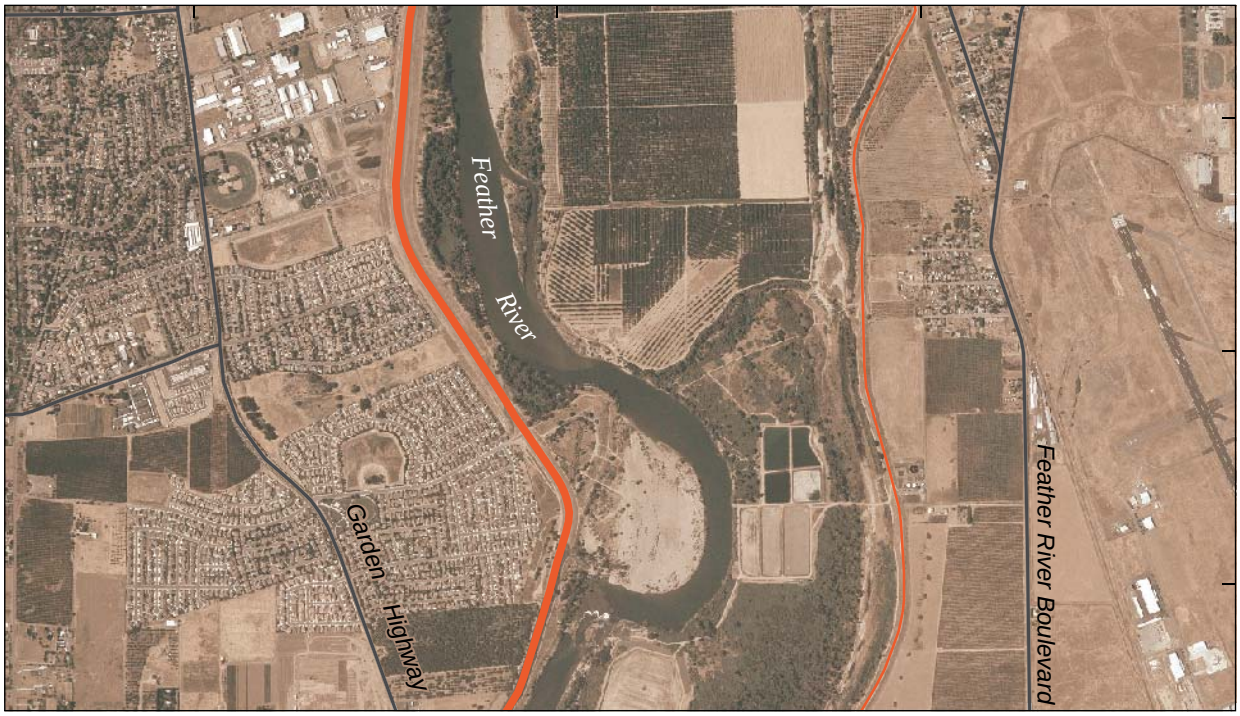
Figure 1

1881 South Feather River

Modified 09.03.09



A. 1937 USDA Air Photo



B. 2006 NAIP Ortho Imagery

Explanation

- Southern Feather River project levee
- Urban project levee
- Major road

N

0 5 10 mi

0 5 10 km

WLA

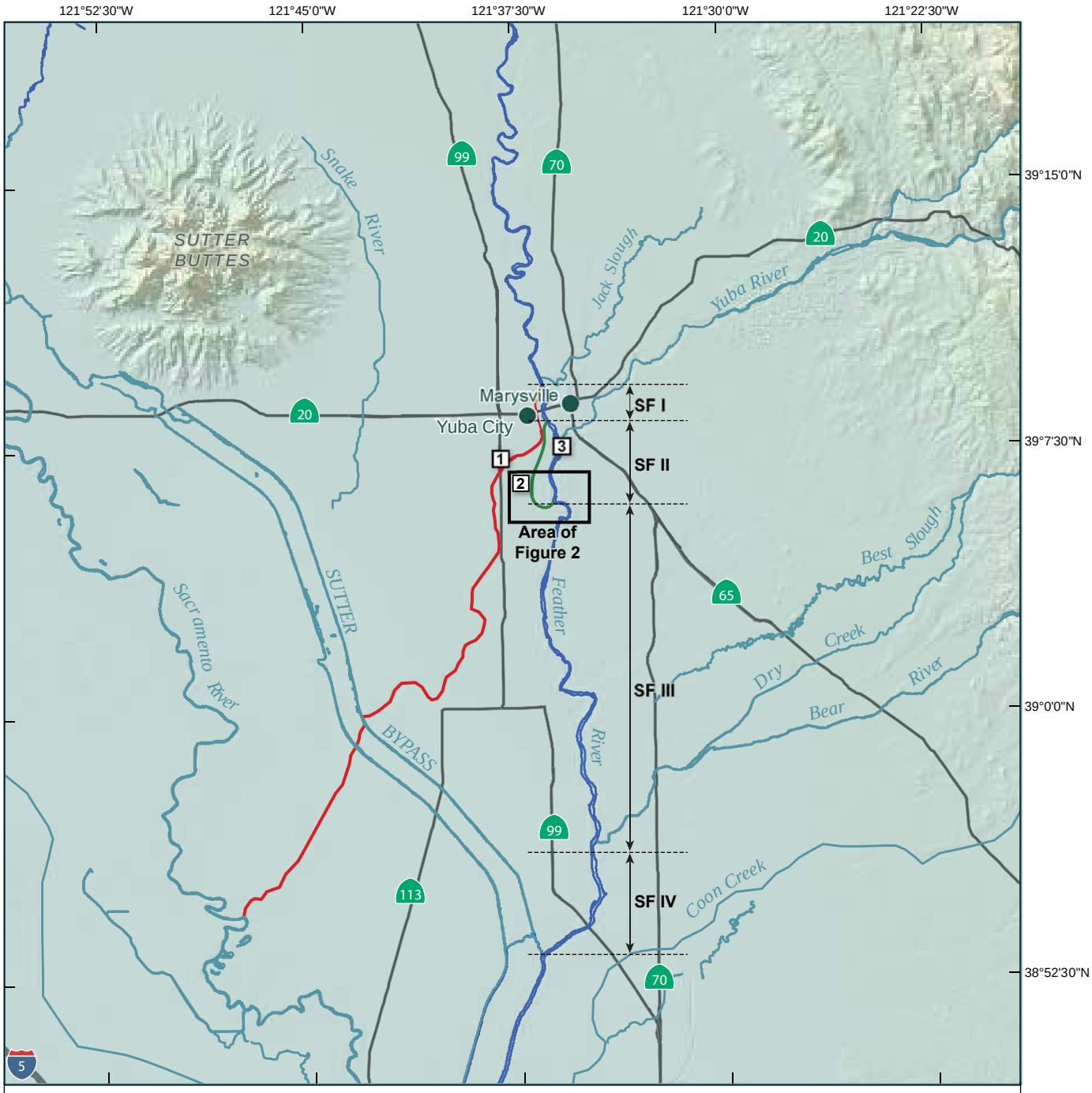
Aerial Imagery of the Feather River at Shanghai Bend

DWR URBAN LEVEE PROJECT

Figure 2

1881 South Feather River

Modified 09.03.09



Source: ESRI, 2006

Projection: UTM Zone 10, NAD83

Explanation

- 3 — Modern Feather River Channel
- 2 — Abandoned arm of the Feather River
- 1 — Ancestral Feather River Channel (Gilsizer Slough)
- SF I — Reach of Southern Feather River Study Area

N

0 5 mi

0 5 km

WLA

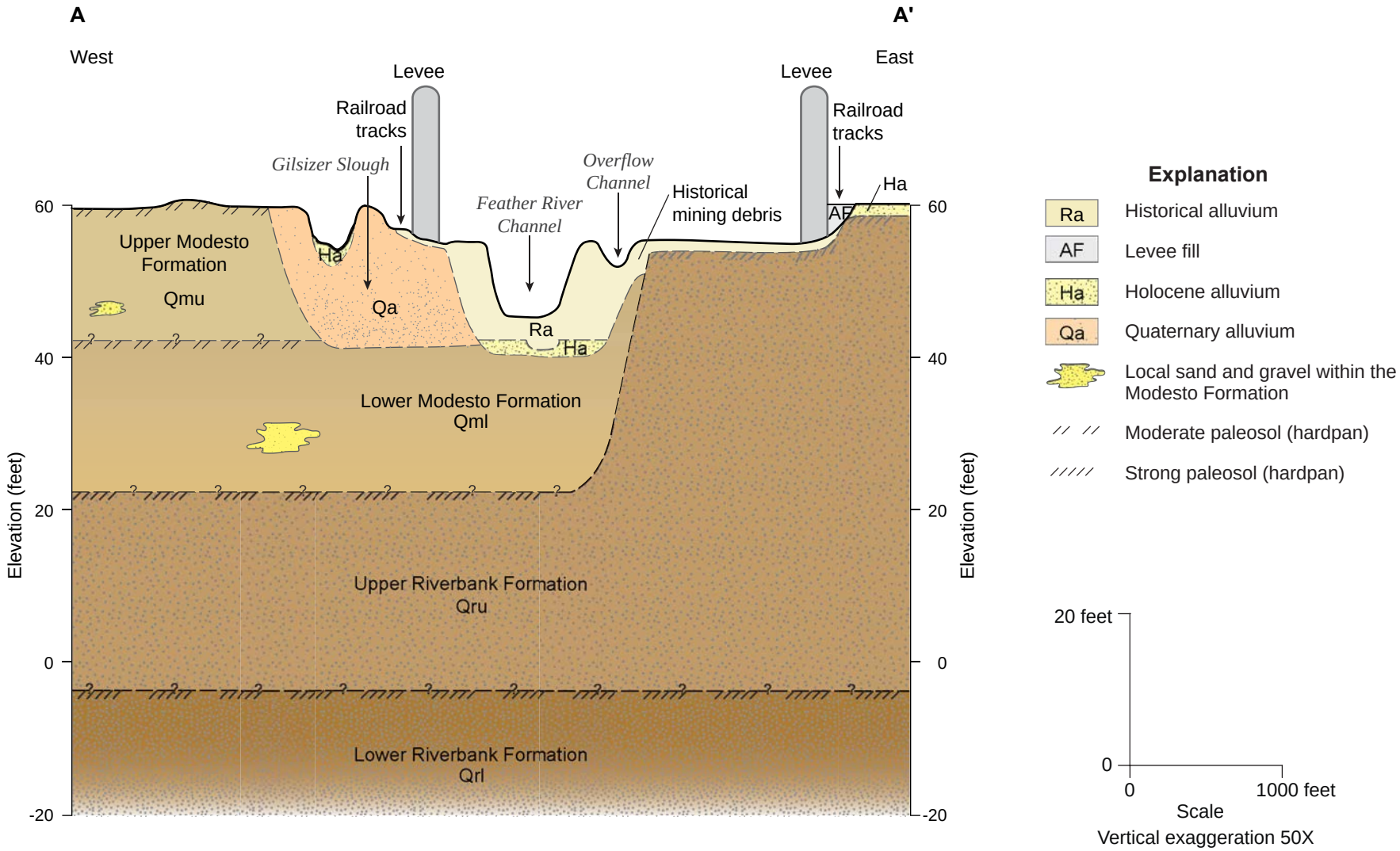
Map Showing the Eastern Migration of the Feather River

DWR URBAN LEVEE PROJECT

Figure 3

1881 South Feather River

Modified 09.03.09



WLA

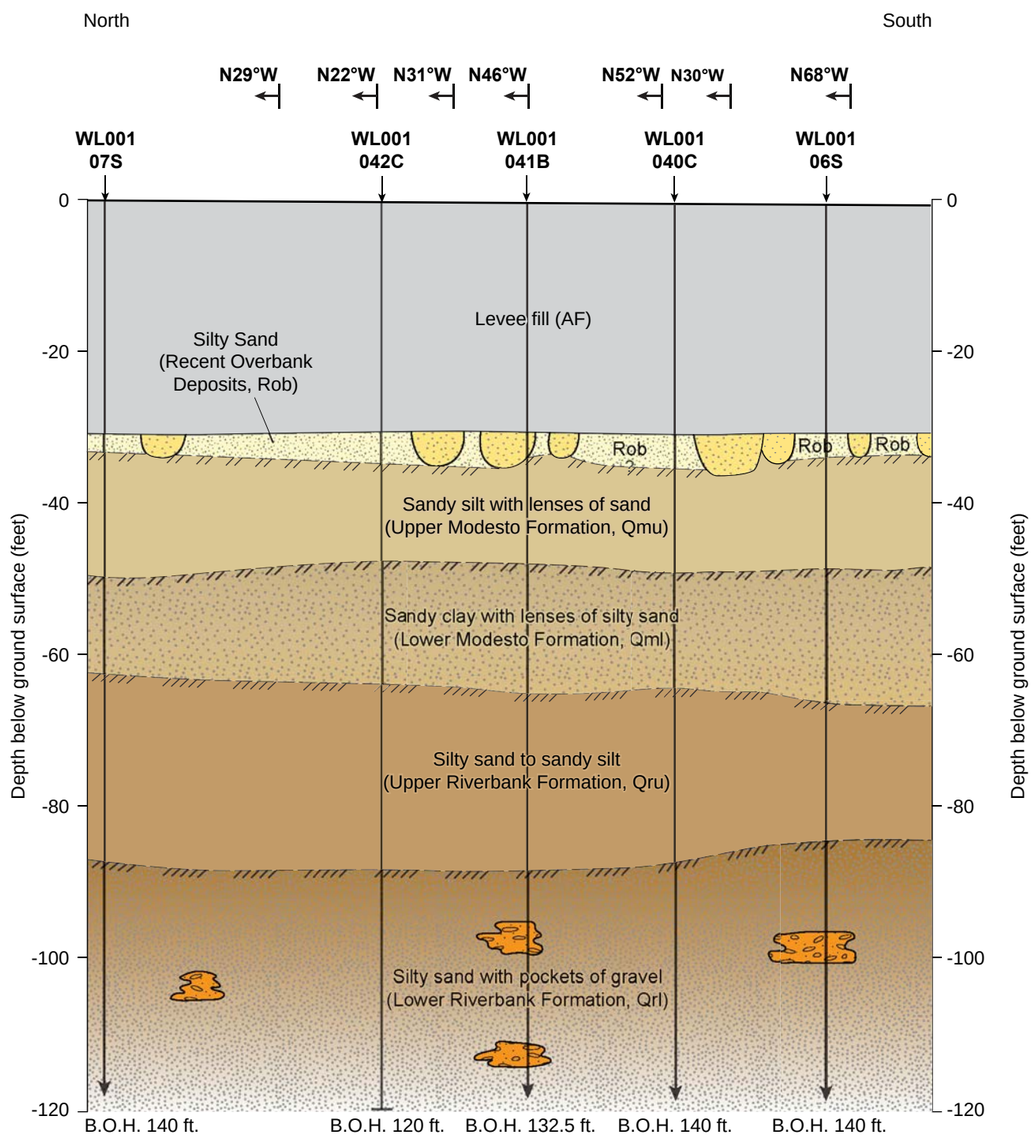
Conceptual Subsurface Diagram across the Feather River at Yuba City

DWR URBAN LEVEE PROJECT

Figure 4

1881 South Feather River

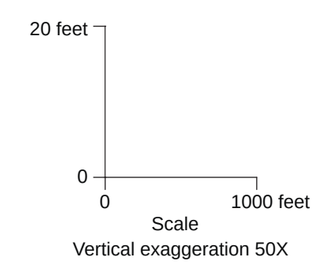
Modified 09.03.09



Explanation

- Recent crevasse splay, surficial geologic map unit Rcs
- Local sand and gravel within the Riverbank Formation
- Moderate paleosol (hardpan)
- Strong paleosol (hardpan)
- N46°W — Bend in Section

Notes:
1. See Plate 1 for location of cross section.
2. Surficial geologic units and contacts from this study and Helley and Harwood (1985).
3. Bottom of hole (BOH) values shown as total depth below ground surface.
4. Borehole names and horizontal distance shown above from draft URS logs and location maps. Geologic relations could change if borehole locations revised
5. Drilling method indicated as last letter in borehole names:
   S = Sonic Vibracore;
   C = Cone Penetrometer Test;
   B = Mud Rotary with SPT



Conceptual Subsurface Diagram, West Levee at Abbott Lake and Star Bend

Figure 5

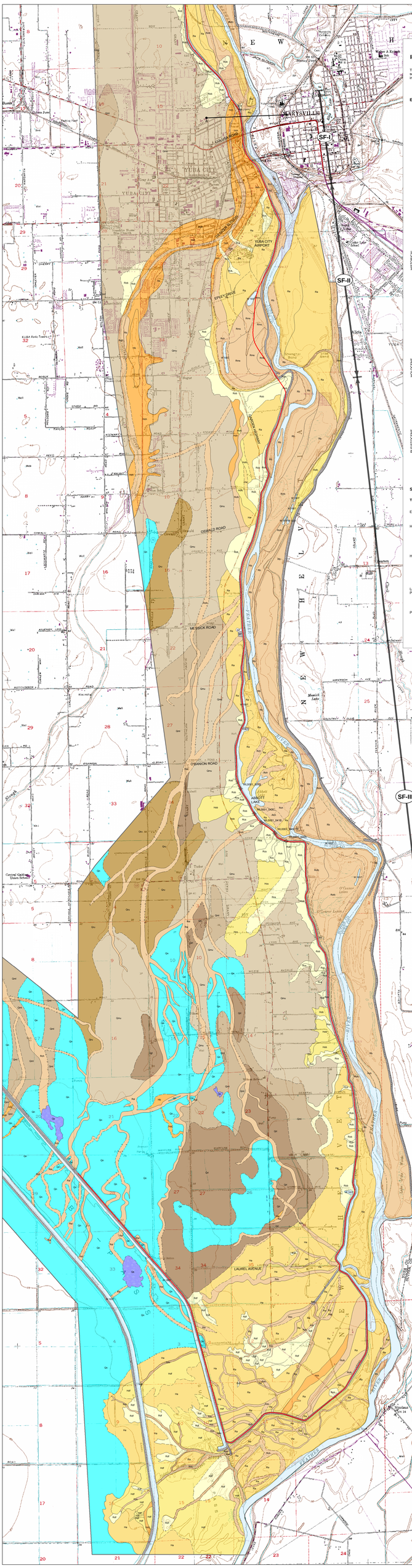


Plate 1 - Surficial Geologic Map of the Feather River, Southern Section

This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on modern U.S. Geological Survey topographic base map prepared in 1952 and photo revised in 1973. See accompanying report for complete descriptions of map units, process descriptions and methodology.

Explanation

Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain; solid contacts within 30' of line shown on map.

SF-II — Geomorphic Reaches Discussed in Text

Project Levees

A — A' — Cross Section

WSL001_0065 — Borehole locations from URS, Corp; locations from Sutter P2 Boring Locations, Region 1 Northern Area map.

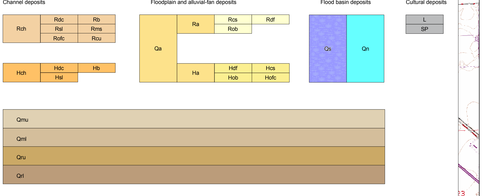
W 1937 — Water bodies, circa 1937.

BP — Borrow pits present in 1937.

Geologic Units

	L	Levees (artificial fill), circa 1937.
	SP	Spoils pile (artificial fill), circa 1937.
HISTORICAL	Rob	Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overtopping channel banks.
	Rcs	Crevasse splay deposits; fine to coarse sand, with minor lenses of clay deposited from breaching of natural or artificial levees.
	Rdf	Distributary fan deposits; sand, silt and clay.
	Rch	Channel deposits; well sorted sands and fine gravels.
	Rms	Channel meander scroll deposits; sand, silt and clay from lateral channel migration.
	Rb	Channel bar deposits; fine gravel, sand, and silt deposited in or along channel lateral margins.
	Rcu	Cut off channel (chute); occurs on insides of meander bends within the river channel; on flood plain — entrenchment of overflow channels into hydraulic mining debris.
	Rdc	Distributary channel deposits, trace gravel, sand, silt, and clay; channelized flow conducting sediment to floodplain.
	Rofc	Overflow channels; vertically stratified sand, silt, and clay in floodplain channels occupied primarily when high-stage water overtops channel banks.
	Rsl	Slough deposits; sand, silt and clay, fining upward facies, low-energy channel deposit.
	Ra	Alluvial deposits, undifferentiated; sand, silt, and minor lenses of fine gravel.
HOLOCENE	Hob	Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overtopping channel banks.
	Hcs	Crevasse splay deposits; fine to coarse sand, with minor lenses of fine gravel deposited from breaching of natural or artificial levees.
	Hdf	Distributary fan deposits; sand, silt and clay.
	Hofc	Overflow channels; vertically stratified sand, silt, and clay in channels occupied when high-stage water overtops channel banks.
	Hch	Channel deposits; sorted sands and silts; fining upward.
	Hb	Channel bar deposits; fine sand, and silt deposited in or along channel lateral margins.
	Hdc	Distributary channel deposits, sand, silt, and clay.
	Hsl	Slough deposits; sand, silt and clay, fining upward facies, low-energy channel deposit.
	Ha	Alluvial deposits; undifferentiated; sand, silt, and minor lenses of gravel; under cultivation in 1937.
	Qa	Basin deposits; fine sand, silt and clay, dark yellow to dark yellowish brown, under cultivation in 1937.
	Qs	Marsh deposits; silt and clay, likely organic-rich; perennially or seasonally submerged on 1937 photography.
PLEISTOCENE	Qmu	Modesto Formation; upper member; unconsolidated gravel, sand, silt, and clay.
	Qml	Modesto Formation; lower member; unconsolidated to semi-consolidated gravel, sand, silt and clay.
	Qru	Riverbank Formation; upper member, semi-consolidated to consolidated gravel, sand, silt and minor clay.
	Qrl	Riverbank Formation; lower member; consolidated gravel, sand, silt, and clay, generally associated with strong duripan horizon.

Stratigraphic Correlation Chart



1:20,000

N

0 0.5 1 Miles

0 0.5 1 Kilometers

Map projection: UTM NAD83 Zone 10N

Topographic base USGS quadrangles:
USGS, Gilsizer Slough topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.
USGS, Marysville topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.
USGS, Olivehurst topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.
USGS, Sutter topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.
USGS, Sutter Causeway topographic quadrangle published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.
USGS, Yuba City topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.

Plate 1 - Surficial Geologic Map of the Feather River, Southern Section

WLA — WILLIAM LETTIS & ASSOCIATES, INC.
Walnut Creek, CA

180_GIS_Feather_South.mxd — 09/04/2009

Geologic Mapping by J. Pierce and A. Streig
Digital Cartography by K. Tom

WILLIAM LETTIS & ASSOCIATES, INC.
1777 Botelho Drive, Suite 262, Walnut Creek, California 94596
tel (925) 256-6070 fax (925) 256-6076

September 8, 2009

Mr. Juan Vargas
URS Corporation
2870 Gateway Oaks Drive, Suite 150
Sacramento, CA 95833

RE: Surficial geologic mapping and geomorphic assessment, California Department of Water Resources Urban Levees Project, Northern Feather River, Sutter County, California

Dear Mr. Vargas:

This letter presents the surficial geologic mapping and preliminary geomorphic assessment of the northern Feather River study area, for the California Department of Water Resources (DWR) Urban Levees Project geotechnical characterization. The goal of this mapping and geomorphic assessment is to provide information on the type and distribution of surface and shallow subsurface deposits that likely underlie the project levees along the western bank of the Feather River between Thermalito Afterbay and Yuba City. The purpose of this study is to develop spatially continuous geologic map data and a conceptual model for stratigraphic interpretations between shallow boreholes. A primary goal is to provide a geologic framework for the geotechnical assessment of potential levee underseepage. This letter presents the technical approach, surficial geologic map, conceptual geomorphic model, and initial results based on map analysis and preliminary review of available Phase 1 geotechnical data.

We appreciated the opportunity to provide these geomorphic and geologic data and preliminary interpretations of the shallow stratigraphic conditions in the northern Feather River study area. Please do not hesitate to call any of the undersigned if there are any questions or comments.

Respectfully,

WILLIAM LETTIS & ASSOCIATES, INC.

Justin Pearce, C.E.G. 2421
Senior Geologist

Ashley Streig
Senior Staff Geologist

Keith Kelson, C.E.G. 1610
Principal Geologist

1.0 Introduction

This technical memorandum presents the results of surficial geologic mapping and geomorphic assessment along the north Feather River between Thermalito Afterbay and Yuba City, for the California Department of Water Resources Urban Levee program. The purpose of this study is to provide detailed information on the type and distribution of surface and shallow subsurface deposits that likely underlie the project levees, with respect to levee underseepage. This study involved integration and analysis of aerial photography, topographic, geologic, and soil maps, other historical documents, and review of readily available geotechnical exploration data. Synthesis of these data allowed us to assess the geomorphic processes responsible for the distribution of surficial deposits within the project area, and construct a preliminary conceptual model for stratigraphic interpretations. This technical memorandum is accompanied by the "Surficial Geologic Map of the Feather River, Northern Section".

1.1 Map and Report Preparation Quality Control

The surficial geologic map data and geomorphic interpretations presented in this memorandum were subject to quality control and quality assurance procedures as required by the Levee Geotechnical Evaluation Project Management Plan (PMP). The surficial geologic map data developed by this study were reviewed for accuracy and completeness through an internal review and an independent technical review by Dr. Janet Sowers of WLA. Results of QA/QC review were documented using PMP Exhibit 2.2-3 (Independent Technical Review Report) and are kept on file according filing control plan. Subsurface data shown on diagrams were provided as draft information, and were not verified for accuracy or completeness by this study.

2.0 Approach

The approach to developing a surficial geologic map of the northern Feather River project area (Figure 1, Plate 1) consisted of analysis of the following data:

- Aerial photography (black and white stereo-pairs taken in 1937, ~1:20,000-scale);
- early USGS topographic maps (i.e., 1911);
- published surficial geologic maps (Bussaca et al., 1989; Helley and Harwood, 1985; Creely, 1965);
- early and modern soil survey maps (Strahorn et al., 1909; Lytle, et al., 1988);
- other maps and documents (Page, 1985).

Synthesis of these data allow for the development of a detailed surficial geologic map that provides an initial understanding of primary geomorphic processes that have acted in the study area during recent and historical geologic time. Through this mapping, primary geomorphic features and associated surficial geologic deposits are identified, such as abandoned paleochannels, channel deposits, splay and overbank deposits and other deposits commonly associated with large active river systems. Knowledge of fluvial processes and the ability to recognize depositional environments in the geologic record are key to identifying locations along levees where underseepage is most likely to occur (Llopis et al., 2007).

The surficial geologic map was developed at the nominal scale of the aerial photography (1:20,000). This scale establishes the resolution of the map (Plate 1), such that display or analysis of the map data at a more detailed scale than 1:20,000 may introduce uncertainties beyond the original resolution of the data. The map unit boundaries shown on the surficial geologic map should be considered approximate, and accurate within 30 feet on either side of the line shown on the map. The 1937 aerial photographs are the primary data set for interpreting the surficial geologic deposits because: (1) they are the oldest high-quality images that pre-date much of the urbanization and landscape alteration within present-day Sutter and Butte Counties and, (2) these data represent a close approximation to the surficial deposits that were likely present at the ground surface prior to the construction of the levees. The 1937 photographs generally were taken in late summer or early autumn (i.e., August). By 1937, the area had experienced moderate cultivation that locally obscures geomorphic conditions. However, integration of data from the 1937 photography, old and recent topographic maps, geologic maps, soil surveys and historical documents provides sufficient information to delineate many of the pre-historical and historical surficial deposits in detail. Taken together, these data provide key insights to the characteristics of shallow deposits beneath the levees, as well as the geomorphic processes responsible for their distribution.

Additional floodplain deposition may have occurred after 1937, due to flood overflows, levee overtopping, or localized levee failure. A time series analysis that interprets successive aerial photographs taken after major flood events (i.e., USDA, black and white stereo-pairs taken in 1958, ~1:20,000-scale) or known local levee failures (i.e., 1986) may reveal additional information on surficial deposits in the northern Feather River area. Such analyses are beyond the scope of this study. The data and interpretations presented herein address the primary goal of characterizing the type and distribution of deposits likely present directly beneath the project levees that may be conducive to underseepage.

3.0 Geologic Setting

The northern Feather River study area lies in the central Sacramento Valley, between the Coast Ranges to the west and the Sierra Nevada foothills to the east. The Feather River drains the western slope of the Sierra Nevada, and emerges from the mountains south of Thermalito Afterbay (Figure 1). The river flows southward from Thermalito Afterbay, over middle –to late Pleistocene alluvium derived from the Sierra Nevada. The regional land surface is nearly flat, with a gentle west-southwest slope that flattens south of the Sutter Butte. The Feather River is entrenched into middle-to-late Pleistocene semi-consolidated sediments (i.e. Modesto Formation). Historical alluvium deposited by the Feather River is present between the modern levees, inset to the older geologic formations, and is present on the western floodplain as subdued natural levees that mantle the older geologic formations. In this study reach, west-flowing Honcut Creek is the only drainage tributary to the northern Feather River, with a confluence east of the town of Live Oak (Figure 1).

A primary influence on the historical processes in the river system was the hydraulic mining that began in the 1850's. Mining continued through the early 1900's in the Feather, Yuba and

Bear River watersheds, and abruptly introduced large quantities of sediment and drastically changed the geomorphic characteristics of these river systems (DWR, 2004; Ellis, 1939). Aggradation within the stream channels was a primary response to the introduction of substantial mining debris (James, 1999); consequently, post-1850 alluvial deposits are common throughout the study area.

4.0 Surficial Geologic Mapping

Previous geologic mapping along the northern Feather River and surrounding areas generalize the surficial deposits as: Quaternary alluvium (Qa) and Quaternary stream channel deposits (Qsc) are mapped within and proximal to the modern Feather River channel, (Bussaca et al., 1989; Helley and Harwood, 1985; Creely, 1965). These map units are considered Holocene in age (less than 11,000 years old). Late Pleistocene Modesto Formation (Qmu, Qml) is present as an escarpment along the western margin of the floodplain. These map units were delineated by Helley and Harwood (1985) at a regional scale (i.e., 1:62,500). The current analysis of the northern Feather River uses this geologic framework as a basis for more detailed mapping of Quaternary deposits and geomorphic features (Plate 1). The surficial geologic map units within the northern Feather River study area are described below, in order from oldest to youngest. Surficial geologic mapping for this study subdivides these general map units and delineates individual deposits based on relative age and depositional process or environment. The map units depicted on Plate 1 are primarily based on analysis of 1937 aerial photography, and thus the map essentially is a “snapshot” of geologic conditions at this time.

The oldest unit exposed along the Feather River is the lower member of the Riverbank Formation (Qrl) of Helley and Harwood (1985). The Riverbank Formation is a semi-consolidated, highly-dissected alluvial surface with textures of weathered gravel, sand and silt, and is associated with the presence of a well-developed hardpan (or, duripan) layer. This hardpan layer is a product of soil-forming processes over substantial geologic time, and reflects an ancient land surface that locally is buried by younger deposits. The Riverbank Formation is late to middle Pleistocene in age, and is estimated to be 130,000 to 450,000 yrs old (Helley and Harwood, 1985). The upper member (map unit Qru; Plate 1) is poorly consolidated dark brown to red alluvium consisting of gravel, sand, silt and minor clay (Busacca et al., 1989, Helley and Harwood, 1985). West of the Feather River, the Riverbank Formation is present near the town of East Biggs (Plate 1). Soils developed on the Riverbank formation are the Gridley clay loam and the Redding gravelly sandy loam (Carpenter et al., 1926).

The latest Pleistocene Modesto Formation is informally divided into two members: a lower (older) unit that is (about 29,000 to 49,000 years old), and consists of unconsolidated slightly weathered gravel, sand, silt and clay; and an upper member, a younger unit, that is about 12,000 to 26,000 years old (Helley and Harwood, 1985). The upper Modesto (map unit Qmu) consists of sand, silt, and some gravel, and is associated with a moderate amount of secondary (pedogenic) clay accumulation. This clay-rich horizon may form laterally continuous zones of low hydraulic conductivity, and may extend across boundaries between coarse and fine-grained strata within the latest Pleistocene alluvium. Soils developed on the Modesto Formation

include the Gridley loam of Strahorn et al. (1909) and the Conejo complex of Lytle et al. (1988), both of which are associated with a shallow "siltstone" horizon, or duripan (hardpan).

Latest Holocene deposits overlie or are inset into the Modesto Formation, and are categorized as channel, floodplain, and basin deposits (stratigraphic correlation chart; Plate 1). Channel deposits include Holocene channels (Hch), sloughs (Hsl), in-stream or lateral bars (Hb), and meander scrolls (Hms). These deposits likely consist of fine to coarse sand, silty sand, and clayey sand, with trace fine gravel. Holocene channel deposits (Hch) present along the western map area as secondary channels, contain fining-upward sequences of sand, silt and clay. These sloughs (map unit Hsl) are former channels associated with Live Oak and Morrison Sloughs (Plate 1), and are likely filled with a fining upward sequence of silt and clay.

Holocene floodplain deposits include crevasse splays (Hcs), and overbank deposits (Hob) and are typically deposited by non-channelized flow. Crevasse splays (Hcs) are from breaching of river banks or natural levees and are usually sand rich. Overbank deposits form by localized overtopping of river banks or natural levees, and subsequent deposition from shallow sheet flow or standing water.

Undifferentiated Holocene and Quaternary alluvium (Ha and Qa, respectively) usually occur proximal to or within the river channel, (Plate 1). The undifferentiated map unit is used in areas where geomorphic features are obscured or obliterated by historical (1937-era) agriculture. The deposits within these agriculturally modified areas are assigned a relative age (Ha or Qa) based on overlapping and cross cutting relationships with the surrounding deposits as follows: Ha if the agriculture-modified area is mapped within or shown overlying Holocene deposits; Qa where it is difficult to evaluate the age based on the relationship with nearby deposits. Soils associated with these undifferentiated units (Qa) are the Sacramento silt loam and Sacramento fine sandy loam, (Strahorn et al., 1909), and the Columbia fine sandy loam of Lyle et al. (1988), which are poorly-developed soils commonly associated with relatively young deposits (i.e. Shlemon, 1967).

Historical deposits mapped in the Northern Feather Study area include channel and floodplain deposits, as well as artificial fill deposits (Plate 1). Historical deposits are estimated to be less than about 150 years old, dating from approximately 1800 to 1937. Historical stream channels (Rch), and overflow channels (Rofc) transport high stage water flow across the ground surface outboard of the levees. These channel deposits likely consist of silt and sand with traces of gravel. The upper few feet of these deposits probably are filled with debris derived from upstream hydraulic mining activities. Lateral bar deposits (Rb) and meander scrolls (Rms) are located adjacent to the present-day Feather River, and are generally present inboard (waterside) of the present-day Feather River levees. In the northern part of the study area, directly south of Thermalito, are multiple anastomosing chutes (map unit Rcu; Plate 1). These chutes are similar to overflow channels in that they transport water flow during high river stage across the ground surface outboard of the levees. These chutes are entrenched into fluvially deposited hydraulic mining debris, and likely have filled with re-worked mining debris. Historical sloughs transport water collected from sheet flow and overland flow west of the Feather River southerly toward the Sutter Basin (i.e., Live Oak and Morrison Slough). Slough deposits (Rsl) likely consist of fining-upward silt and clay. Historical flood plain deposits include crevasse

splay (Rcs), and overbank (Rob) deposits, which generally consist of a gradational or abrupt fining upward sequence of sand, silt, and clay. Historical overbank (Rob) deposits are slightly finer grained sand, silt, and clay deposited via sheet flow. These historical deposits are differentiated from older deposits based on cross-cutting and superposition relationships relative to cultural features visible on the 1937 photographs.

Historical alluvial deposits (Ra), generally located between the Feather River channel levees, and on the land side of the levees in the area directly south of the Thermalito Afterbay, consist of undifferentiated sand, silt, and minor lenses of gravel. Soils associated with this sandy alluvium are the Columbia very fine sandy loam and Columbia loam, as shown on the Soil Survey Map of the Oroville Area (Carpenter et al., 1926). This series of soils has been correlated with Holocene age deposits by Shlemon (1967). Historical artificial fills are culturally-emplaced heterogeneous deposits, with varying amounts of clay, silt, sand, and gravel from local sources. These deposits include levee structures and canal levee systems (map unit L; Plate 1) and dredge tailings (map unit DT).

The distribution of historical and Holocene deposits shown on Plate 1 generally is consistent with early, less-detailed soil survey mapping along the western banks of the Feather River as areas of Marcuse clay loam, Gridley loam, Sacramento Series fine sand, sandy loam and silt loam and the Columbia very fine sandy loam soils (Strahorn et al., 1909; Carpenter et al., 1926). The Gridley loam occurs along the northern Feather River from the Thermalito Afterbay south to the confluence with the Bear River, and closely corresponds to the Modesto Formation of Helley and Harwood (1985). The relationship between the mapped surficial geologic units and the potential for underseepage is summarized below.

5.0 Geomorphic Conceptual Model

This section provides a preliminary geomorphic conceptual model based on general relationships among surface and subsurface geologic deposits along the western side of the Feather River, as described above and shown on Plate 1. This conceptual model provides a consistent basis for understanding the type and distribution surficial geologic deposits, primary geomorphic processes, and shallow subsurface stratigraphy in the study reach. This conceptual model does not address planform or gradient changes of the Feather River itself, nor the susceptibility of stream banks to erosion. Future studies of these changes would be valuable in understanding process response of the Feather River, and provide key data for estimating rates of channel changes (i.e. lateral migration). However, these analyses are not directly relevant to evaluating the possibility of underseepage with respect to levee stability.

Published geologic maps of the project area show a complex series of westward aggrading alluvial fans and terraces derived from erosion of the Sierra Nevada, identified as the Riverbank and Modesto Formations (Bussaca et al., 1989; Helley and Harwood, 1985; Creely, 1965). The Riverbank Formation and Modesto Formation in general are semi-consolidated to unconsolidated deposits characterized by intraformational paleochannels and lateral and vertical stratigraphic complexity related to past fluvial processes and buried paleo-topography. The oldest map unit, the Riverbank Formation unconformably overlies the Pliocene-Pleistocene

age Laguna Formation, which consists of interbedded alluvial gravel, sand and silt (Busacca et al., 1989; Helley and Harwood, 1985). The overlying Pleistocene Riverbank Formation consists of very dense gravel deposits that are, in turn, overlain by a medium dense sand and gravelly sand package of the latest Pleistocene Modesto Formation (Busacca et al., 1989). The upper member of the Modesto Formation is exposed at the ground surface adjacent to the western bank of the Feather River. The Modesto Formation is locally mantled by unconsolidated, sand rich Holocene deposits (Plate 1). East of the Feather River the older stratigraphic units are uplifted and dissected and younger deposits are inset into them with older deposits buried beneath younger deposits. West of the Feather River, the stratigraphic units are found in typical succession. This is the result of overall westward tilting and uplift of the Sierra Nevada, incision along the tributary drainages (i.e. Honcut creek), and progradational fan deposition west of the river.

Surficial geologic mapping (Plate 1) shows differences in deposit type and distribution from north to south along the northern Feather River study area, which are primarily associated with proximity to the Sierra Nevada mountain front near Thermalito Afterbay. These differences illustrate the diversity of past geomorphic processes along the river and, as a consequence, the type of geologic deposits at and near the ground surface. The surficial geologic map allows the delineation of reaches along the river within which geomorphic processes and their associated deposits appear to be relatively consistent.

The northern Feather River project area is divided into three reaches based on characteristic deposit types and distributions. The levee reaches are numbered Northern Feather one through three (NF-I through NF-III), sequentially from north to south (Figure 2, Plate 1). This section describes the surficial geologic characteristics of Reach NF-I, NF-II, and NF-III of the Feather River between Thermalito Afterbay and Yuba City.

5.1 Reach NF-I

Reach NF-I extends from the Thermalito Afterbay to Reimer Road and is about 11.1 levee miles long (Plate 1). Widespread deposits of historical alluvium (map unit Ra) blanket the area adjacent to the Feather River along the length of this reach where the river flows in the Sacramento Valley. Much of this unconsolidated historical alluvium contains clasts from many source lithologies and is derived from hydraulic mining debris (James, 1999). A complex pattern of anastomosing chutes or cut-off channels (map unit Rcu) eroded the historical alluvium by 1937 (Ra). These chutes underlie the project levees along the length of this reach (Plate 1). Project levees were built after 1937 along NF-I, from Thermalito Afterbay south to Ord Ranch Road.

Hardpan horizons were not identified in subsurface data along this reach, suggesting a substantial thickness of unconsolidated alluvial deposits unconformably overlying the Modesto Formation. Three alluvial units were identified in subsurface data overlying a semi-consolidated alluvial unit that we identified as the lower member of the Modesto Formation. Boreholes revealed an approximately 20-foot-thick package of young, unconsolidated silty sands and sandy clays, above a 10 to 16 foot thick silty sand, and 15-to 20-foot-thick gravel bed (Figure 3).

Hydraulic mining debris was dredged for its gold content along the northern half of the river banks along this reach, from Lapkin Road at Thermalito Afterbay to the area just south of Almond Avenue (Plate 1). Some dredge tailing spoils were apparent in 1937 aerial photography, though the majority of dredge tailing spoils post-date these air photos. The full extent of dredging tailing is apparent in modern USGS topographic maps (i.e. USGS, Biggs topographic quadrangle, 1:24,000 scale, 1970) and is shown on this surficial geologic map (map unit DT). Chutes (map unit Rcu) present in 1937 aerial images, though now obliterated by dredge operations are shown as dotted contacts in the Surficial Geologic Map (Plate 1). In this area project levees either overlie or bound the western edge of the Dredge Tailings (map unit DT). South of the dredged areas, the levee along Ord Ranch Road overlies deposits that fill an abandoned channel meander, map unit Hch (Plate 1). This abandoned meander matches the present river geometry and possibly reflects a southward migration of this meander within the active channel.

5.2 Reach NF-II

The second reach of the north Feather River project area, NF-II, extends from Reimer Road to Sanders Road, and has a length of about 9.4 levee miles. In this reach the project levee is typically perched at the top of a 5- to 15-foot-high east-facing escarpment cut into the Modesto Formation. The active meander belt of the Feather River with its flood plain, meander scrolls, and channel deposits, lies to the east of the levee at the base of the escarpment. West of the escarpment, historical overbank (Rob) and crevasse splay (Rcd) deposits locally overlie the Modesto. They represent locations where flooding of the Feather River overtopped the escarpment in the past and are assumed to pre-date the construction of the levee. An extensive continuous Holocene natural levee deposit has not built up along reach II, in contrast to reach I. The river may be incised too deeply below the surface of the Modesto Formation for floods to regularly overtop the escarpment.

Most of the Reach II levee sits directly on Modesto Formation with about 3.5 of the 9.4 miles of the levee sitting on the above-mentioned Holocene overbank and crevasse splay deposits that overlie Modesto Formation. Borehole WL0009_004S (Plate 1), located in the southern portion of this reach, shows project levee fill directly above the hard, consolidated Modesto Formation.

5.3 Reach NF-III

Levee reach NF-III extends from Sanders Road at the north to Yuba City at the south, and is about 4 miles in length (Plate 1). Along this reach the project levee almost entirely overlies Historical alluvial deposits that mantle, or crosscut the Modesto Formation. Crevasse splay (Rcs), overflow channels (Rofc), historical alluvium (Ra), channel deposits (Rch), and overbank deposits (Rob) are present along this reach. Crevasse splay deposits are present at the northern end of NF-III (Sanders Road, Plate 1), directly adjacent to a westerly bend of the Feather River. Aerial photography from 1937 shows multiple generations of crevasse splay deposits at this location. The levee appears to be constructed overtop these deposits. A pump station is noted on the 1970's topographic map, suggesting this location may have had seepage problems.

Immediately south of Sanders Road, an overflow channel (map unit Rofc) diverges from the Feather River, transporting flow outboard of the levees, and flowing back into the river about 1.5 miles south at Rednall Road (Plate 1). The overflow channel likely consists of a fining upward sequence of sand, silt, clay and some gravel, and could be slightly incised into the Modesto Formation. Undifferentiated historical alluvium (map unit Ra) underlies the levees within the area directly east of these overflow channels. This alluvium was laid down over the surface of the Modesto Formation by unchannelized flow of the Feather River (Plate 1). Historical channel deposits (map unit Rch) from the Feather River underlie about 0.7 miles of the levees north of Rednall Road (Plate 1). Overbank deposits are present near Pease Road (Plate 1) and continue along the levee for about 0.5 miles. Historical crevasse splay and overbank deposits likely consist of a massive to fining upward sequence of sand and silt derived from upstream hydraulic mining activities.

6.0 Applications to the Urban Levee Project

Based on an initial analysis of surface and subsurface geologic and geomorphic data, the levee bordering the western side of the Feather River from the Thermalito Afterbay to Yuba City, overlies three different types of deposits, Reach NF-I overlies a thick package of historical alluvium, NF-II directly overlies the Modesto Formation with local areas of historical alluvium, and Reach NF-III directly overlies a continuous blanket of sediment derived from historical crevasse splay (Rcs), overflow channel (Rofc), alluvium (Ra), channel (Rch) and overbank (Rob) deposits, above the Modesto Formation. The preliminary conceptual surface and subsurface geologic relationships as they relate to levee structures and potential underseepage along each reach of the river are described below. This study does not account for any existing seepage mitigation structures (i.e. cutoff walls) that may be present.

Along Reach NF-I the levees are underlain by a package of young coarse-grained fluvial sediment, most likely of mining debris origin, and chutes filled with coarse grained fining upward sequences of sediment also derived from hydraulic mining debris (Figure 3). This material is laterally extensive and poorly consolidated, with localized chute deposits (map unit Rcu). The chutes extend beneath the levee with an orientation that is roughly orthogonal to the levee crest, and may provide relatively high conductivity pathways for levee underseepage within the already very permeable fluvial sediments. The sediments along the northern half of reach NF-I were dredged for gold during the first half of the 20th century, well-graded dredge tailings remain in these areas. Dredge tailings are unconsolidated and consist of silt, sand, and gravel. At the north near Vance Avenue the project levees appear to overlie these highly permeable tailings, and everywhere else bound the western edge of the tailing spoils. Levees along this entire reach are judged to be highly susceptible to underseepage.

Levee reach NF-II is likely underlain by a combination of coarse grained, semi-consolidated alluvium of the Modesto Formation and localized areas of historical, poorly consolidated coarse-grained avulsion deposits (overbank and crevasse splay deposits) overlying the Modesto Formation. These avulsion deposits likely are permeable and may provide localized areas susceptible to underseepage. Project levees underlain by the Modesto Formation likely are less

susceptible to underseepage problems, however the natural variability within the Modesto may also provide local pathways for underseepage.

Levee reach NF-III generally consists of westward aggrading avulsion deposits overlying the Modesto Formation. The levee is underlain by coarse-grained, poorly consolidated silt, sand and gravel, blanketing the consolidated Modesto Formation and in some places incised into the Modesto Formation. These deposits likely are permeable and susceptible to underseepage.

In summary, lateral and vertical variabilities in the shallow subsurface deposits have resulted from past fluvial geomorphic processes. Surficial geologic mapping along the north Feather River allows reach classifications within which conditions may be relatively similar. The conceptual geomorphic framework suggests that stratigraphic relationships may promote localized levee underseepage, given certain hydraulic conditions throughout the Northern Feather River Study area, particularly along reach NF-I. Areas where levees may overlie historical or Holocene-age coarse grained deposits are of special concern. Further spatial analyses of the surficial geologic mapping and subsurface geotechnical exploration data are needed to better constrain and characterize areas that are most susceptible to underseepage in the study area. We anticipate that this conceptual model will be revised and updated as new information becomes available.

7.0 Limitations

This geomorphic assessment and associated data interpretation have been performed in accordance with the standard of care commonly used as the state-of-practice in the geologic engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this geographic area performing the same services under similar circumstances during the same time period.

Discussions of surface and subsurface conditions summarized in this technical memorandum are based on geologic interpretations of subsurface soil data at limited exploration locations available to this assessment through September of 2007. Variations in subsurface conditions may exist between exploration locations, and the project team may not be able to identify all adverse conditions in the levee and its foundation. This memorandum is for the use and benefit of DWR. Use by any other party is at their own discretion and risk.

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USGS, Gridley topographic quadrangle, surveyed 1909-1910, published 1912; map scale 1:31,680, five foot contour interval.

USGS, Honcut topographic quadrangle, surveyed 1909-1910, published 1912; map scale 1:31,680, five foot contour interval.

USGS, Oroville topographic quadrangle, surveyed 1910, published 1912; map scale 1:31,680, five foot contour interval.

USGS, Palermo topographic quadrangle, surveyed 1910, published 1912; map scale 1:31,680, five foot contour interval.

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USGS, Gridley topographic quadrangle, published 1952, remapped 1973; map scale 1:24,000, five foot contour interval.

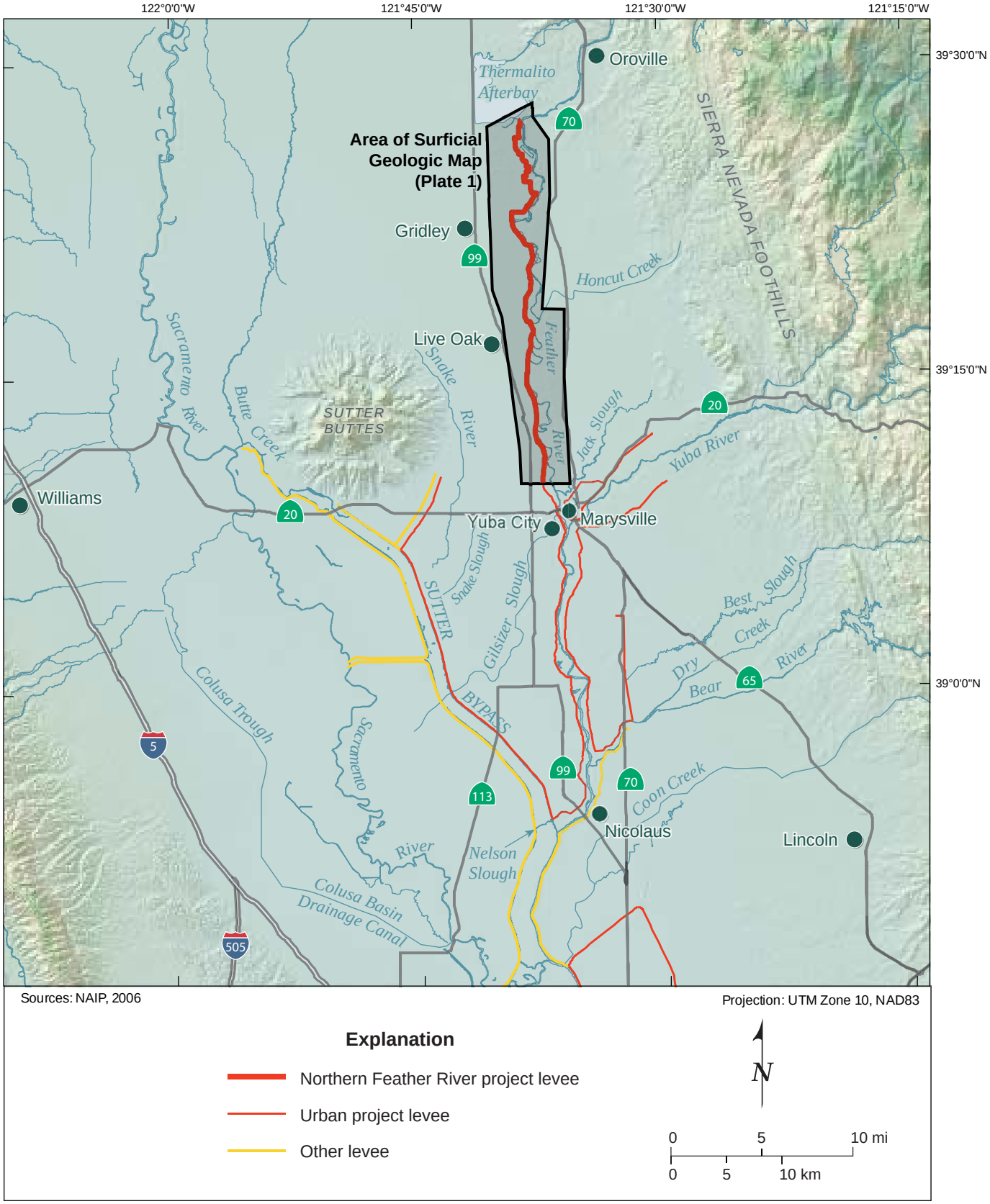
USGS, Honcut topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.

USGS, Oroville topographic quadrangle published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.

USGS, Palermo topographic quadrangle published 1952, remapped 1970; map scale 1:24,000, five foot contour interval.

USGS, Sutter topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.

USGS, Yuba City topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.



WLA

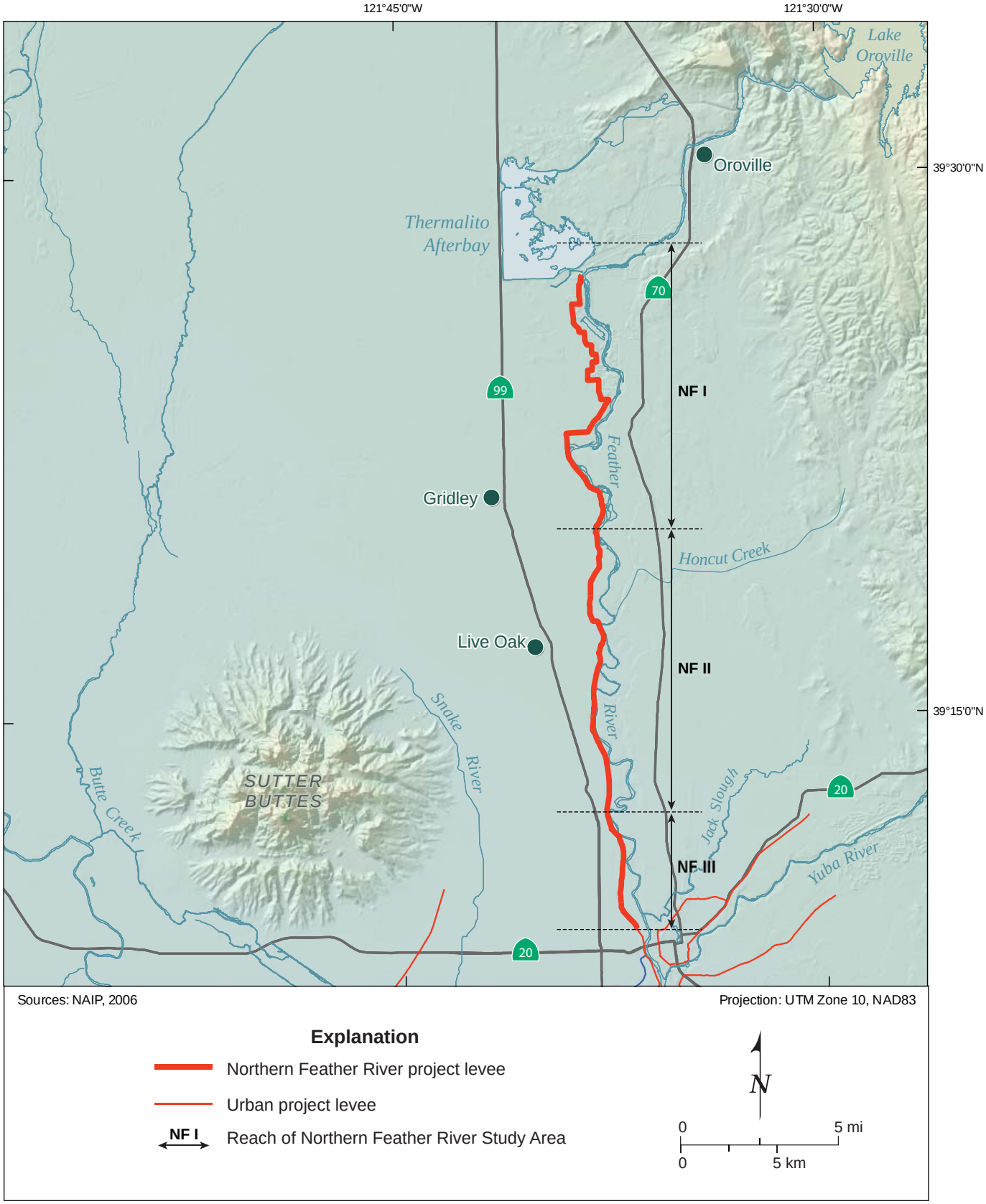
Map of Central Valley near Sutter Buttes, California

DWR URBAN LEVEE PROJECT

Figure 1

1881 North Feather River

Modified 09.03.09



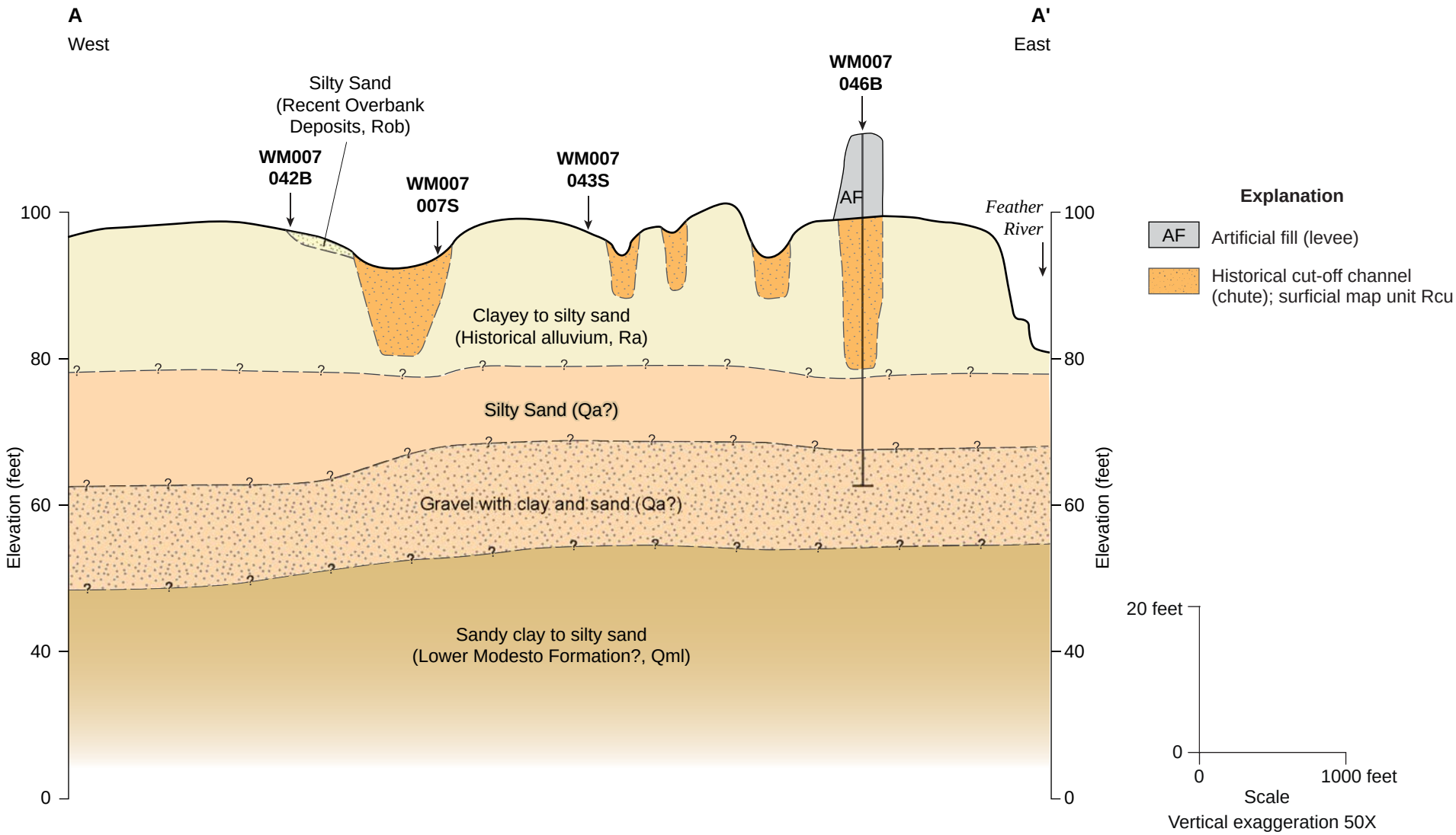
Map of the Reaches Identified along the Northern Feather River Study Area

DWR URBAN LEVEE PROJECT

Figure 2

1881 North Feather River

Modified 09.03.09



WLA

Conceptual Subsurface Diagram across the Northern Feather River, A-A'

DWR URBAN LEVEE PROJECT

Figure 3

1881 North Feather River

Modified 09.03.09

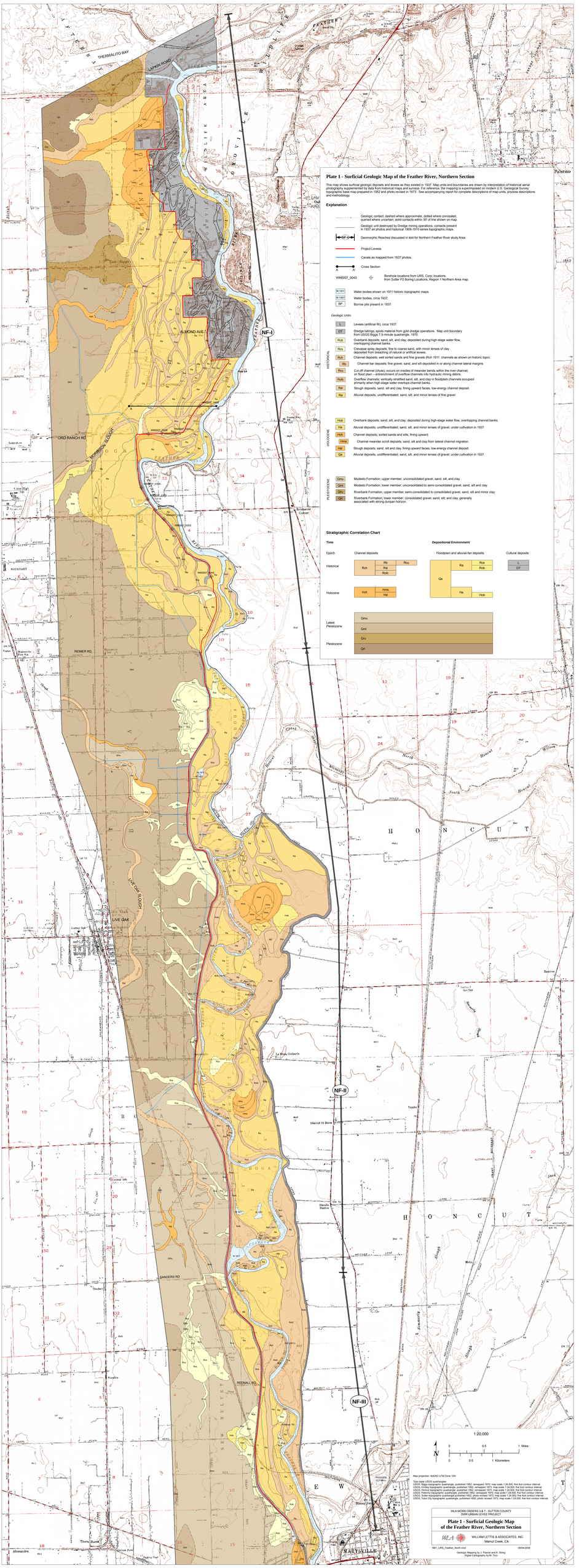


Plate 1 - Surficial Geologic Map of the Feather River, Northern Section
This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on modern U.S. Geological Survey topographic base map prepared in 1952 and photo revised in 1973. See accompanying report for complete descriptions of map units, process descriptions and methodology.
Explanation
Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain; solid contacts within 30' of line shown on map.
Geologic unit destroyed by Dredge mining operations, contacts present in 1937 air photos and historical 1909-1910 series topographic maps.
NF-I
Geomorphic Reaches discussed in text for Northern Feather River study Area.
Project Levees
Canals as mapped from 1937 photos.
A
A'
Cross Section
WM0007_004S
Borehole locations from URS, Corp; locations from Sutter PZ Boring Locations, Region 1-Northern Area map.
M 1911
Water bodies shown on 1911 historic topographic maps.
M 1937
Water bodies, circa 1937.
BP
Borrow pits present in 1937.
Geologic Units
HISTORICAL
L
Levees (artificial fill), circa 1937.
DT
Dredge tailings; spoils material from gold dredge operations. Map unit boundary from USGS Biggs 7.5-minute quadrangle, 1970.
Rob
Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overtopping channel banks.
Rcs
Crevasse splay deposits; fine to coarse sand, with minor lenses of clay deposited from breaching of natural or artificial levees.
Rch
Channel deposits; well sorted sands and fine gravels (Rch 1911: channels as shown on historic topo).
Rb
Channel bar deposits; fine gravel, sand, and silt deposited in or along channel lateral margins.
Rcu
Cut-off channel (chute); occurs on insides of meander bends within the river channel; on flood plain – entrenchment of overflow channels into hydraulic mining debris.
Rofc
Overflow channels; vertically stratified sand, silt, and clay in floodplain channels occupied primarily when high-stage water overtops channel banks.
Rsl
Slough deposits; sand, silt and clay, fining upward facies, low-energy channel deposit.
Ra
Alluvial deposits, undifferentiated; sand, silt, and minor lenses of fine gravel.
HOLOCENE
Hob
Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overtopping channel banks.
Ha
Alluvial deposits; undifferentiated; sand, silt, and minor lenses of gravel; under cultivation in 1937.
Hch
Channel deposits; sorted sands and silts; fining upward.
Hms
Channel meander scroll deposits; sand, silt and clay from lateral channel migration.
Hsl
Slough deposits; sand, silt and clay, fining upward facies, low-energy channel deposit.
Qa
Alluvial deposits, undifferentiated; sand, silt, and minor lenses of gravel; under cultivation in 1937.
PLEISTOCENE
Qmu
Modesto Formation; upper member; unconsolidated gravel, sand, silt, and clay.
Qml
Modesto Formation; lower member; unconsolidated to semi-consolidated gravel, sand, silt and clay.
Qru
Riverbank Formation; upper member; semi-consolidated to consolidated gravel, sand, silt and minor clay.
Qrl
Riverbank Formation; lower member; consolidated gravel, sand, silt, and clay, generally associated with strong duripan horizon.
Stratigraphic Correlation Chart
Time
Depositional Environment
Epoch
Channel deposits
Floodplain and alluvial-fan deposits
Cultural deposits
Historical
Holocene
Latest Pleistocene
Pleistocene
1:20,000
0 0.5 1 Miles
0 0.5 1 Kilometers
Map projection: NAD83 UTM Zone 10N
Topo base USGS quadrangles:
USGS: Chico topographic quadrangle, published 1952, remapped 1970; map scale 1:24,000; five foot contour interval.
USGS: Gridley topographic quadrangle, published 1952, remapped 1973; map scale 1:24,000; five foot contour interval.
USGS: Honcut topographic quadrangle, published 1952, remapped 1973; map scale 1:24,000; five foot contour interval.
USGS: Nicolas topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000; five foot contour interval.
USGS: Sutter topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000; five foot contour interval.
USGS: Yuba City topographic quadrangle, published 1952; photo revised 1973; map scale 1:24,000; five foot contour interval.
WLA WORK ORDERS 3 & 7 - SUTTER COUNTY
DWR URBAN LEVEE PROJECT
Plate 1 - Surficial Geologic Map of the Feather River, Northern Section
WILLIAM LETTIS & ASSOCIATES, INC.
Walnut Creek, CA
1911_URS_Feather_North.mxd
09/04/2009
Geologic Mapping by J. Pierce and A. Streig
Digital Cartography by M. Tozo
THERMALITO BAY
LAPHON ROAD
ALMOND AVE
ORD RANCH RD
NORTHAM SLOUGH
REIMER RD
LIVE OAK SLOUGH
LIVE OAK
SANDERS RD
REDNALL RD
NF-I
NF-II
NF-III
MARYSVILLE
HONCUT
BOGA
FEATHER
Palermo
Oroville
Biggs
Gridley
Yuba City
Marysville
Olivehurst
Linda
Arboga
Alleghany
Alexandria
Thorn Slough

ENCLOSURE E

SEMI-PROBABALISTIC LEVEE STAGE-PERFORMANCE FUNCTIONS

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Wadsworth Canal
Basin and Reach: East Levee

Levee Mile: 0.83
Coordinates: 2170954.86 N; 6629916.3 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.80
L/S Toe Elev.: 43.80
W/S Toe Elev.: 41.80

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WSEWWC_010C	7					8					CL	0.0071	SM	2.8	394				
WSEWWC_001B	8.5					7					CL	0.0071	SM	2.8	394				
WSEWWC_009C	7					7					Cl	0.0071	SM	2.8	394				
WSEWWC_008C	6					5					CL	0.0071	SM	2.8	394				
WSEWWC_007C	3					9					CL	0.0071	SM	2.8	394				
WSEWWC_006C	8	7	2	13	29	2	7	3	14	43	CL	0.0071	SM	2.8	394	493	455	204287	92
WSEWWC_001A	10.5					11					CL, CH	0.0071	SM/SP-SM	11.14	1569				
WSEWWC_029B	4					7					CL	0.28	SP-SM	2.8	10				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WSEWWC_010C	CL	7	0.0071				7	SM	8	2.8							2.8
WSEWWC_001B	CL	8.5	0.0071				8.5	SM	7	2.8							2.8
WSEWWC_009C	Cl	7	0.0071				7	SM	7	2.8							2.8
WSEWWC_008C	CL	6	0.0071				6	SM	5	2.8							2.8
WSEWWC_007C	CL	3	0.0071				3	SM	9	2.8							2.8
WSEWWC_006C	CL	8	0.0071				8	SM	2	2.8							2.8
WSEWWC_001A	CL, CH	10.5	0.0071				10.5	SM	2.5	1.4	SP-SM	8.5	14				11.14
WSEWWC_029B	CL	4	0.28				4	SP-SM	7	2.8							2.8

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Wadsworth Canal
River Section: East Levee

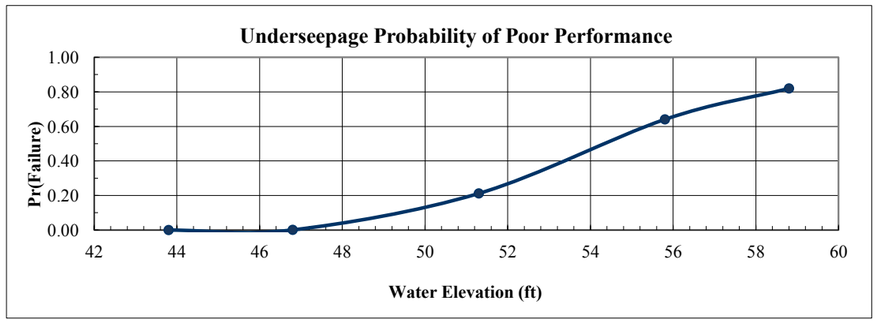
Levee Mile: 0.83
River Mile: 2170954.86 N; 6629916.3 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.80
L/S Toe Elev.: 43.80
W/S Toe Elev.: 41.80

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	493	455	92
Blanket Thickness (z)	7	2	29
Aquifer Thickness (d)	7	3	43

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	10	101	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.80	0.0000
Toe+3ft	3.00	46.80	0.0011
Half Height	7.50	51.30	0.2121
Crest-3ft	12.00	55.80	0.6407
Crest	15.00	58.80	0.8199

Crest	Rh
Head = 15.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	493	7.00	7.00	9.99	155.43	0.0263	8.75	1.25		
2	948	7.00	7.00	9.99	215.53	0.0214	9.90	1.41	0.164025	60.43
3	38	7.00	7.00	9.82	43.15	0.0455	4.20	0.60		
4	493	9.00	7.00	9.99	176.24	0.0244	9.20	1.02	0.093025	34.27
5	493	5.00	7.00	9.98	131.36	0.0289	8.13	1.63		
6	493	7.00	10.00	9.99	185.77	0.0337	9.39	1.34	0.014400	5.30
7	493	7.00	4.00	9.98	117.49	0.0175	7.71	1.10		
								Total	0.271450	100.00

E[I] = 1.250000
Var[I]= 0.271450
σ[I]= 0.521009
V(I) = 0.416807

E[ln I] = 0.143051
σ [ln I] = 0.400231

Ic= 0.80
ln(I crit) = -0.223144

β = 0.357421
F(z) = 0.180107
Pr(f) % = 81.989307

Crest-3ft	Rh
Head = 12.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	493	7.00	7.00	9.99	155.43	0.0263	7.00	1.00		
2	948	7.00	7.00	9.99	215.53	0.0214	7.92	1.13	0.105625	61.32
3	38	7.00	7.00	9.82	43.15	0.0455	3.36	0.48		
4	493	9.00	7.00	9.99	176.24	0.0244	7.36	0.82	0.057600	33.44
5	493	5.00	7.00	9.98	131.36	0.0289	6.50	1.30		
6	493	7.00	10.00	9.99	185.77	0.0337	7.51	1.07	0.009025	5.24
7	493	7.00	4.00	9.98	117.49	0.0175	6.17	0.88		
								Total	0.172250	100.00

E[I] = 1.000000
Var[I]= 0.172250
σ[I]= 0.415030
V(I) = 0.415030

E[ln I] = -0.079462
σ [ln I] = 0.398654

Ic= 0.80
ln(I crit) = -0.223144

β = -0.199327
F(z) = 0.359268
Pr(f) % = 64.073178

Half Height	Rh
Head = 7.50	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	493	7.00	7.00	9.99	155.43	0.0263	4.38	0.63		
2	948	7.00	7.00	9.99	215.53	0.0214	4.95	0.71	0.042025	61.69
3	38	7.00	7.00	9.82	43.15	0.0455	2.10	0.30		
4	493	9.00	7.00	9.99	176.24	0.0244	4.60	0.51	0.022500	33.03
5	493	5.00	7.00	9.98	131.36	0.0289	4.07	0.81		
6	493	7.00	10.00	9.99	185.77	0.0337	4.69	0.67	0.003600	5.28
7	493	7.00	4.00	9.98	117.49	0.0175	3.86	0.55		
								Total	0.068125	100.00

E[I] = 0.630000
Var[I]= 0.068125
σ[I]= 0.261008
V(I) = 0.414298

E[ln I] = -0.541239
σ [ln I] = 0.398004

Ic= 0.80
ln(I crit) = -0.223144

β = -1.359885
F(z) = 0.787921
Pr(f) % = 21.207929

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	493	7.00	7.00	9.99	155.43	0.0263	1.75	0.25		
2	948	7.00	7.00	9.99	215.53	0.0214	1.98	0.28	0.006400	56.89
3	38	7.00	7.00	9.82	43.15	0.0455	0.84	0.12		
4	493	9.00	7.00	9.99	176.24	0.0244	1.84	0.20	0.004225	37.56
5	493	5.00	7.00	9.98	131.36	0.0289	1.63	0.33		
6	493	7.00	10.00	9.99	185.77	0.0337	1.88	0.27	0.000625	5.56
7	493	7.00	4.00	9.98	117.49	0.0175	1.54	0.22		
								Total	0.011250	100.00

E[I] = 0.250000
Var[I]= 0.011250
σ[I]= 0.106066
V(I) = 0.424264

E[ln I] = -1.469052
σ [ln I] = 0.406835

Ic= 0.80
ln(I crit) = -0.223144

β = -3.610930
F(z) = 0.998902
Pr(f) % = 0.109769

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Wadsworth Canal
River Section: East Levee

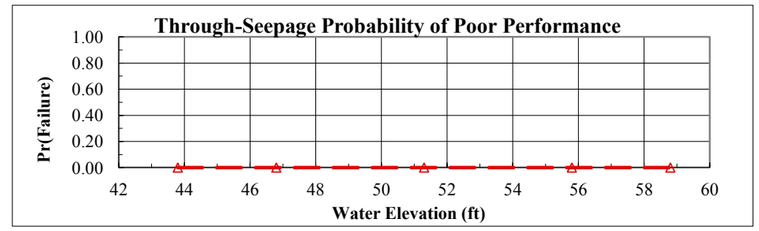
Levee Mile: 0.83
River Mile: 2170954.86 N; 6629916.3 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.80
L/S Toe Elev.: 43.80
W/S Toe Elev.: 41.80

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.80	0.0000
Toe+3ft	3.00	46.80	0.000000
Half Height	7.50	51.30	0.000000
Crest-3ft	12.00	55.80	0.000000
Crest	15.00	58.80	0.000000

Crest | **Head =** 15.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Crest-3ft | **Head =** 12.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height | **Head =** 7.50 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

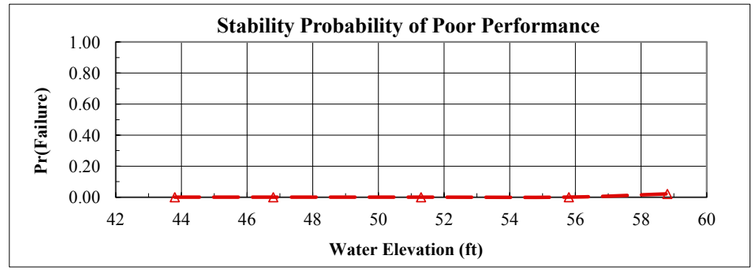
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal
River Section: East Levee

Levee Mile: 0.83
River Mile: 2170954.86 N; 6629916.3 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.80
L/S Toe Elev.: 43.80
W/S Toe Elev.: 41.80

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee ϕ'	31	4	12.00
Levee γ	125	6	5.00
Foundation c'	150	50	33.00
Foundation γ	115	6	5.00
Foundation ϕ'	28	3	12.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.80	0.0000
Toe+3ft	3.00	46.80	0.000000
Half Height	7.50	51.30	0.000000
Crest-3ft	12.00	55.80	0.000322
Crest	15.00	58.80	0.021343

Crest	Head =	15.00	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28	1.50		
2	27	125	150	115	28	1.48	0.001225	1.44
3	35	125	150	115	28	1.55		
4	31	119	150	115	28	1.52	0.000169	0.20
5	31	131	150	115	28	1.50		
6	31	125	100	115	28	1.11	0.074529	87.51
7	31	125	200	115	28	1.66		
8	31	125	150	109	28	1.44	0.005402	6.34
9	31	125	150	121	28	1.58		
10	31	125	150	115	25	1.45	0.003844	4.51
11	31	125	150	115	31	1.57		

E[FS] = 1.504000 E[ln FS] = 0.389648 Total 0.085169 100.00
Var[FS]= 0.085169
σ[FS]= 0.291838 σ[ln FS]= 0.192251
V(FS) = 0.194041
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	2.026769
F(z) =	0.021343
Pr(f) % =	2.134304

Crest-3ft	Head =	12.00	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28	1.80		
2	27	125	150	115	28	1.75	0.001936	2.11
3	35	125	150	115	28	1.84		
4	31	119	150	115	28	1.83	0.000812	0.88
5	31	131	150	115	28	1.77		
6	31	125	100	115	28	1.38	0.078400	85.41
7	31	125	200	115	28	1.94		
8	31	125	150	109	28	1.73	0.004556	4.96
9	31	125	150	121	28	1.86		
10	31	125	150	115	25	1.72	0.006084	6.63
11	31	125	150	115	31	1.87		

E[FS] = 1.796000 E[ln FS] = 0.571533 Total 0.091789 100.00
Var[FS]= 0.091789
σ[FS]= 0.302966 σ[ln FS]= 0.167507
V(FS) = 0.168689
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	3.411982
F(z) =	0.000322
Pr(f) % =	0.032246

Half Height	Head =	7.50	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

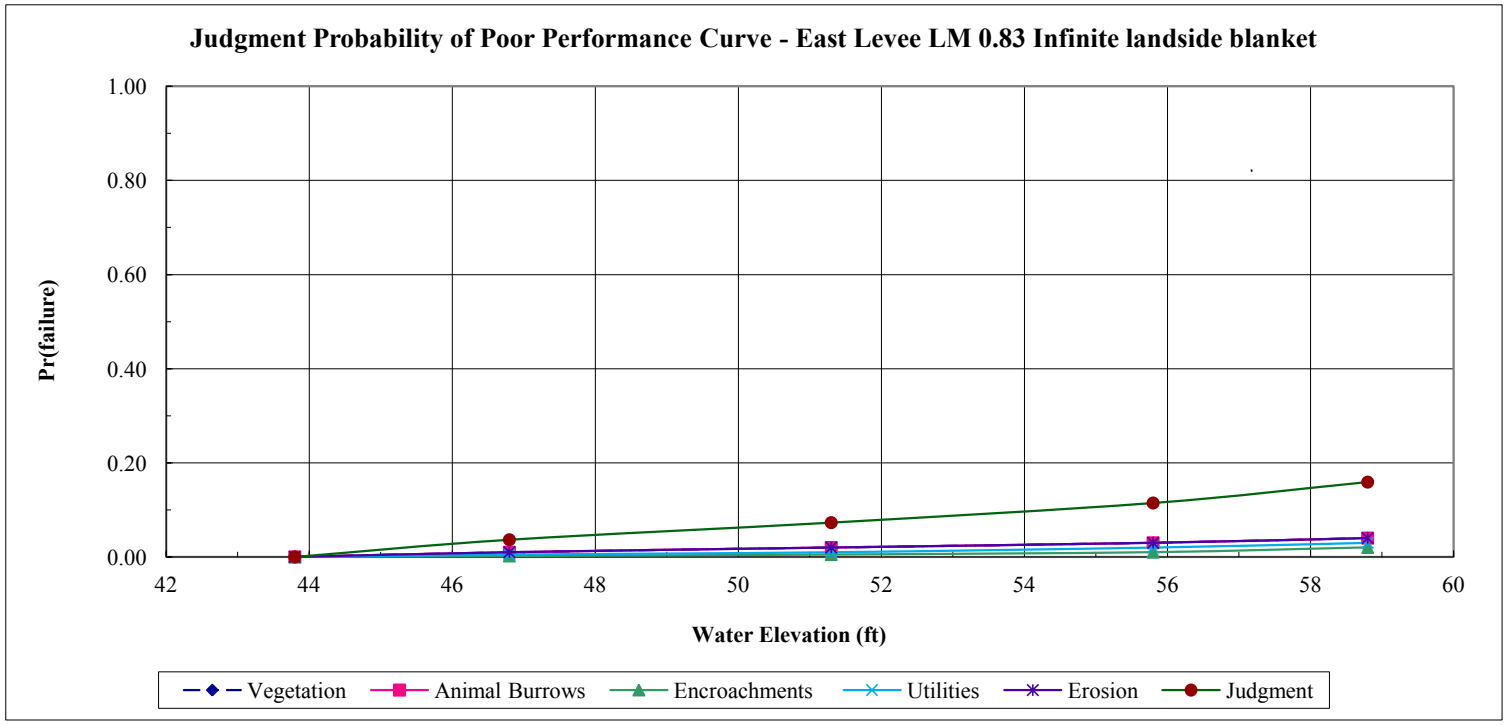
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal
River Section: East Levee

Levee Mile: 0.83
River Mile: 2170954.86 N
Analysis Case: Infinite landside blanket

Crest Elev.: 58.80
L/S Toe Elev.: 43.80
W/S Toe Elev.: 41.80

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 9/13/

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.80	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
46.80	0.0100	0.9900	0.0100	0.9900	0.0020	0.9980	0.0050	0.9950	0.0100	0.9900	0.0365	0.9635
51.30	0.0200	0.9800	0.0200	0.9800	0.0050	0.9950	0.0100	0.9900	0.0200	0.9800	0.0729	0.9271
55.80	0.0300	0.9700	0.0300	0.9700	0.0100	0.9900	0.0200	0.9800	0.0300	0.9700	0.1145	0.8855
58.80	0.0400	0.9600	0.0400	0.9600	0.0200	0.9800	0.0300	0.9700	0.0400	0.9600	0.1590	0.8410



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

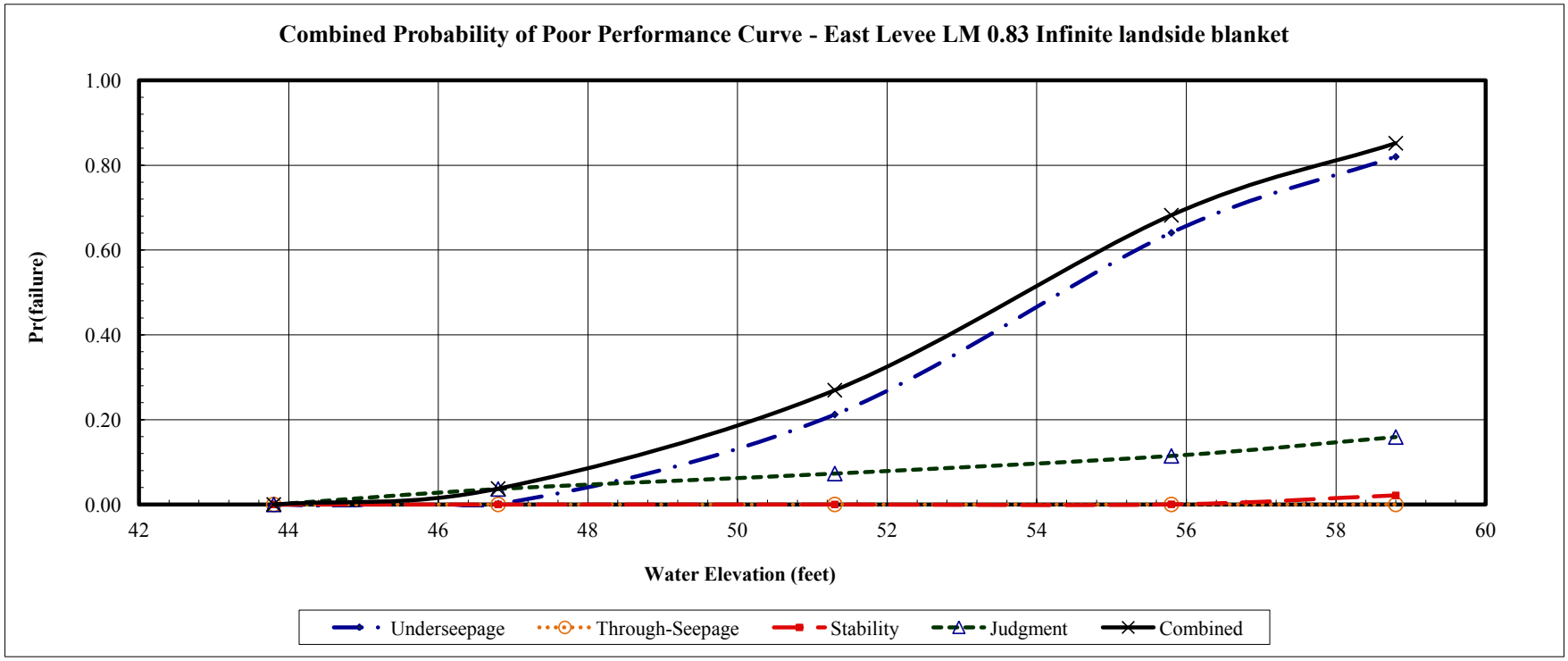
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal
River Section: East Levee

Levee Mile: 0.83
River Mile: 2170954.86 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 58.80
L/S Toe Elev.: 43.80
W/S Toe Elev.: 41.80

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/13/20

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.80	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
46.80	0.0011	0.9989	0.0000	1.0000	0.0000	1.0000	0.0365	0.9635	0.0375	0.9625
51.30	0.2121	0.7879	0.0000	1.0000	0.0000	1.0000	0.0729	0.9271	0.2695	0.7305
55.80	0.6407	0.3593	0.0000	1.0000	0.0003	0.9997	0.1145	0.8855	0.6820	0.3180
58.80	0.8199	0.1801	0.0000	1.0000	0.0213	0.9787	0.1590	0.8410	0.8518	0.1482



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Sutter Bypass
Basin and Reach: East Levee

Levee Mile: 6.20
Coordinates: 2158855 N; 6631970 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.30
L/S Toe Elev.: 32.00
W/S Toe Elev.: 32.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: 9/13/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WSESBP_011B	14					9					sCL/CH	0.007	SP-SM	10	1429				
WSESBP_015B	9					16.5					CLs,CL,ML	0.1	SM	3	30				
WSESBP_016B	10.5					9					SM/CL	0.007	SP-SM	10	1429				
WSESBP_017B	8	10	4	25	40	2	10	6	43	60	CL,SM	0.3	SP-SM	10	33	725	650	427548	90
WSESBP_018B	14					8					CL,SM/CL	0.007	SP-SM,ML,sMI	3	429				
WSESBP_019B	4.8					17.5					CL/ML	0.01	SP-SM	10	1000				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WSESBP_011B	sCL	6	0.007	CH	8	0.007	14	SP-SM	9	10							10
WSESBP_015B	CLs,CL,ML	9	0.1				9	SM	16.5	3							3
WSESBP_016B	SM	2	0.007	CL	8.5	0.007	10.5	SP-SM	9	10							10
WSESBP_017B	CL,SM	8	0.3				8	SP-SM	2	10							10
WSESBP_018B	CL,SM	2.5	0.007	CL	11.5	0.007	14	SP-SM,ML,sMI	8	3							3
WSESBP_019B	CL	4.5	0.01	ML	3	0.1	4.8	SP-SM	17.5	10							10

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

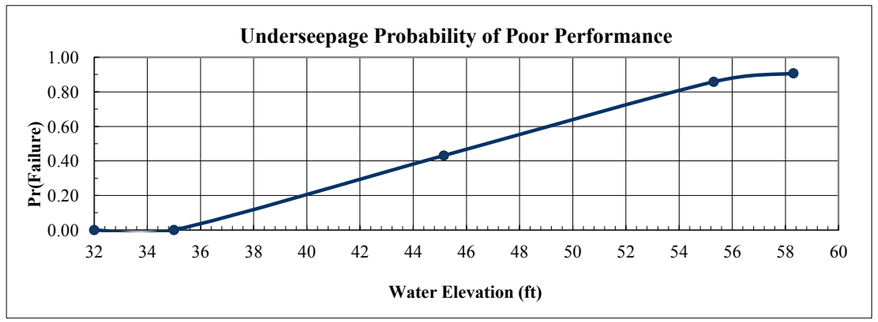
Levee Mile: 6.20
River Mile: 2158855 N; 6631970 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.30
L/S Toe Elev.: 32.00
W/S Toe Elev.: 32.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: 9/13/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	725	650	90
Blanket Thickness (z)	10	4	40
Aquifer Thickness (d)	10	6	60

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	15	150	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.00	0.0000
Toe+3ft	3.00	35.00	0.0004
Half Height	13.15	45.15	0.4311
Crest-3ft	23.30	55.30	0.8583
Crest	26.30	58.30	0.9076

Crest	Rh
Head = 26.30	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	16.31	1.63		
2	1375	10.00	10.00	14.99	370.81	0.0187	18.20	1.82	0.207025	33.43
3	75	10.00	10.00	14.85	86.60	0.0398	9.06	0.91		
4	725	14.00	10.00	14.99	318.59	0.0207	17.33	1.24	0.366025	59.11
5	725	6.00	10.00	14.97	208.57	0.0268	14.68	2.45		
6	725	10.00	16.00	14.99	340.59	0.0316	17.72	1.77	0.046225	7.46
7	725	10.00	4.00	14.96	170.29	0.0119	13.36	1.34		
								Total	0.619275	100.00

E[I] = 1.630000
Var[I]= 0.619275
σ[I]= 0.786940
V(I) = 0.482785

E[ln I] = 0.383822
σ [ln I] = 0.457730

Ic= 0.80
ln(I crit) = -0.223144

β =	0.838533
F(z) =	0.092414
Pr(f) % =	90.758579

Crest-3ft	Rh
Head = 23.30	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	14.45	1.45		
2	1375	10.00	10.00	14.99	370.81	0.0187	16.13	1.61	0.164025	33.59
3	75	10.00	10.00	14.85	86.60	0.0398	8.02	0.80		
4	725	14.00	10.00	14.99	318.59	0.0207	15.35	1.10	0.286225	58.62
5	725	6.00	10.00	14.97	208.57	0.0268	13.01	2.17		
6	725	10.00	16.00	14.99	340.59	0.0316	15.70	1.57	0.038025	7.79
7	725	10.00	4.00	14.96	170.29	0.0119	11.84	1.18		
								Total	0.488275	100.00

E[I] = 1.450000
Var[I]= 0.488275
σ[I]= 0.698767
V(I) = 0.481908

E[ln I] = 0.267149
σ [ln I] = 0.456979

Ic= 0.80
ln(I crit) = -0.223144

β =	0.584597
F(z) =	0.141658
Pr(f) % =	85.834162

Half Height	Rh
Head = 13.15	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	8.15	0.82		
2	1375	10.00	10.00	14.99	370.81	0.0187	9.10	0.91	0.052900	34.13
3	75	10.00	10.00	14.85	86.60	0.0398	4.53	0.45		
4	725	14.00	10.00	14.99	318.59	0.0207	8.66	0.62	0.090000	58.06
5	725	6.00	10.00	14.97	208.57	0.0268	7.34	1.22		
6	725	10.00	16.00	14.99	340.59	0.0316	8.86	0.89	0.012100	7.81
7	725	10.00	4.00	14.96	170.29	0.0119	6.68	0.67		
								Total	0.155000	100.00

E[I] = 0.820000
Var[I]= 0.155000
σ[I]= 0.393700
V(I) = 0.480122

E[ln I] = -0.302168
σ [ln I] = 0.455450

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.663450
F(z) =	0.568874
Pr(f) % =	43.112558

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	1.86	0.19		
2	1375	10.00	10.00	14.99	370.81	0.0187	2.08	0.21	0.003025	35.38
3	75	10.00	10.00	14.85	86.60	0.0398	1.03	0.10		
4	725	14.00	10.00	14.99	318.59	0.0207	1.98	0.14	0.004900	57.31
5	725	6.00	10.00	14.97	208.57	0.0268	1.68	0.28		
6	725	10.00	16.00	14.99	340.59	0.0316	2.02	0.20	0.000625	7.31
7	725	10.00	4.00	14.96	170.29	0.0119	1.52	0.15		
								Total	0.008550	100.00

E[I] = 0.190000
Var[I]= 0.008550
σ[I]= 0.092466
V(I) = 0.486664

E[ln I] = -1.767012
σ [ln I] = 0.461044

Ic= 0.80
ln(I crit) = -0.223144

β =	-3.832633
F(z) =	0.999594
Pr(f) % =	0.040605

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

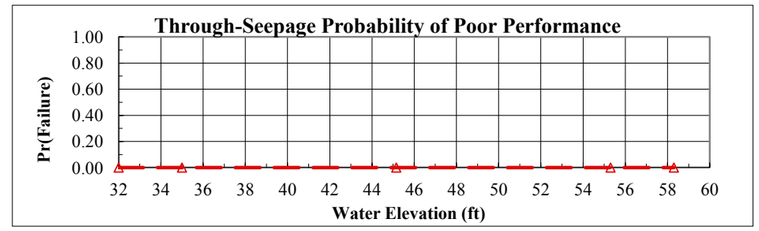
Levee Mile: 6.20
River Mile: 2158855 N; 6631970 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.30
L/S Toe Elev.: 32.00
W/S Toe Elev.: 32.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: 9/13/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.00	0.0000
Toe+3ft	3.00	35.00	0.000000
Half Height	13.15	45.15	0.000000
Crest-3ft	23.30	55.30	0.000000
Crest	26.30	58.30	0.000000

Crest | **Head =** 26.30 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 23.30 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 13.15 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

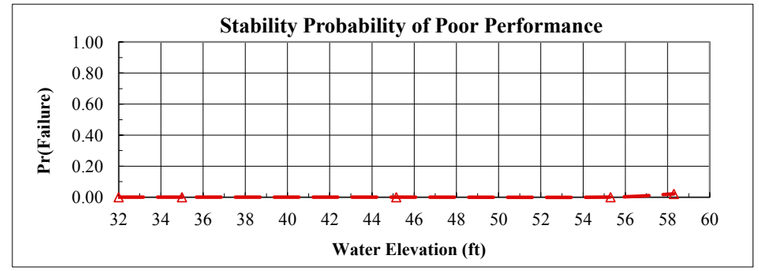
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 6.20
River Mile: 2158855 N; 6631970 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.30
L/S Toe Elev.: 32.00
W/S Toe Elev.: 32.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: 9/13/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee ϕ'	31	4	12.00
Levee γ	125	6	5.00
Foundation c'	150	50	33.00
Foundation γ	115	6	5.00
Foundation ϕ'	28	3	12.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.00	0.0000
Toe+3ft	3.00	35.00	0.000000
Half Height	13.15	45.15	0.000000
Crest-3ft	23.30	55.30	0.000322
Crest	26.30	58.30	0.021343

Crest	Head =	26.30	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28	1.50		
2	27	125	150	115	28	1.48	0.001225	1.44
3	35	125	150	115	28	1.55		
4	31	119	150	115	28	1.52	0.000169	0.20
5	31	131	150	115	28	1.50		
6	31	125	100	115	28	1.11	0.074529	87.51
7	31	125	200	115	28	1.66		
8	31	125	150	109	28	1.44	0.005402	6.34
9	31	125	150	121	28	1.58		
10	31	125	150	115	25	1.45	0.003844	4.51
11	31	125	150	115	31	1.57		

E[FS] = 1.504000 E[ln FS] = 0.389648 Total 0.085169 100.00
Var[FS]= 0.085169
σ[FS]= 0.291838 σ[ln FS]= 0.192251
V(FS) = 0.194041
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	2.026769
F(z) =	0.021343
Pr(f) % =	2.134304

Crest-3ft	Head =	23.30	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28	1.80		
2	27	125	150	115	28	1.75	0.001936	2.11
3	35	125	150	115	28	1.84		
4	31	119	150	115	28	1.83	0.000812	0.88
5	31	131	150	115	28	1.77		
6	31	125	100	115	28	1.38	0.078400	85.41
7	31	125	200	115	28	1.94		
8	31	125	150	109	28	1.73	0.004556	4.96
9	31	125	150	121	28	1.86		
10	31	125	150	115	25	1.72	0.006084	6.63
11	31	125	150	115	31	1.87		

E[FS] = 1.796000 E[ln FS] = 0.571533 Total 0.091789 100.00
Var[FS]= 0.091789
σ[FS]= 0.302966 σ[ln FS]= 0.167507
V(FS) = 0.168689
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	3.411982
F(z) =	0.000322
Pr(f) % =	0.032246

Half Height	Head =	13.15	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

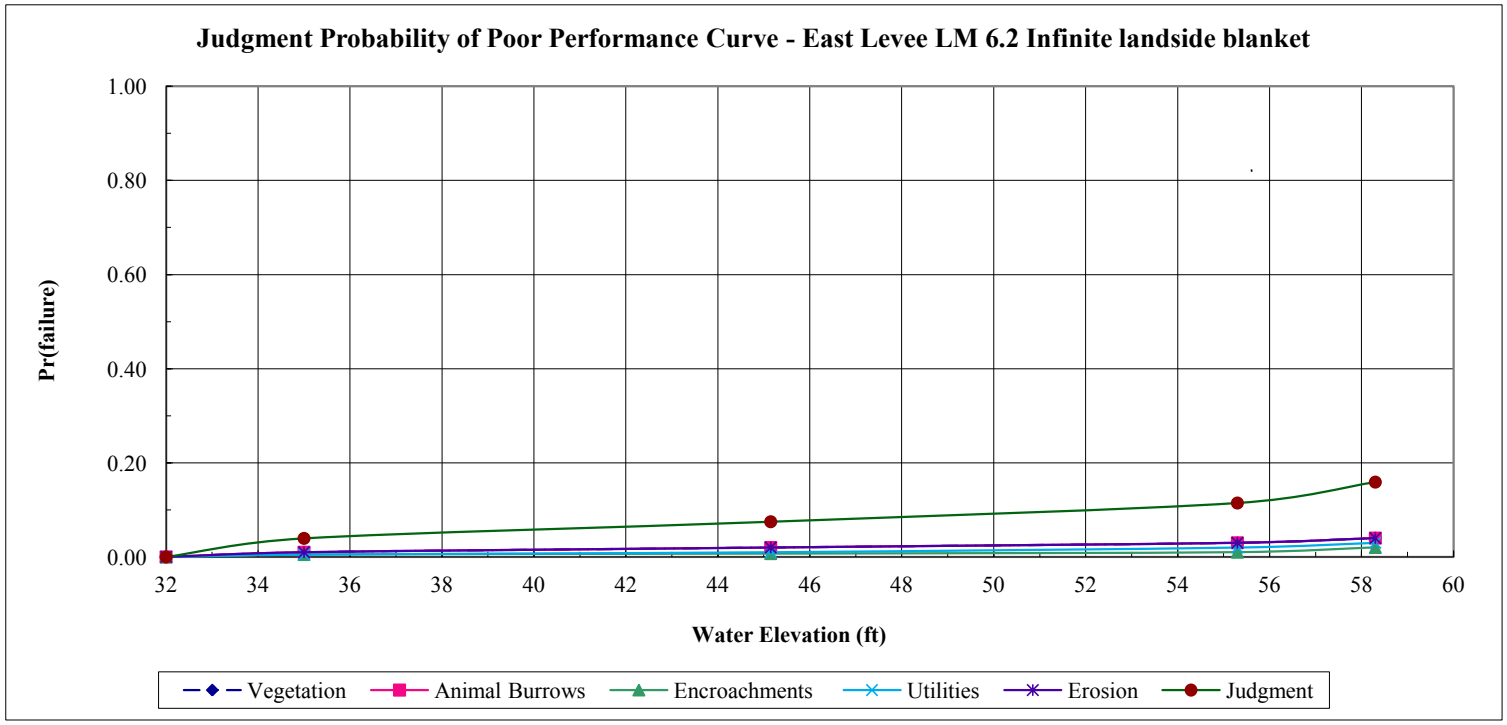
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 6.20
River Mile: 2158855 N; 6
Analysis Case: Infinite landside blanket

Crest Elev.: 58.30
L/S Toe Elev.: 32.00
W/S Toe Elev.: 32.00

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: 9/13/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.00	0.0100	0.9900	0.0100	0.9900	0.0050	0.9950	0.0050	0.9950	0.0100	0.9900	0.0394	0.9606
45.15	0.0200	0.9800	0.0200	0.9800	0.0070	0.9930	0.0100	0.9900	0.0200	0.9800	0.0747	0.9253
55.30	0.0300	0.9700	0.0300	0.9700	0.0100	0.9900	0.0200	0.9800	0.0300	0.9700	0.1145	0.8855
58.30	0.0400	0.9600	0.0400	0.9600	0.0200	0.9800	0.0300	0.9700	0.0400	0.9600	0.1590	0.8410



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

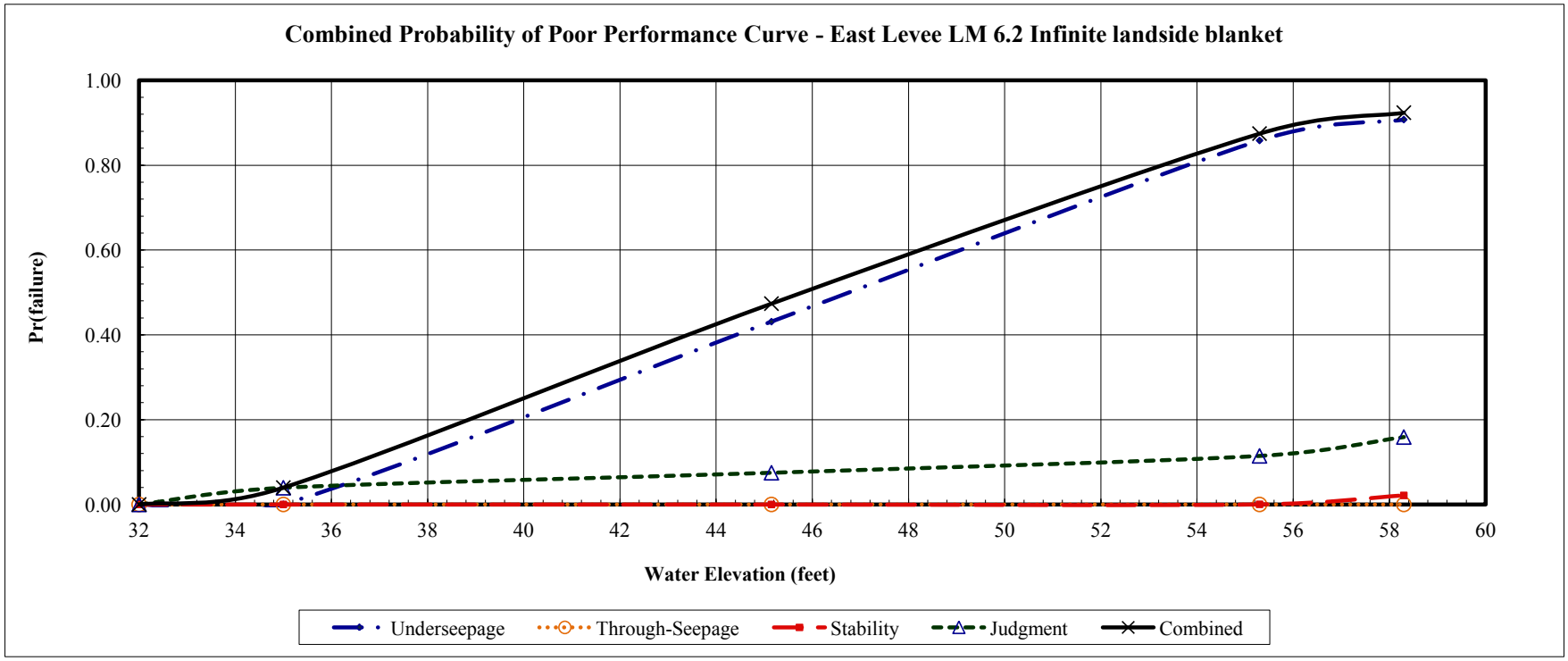
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 6.20
River Mile: 2158855 N; 663
Analysis Case: Infinite landside blanket

Crest Elev.: 58.30
L/S Toe Elev.: 32.00
W/S Toe Elev.: 32.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: 9/13/2012

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.00	0.0004	0.9996	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0398	0.9602
45.15	0.4311	0.5689	0.0000	1.0000	0.0000	1.0000	0.0747	0.9253	0.4736	0.5264
55.30	0.8583	0.1417	0.0000	1.0000	0.0003	0.9997	0.1145	0.8855	0.8746	0.1254
58.30	0.9076	0.0924	0.0000	1.0000	0.0213	0.9787	0.1590	0.8410	0.9239	0.0761



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Sutter Bypass
Basin and Reach: East Levee

Levee Mile: 17.30
Coordinates: 2113476.9763 N; 6655398.0817 E
Analysis Case Infinite landside blanket

Crest Elev.: 54.10
L/S Toe Elev.: 32.10
W/S Toe Elev.: 37.78

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 13 August 2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WSESBP_001B	4					4					CH,sML	0.14	SM	3	21				
WSESBP_002B	26.23					10.5					sCL,SC/ML	0.007	SM	3	429				
WSESBP_003B	11					2					sCL,CH	0.007	SM	3	429				
WSESBP_004B	27	15	10	111	67	31	13	13	164	98	sML, CL,SC	0.1	SM/SP-SM	8.4	84	1117	1398	1830429	98
WSESBP_005B	7.65					31.5					sCL/CH, sML	0.007	SP-SM/SW-SM	10	1429				
WSESBP_008B	23					7					sCL, CH	0.007	SP-SM/SW-SM	10	1429				
WSESBP_009B	8.25					3					CLs/ML	0.007	SP	28	4000				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WSESBP_001B	CH,sML	4	0.14				4	SM	4	3							3
WSESBP_002B	sCL,SC	26	0.007	ML	4.5	0.14	26.23	SM	10.5	3							3
WSESBP_003B	sCL,CH	11	0.007				11	SM	2	3							3
WSESBP_004B	sML, CL,SC	27	0.1				27	SM	7.1	3	SP-SM	23.9	10				8.4
WSESBP_005B	sCL	7.25	0.007	CH, sML	5.75	0.1	7.65	SP-SM	13	10	SW-SM	18.5	10				10
WSESBP_008B	sCL, CH	23	0.007				23	SP-SM	5	10	SW-SM	2	10				10
WSESBP_009B	CLs	8	0.007	ML	5	0.14	8.25	SP	3	28							28

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

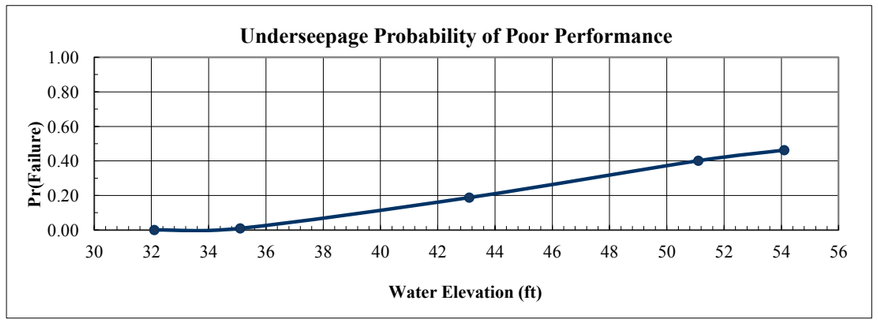
Levee Mile: 17.30
River Mile: 2113476.9763 N; 6655398.0817 E
Analysis Case Infinite landside blanket

Crest Elev.: 54.10
L/S Toe Elev.: 32.10
W/S Toe Elev.: 37.78

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 13 August 2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	1117	1095	98
Blanket Thickness (z)	15	10	67
Aquifer Thickness (d)	13	13	98

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	15	150	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.10	0.0000
Toe+3ft	3.00	35.10	0.0094
Half Height	11.00	43.10	0.1876
Crest-3ft	19.00	51.10	0.4011
Crest	22.00	54.10	0.4623

Crest	Rh
Head = 22.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1117	15.00	13.00	14.99	466.71	0.0206	16.25	1.08		
2	2212	15.00	13.00	15.00	656.71	0.0158	17.58	1.17	0.140625	10.48
3	22	15.00	13.00	14.75	66.00	0.0563	6.29	0.42		
4	1117	25.05	13.00	15.00	603.12	0.0169	17.27	0.69	1.060900	79.04
5	1117	4.95	13.00	14.98	268.10	0.0300	13.62	2.75		
6	1117	15.00	25.74	15.00	656.71	0.0313	17.58	1.17	0.140625	10.48
7	1117	15.00	0.26	14.75	66.00	0.0011	6.29	0.42		
								Total	1.342150	100.00

E[I] = 1.080000
Var[I]= 1.342150
σ[I]= 1.158512
V(I) = 1.072696

E[ln I] = -0.305930
σ [ln I] = 0.875090

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.349599
F(z) =	0.537685
Pr(f) % =	46.231478

Crest-3ft	Rh
Head = 19.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1117	15.00	13.00	14.99	466.71	0.0206	14.04	0.94		
2	2212	15.00	13.00	15.00	656.71	0.0158	15.18	1.01	0.105625	10.53
3	22	15.00	13.00	14.75	66.00	0.0563	5.43	0.36		
4	1117	25.05	13.00	15.00	603.12	0.0169	14.92	0.60	0.792100	78.95
5	1117	4.95	13.00	14.98	268.10	0.0300	11.76	2.38		
6	1117	15.00	25.74	15.00	656.71	0.0313	15.18	1.01	0.105625	10.53
7	1117	15.00	0.26	14.75	66.00	0.0011	5.43	0.36		
								Total	1.003350	100.00

E[I] = 0.940000
Var[I]= 1.003350
σ[I]= 1.001674
V(I) = 1.065610

E[ln I] = -0.441232
σ [ln I] = 0.871041

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.506557
F(z) =	0.598852
Pr(f) % =	40.114814

Half Height	Rh
Head = 11.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1117	15.00	13.00	14.99	466.71	0.0206	8.13	0.54		
2	2212	15.00	13.00	15.00	656.71	0.0158	8.79	0.59	0.036100	10.54
3	22	15.00	13.00	14.75	66.00	0.0563	3.15	0.21		
4	1117	25.05	13.00	15.00	603.12	0.0169	8.64	0.34	0.270400	78.93
5	1117	4.95	13.00	14.98	268.10	0.0300	6.81	1.38		
6	1117	15.00	25.74	15.00	656.71	0.0313	8.79	0.59	0.036100	10.54
7	1117	15.00	0.26	14.75	66.00	0.0011	3.15	0.21		
								Total	0.342600	100.00

E[I] = 0.540000
Var[I]= 0.342600
σ[I]= 0.585320
V(I) = 1.083927

E[ln I] = -1.004677
σ [ln I] = 0.881465

Ic= 0.80
ln(I crit) = -0.223144

β =	-1.139780
F(z) =	0.812361
Pr(f) % =	18.763921

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1117	15.00	13.00	14.99	466.71	0.0206	2.22	0.15		
2	2212	15.00	13.00	15.00	656.71	0.0158	2.40	0.16	0.002500	9.61
3	22	15.00	13.00	14.75	66.00	0.0563	0.86	0.06		
4	1117	25.05	13.00	15.00	603.12	0.0169	2.36	0.09	0.021025	80.79
5	1117	4.95	13.00	14.98	268.10	0.0300	1.86	0.38		
6	1117	15.00	25.74	15.00	656.71	0.0313	2.40	0.16	0.002500	9.61
7	1117	15.00	0.26	14.75	66.00	0.0011	0.86	0.06		
								Total	0.026025	100.00

E[I] = 0.150000
Var[I]= 0.026025
σ[I]= 0.161323
V(I) = 1.075484

E[ln I] = -2.281402
σ [ln I] = 0.876678

Ic= 0.80
ln(I crit) = -0.223144

β =	-2.602327
F(z) =	0.990558
Pr(f) % =	0.944249

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

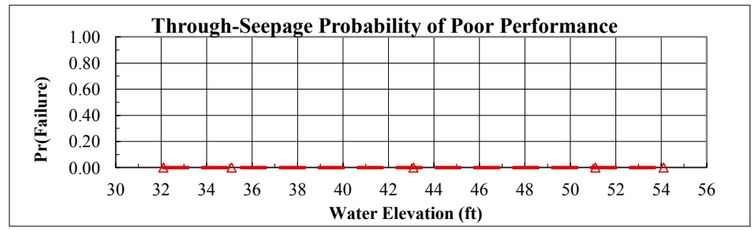
Levee Mile: 17.30
River Mile: 2113476.9763 N; 6655398.0817 E
Analysis Case Infinite landside blanket

Crest Elev.: 54.10
L/S Toe Elev.: 32.10
W/S Toe Elev.: 37.78

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 13 August 2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	15	1.5	10.00
Initial Porosity (n)	45	4.50	10.00
Initial Permeability (Ko)	1.00E-10	3.00E-11	30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.10	0.0000
Toe+3ft	3.00	35.10	0.000000
Half Height	11.00	43.10	0.000000
Crest-3ft	19.00	51.10	0.000000
Crest	22.00	54.10	0.000000

Crest | **Head =** 22.00 | **Horizontal Gradient (Ix) =** 0.297

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 19.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 11.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

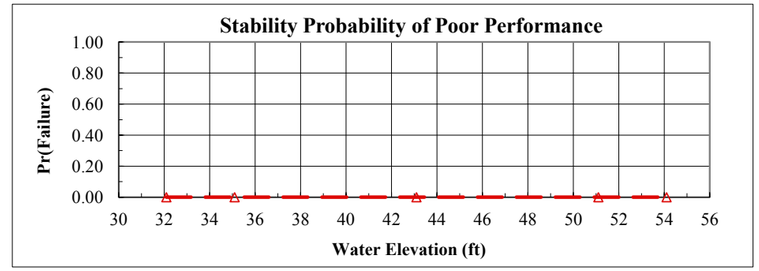
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 17.30
River Mile: 2113476.9763 N; 6655398.0817 E
Analysis Case Infinite landside blanket

Crest Elev.: 54.10
L/S Toe Elev.: 32.10
W/S Toe Elev.: 37.78

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 13 August 2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee ϕ'	31	4	12.00
Levee γ	125	6	5.00
Foundation c'	150	50	33.00
Foundation γ	115	6	5.00
Foundation ϕ'	28	3	12.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.10	0.0000
Toe+3ft	3.00	35.10	0.000000
Half Height	11.00	43.10	0.000000
Crest-3ft	19.00	51.10	0.000000
Crest	22.00	54.10	0.000076

Crest	Head =	22.00	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28	1.44		
2	27	125	150	115	28	1.43	0.000020	0.11
3	35	125	150	115	28	1.44		
4	31	119	150	115	28	1.45	0.000090	0.48
5	31	131	150	115	28	1.43		
6	31	125	100	115	28	1.41	0.014520	77.49
7	31	125	200	115	28	1.65		
8	31	125	150	109	28	1.50	0.000012	0.07
9	31	125	150	121	28	1.51		
10	31	125	150	115	25	1.37	0.004096	21.86
11	31	125	150	115	31	1.50		

E[FS] = 1.439000 E[ln FS] = 0.359444 Total 0.018739 100.00
Var[FS]= 0.018739
σ[FS]= 0.136890 σ[ln FS]= 0.094915
V(FS) = 0.095129
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	3.787021
F(z) =	0.000076
Pr(f) % =	0.007623

Crest-3ft	Head =	19.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	11.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

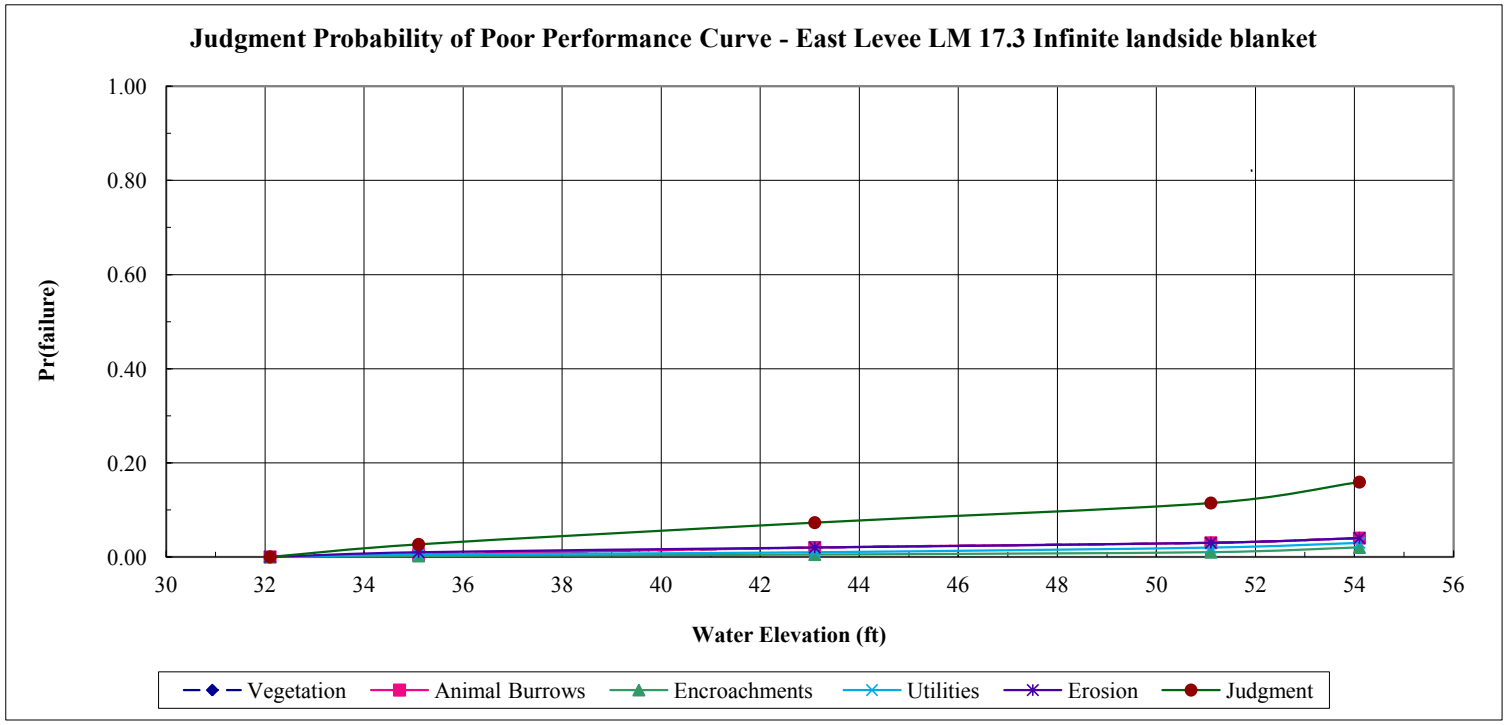
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 17.30
River Mile: 2113476.9763
Analysis Case: Infinite landside blanket

Crest Elev.: 54.10
L/S Toe Elev.: 32.10
W/S Toe Elev.: 37.78

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 13 A

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.10	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.10	0.0050	0.9950	0.0050	0.9950	0.0020	0.9980	0.0050	0.9950	0.0100	0.9900	0.0267	0.9733
43.10	0.0200	0.9800	0.0200	0.9800	0.0050	0.9950	0.0100	0.9900	0.0200	0.9800	0.0729	0.9271
51.10	0.0300	0.9700	0.0300	0.9700	0.0100	0.9900	0.0200	0.9800	0.0300	0.9700	0.1145	0.8855
54.10	0.0400	0.9600	0.0400	0.9600	0.0200	0.9800	0.0300	0.9700	0.0400	0.9600	0.1590	0.8410



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

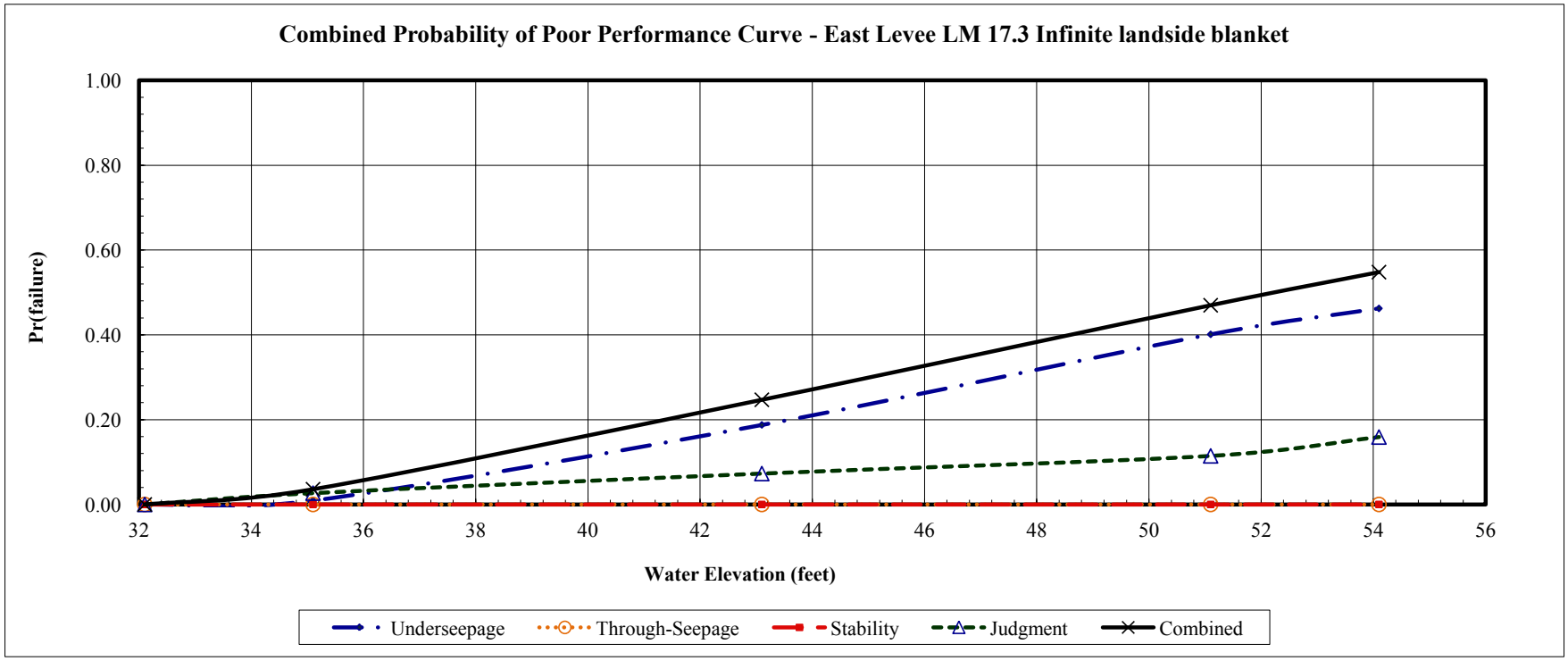
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 17.30
River Mile: 2113476.9763 N
Analysis Case: Infinite landside blanket

Crest Elev.: 54.10
L/S Toe Elev.: 32.10
W/S Toe Elev.: 37.78

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 13 Augu

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.10	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.10	0.0094	0.9906	0.0000	1.0000	0.0000	1.0000	0.0267	0.9733	0.0359	0.9641
43.10	0.1876	0.8124	0.0000	1.0000	0.0000	1.0000	0.0729	0.9271	0.2468	0.7532
51.10	0.4011	0.5989	0.0000	1.0000	0.0000	1.0000	0.1145	0.8855	0.4697	0.5303
54.10	0.4623	0.5377	0.0000	1.0000	0.0001	0.9999	0.1590	0.8410	0.5478	0.4522



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Feather River South
Basin and Reach: MA 3

Levee Mile: 4.92
Coordinates: 2106963.58 N; 6679261.24E
Analysis Case Infinite landside blanket

Crest Elev.: 64.59
L/S Toe Elev.: 45.70
W/S Toe Elev.: 45.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 09/12/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WM0003_012B	16					75					SC-SM/CL,CLs	0.007	SM,GP-GM,SP,	10	1429				
WM0003_016B	18.5					17.5					MLS	0.14	SM-SPg	1.12	8				
WM0003_004S	25					88					MLs	0.14	M, SPg,GW-GM	3	21				
WM0003_020B	22.6					78					CLs/sML,CL	0.007	SMSW-SM,GW	30	4286				
WM0003_022B	24					89.5					CLs	0.007	M, SPM-SM.SP	30	4286				
WL0001_020B	30					89.5					CLs,CL	0.01	SMg,SP-SC,GP	30	3000				
WL0001_025B	14																		
WL0001_031B	25.75																		
		22	5	133	23		73	28	1849	38						2172	1974	3422159	91

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WM0003_012B	SC-SM	1	0.007	CL,CLs	15	0.007	16	SM,GP-GM,SP,	75	10							10
WM0003_016B	MLS	18.5	0.14				18.5	SM-SPg	17.5	1.12							1.12
WM0003_004S	MLs	25	0.14				25	M, SPg,GW-GM	88	3							3
WM0003_020B	CLs	22	0.007	sML,CL	12	0.14	22.6	SMSW-SM,GW	78	30							30
WM0003_022B	CLs	24	0.007				24	M, SPM-SM.SP	89.5	30							30
WL0001_020B	CLs,CL	30	0.01				30	SMg,SP-SC,GP	89.5	30							30
WL0001_025B	sCL, SM, CL	14	0.01				14	SP-SC, SP-SM	4	3							3

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: MA 3

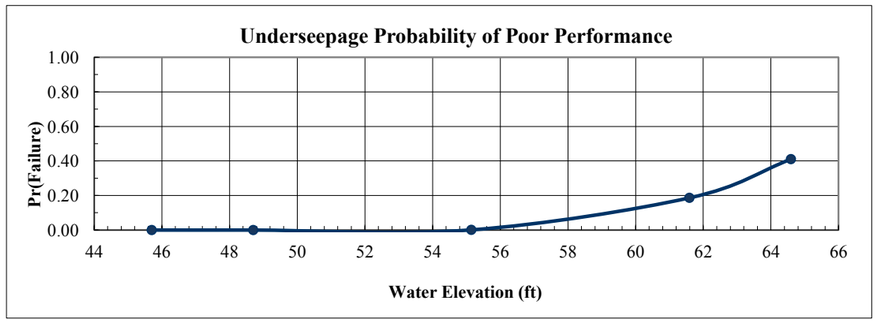
Levee Mile: 4.92
River Mile: 2106963.58 N; 6679261.24E
Analysis Case Infinite landside blanket

Crest Elev.: 64.59
L/S Toe Elev.: 45.70
W/S Toe Elev.: 45.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 09/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	2172	1977	91
Blanket Thickness (z)	22	5	23
Aquifer Thickness (d)	73	28	38

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	50	130	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	45.70	0.0000
Toe+3ft	3.00	48.70	0.0000
Half Height	9.45	55.15	0.0011
Crest-3ft	15.89	61.59	0.1867
Crest	18.89	64.59	0.4106

Crest	Rh
Head = 18.89	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	2172	22.00	73.00	49.99	1867.68	0.0357	17.23	0.78		
2	4149	22.00	73.00	49.99	2581.19	0.0264	17.66	0.80	0.005625	14.75
3	195	22.00	73.00	49.87	560.30	0.0986	14.30	0.65		
4	2172	27.06	73.00	49.99	2071.36	0.0324	17.38	0.64	0.032400	84.98
5	2172	16.94	73.00	49.98	1638.88	0.0401	17.02	1.00		
6	2172	22.00	100.74	49.99	2194.03	0.0424	17.46	0.79	0.000100	0.26
7	2172	22.00	45.26	49.98	1470.61	0.0274	16.83	0.77		
								Total	0.038125	100.00

E[I] = 0.780000
Var[I]= 0.038125
σ[I]= 0.195256
V(I) = 0.250329

E[ln I] = -0.278851
σ [ln I] = 0.246535

Ic= 0.80
ln(I crit) = -0.223144

β =	-1.131083
F(z) =	0.589385
Pr(f) % =	41.061547

Crest-3ft	Rh
Head = 15.89	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	2172	22.00	73.00	49.99	1867.68	0.0357	14.49	0.66		
2	4149	22.00	73.00	49.99	2581.19	0.0264	14.85	0.68	0.004225	14.84
3	195	22.00	73.00	49.87	560.30	0.0986	12.03	0.55		
4	2172	27.06	73.00	49.99	2071.36	0.0324	14.62	0.54	0.024025	84.37
5	2172	16.94	73.00	49.98	1638.88	0.0401	14.32	0.85		
6	2172	22.00	100.74	49.99	2194.03	0.0424	14.69	0.67	0.000225	0.79
7	2172	22.00	45.26	49.98	1470.61	0.0274	14.16	0.64		
								Total	0.028475	100.00

E[I] = 0.660000
Var[I]= 0.028475
σ[I]= 0.168745
V(I) = 0.255675

E[ln I] = -0.447176
σ [ln I] = 0.251638

Ic= 0.80
ln(I crit) = -0.223144

β =	-1.777061
F(z) =	0.813347
Pr(f) % =	18.665317

Half Height	Rh
Head = 9.45	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	2172	22.00	73.00	49.99	1867.68	0.0357	8.61	0.39		
2	4149	22.00	73.00	49.99	2581.19	0.0264	8.83	0.40	0.001225	13.00
3	195	22.00	73.00	49.87	560.30	0.0986	7.15	0.33		
4	2172	27.06	73.00	49.99	2071.36	0.0324	8.69	0.32	0.008100	85.94
5	2172	16.94	73.00	49.98	1638.88	0.0401	8.51	0.50		
6	2172	22.00	100.74	49.99	2194.03	0.0424	8.73	0.40	0.000100	1.06
7	2172	22.00	45.26	49.98	1470.61	0.0274	8.42	0.38		
								Total	0.009425	100.00

E[I] = 0.390000
Var[I]= 0.009425
σ[I]= 0.097082
V(I) = 0.248929

E[ln I] = -0.971669
σ [ln I] = 0.245197

Ic= 0.80
ln(I crit) = -0.223144

β =	-3.962806
F(z) =	0.998866
Pr(f) % =	0.113378

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	2172	22.00	73.00	49.99	1867.68	0.0357	2.74	0.12		
2	4149	22.00	73.00	49.99	2581.19	0.0264	2.80	0.13	0.000225	19.57
3	195	22.00	73.00	49.87	560.30	0.0986	2.27	0.10		
4	2172	27.06	73.00	49.99	2071.36	0.0324	2.76	0.10	0.000900	78.26
5	2172	16.94	73.00	49.98	1638.88	0.0401	2.70	0.16		
6	2172	22.00	100.74	49.99	2194.03	0.0424	2.77	0.13	0.000025	2.17
7	2172	22.00	45.26	49.98	1470.61	0.0274	2.67	0.12		
								Total	0.001150	100.00

E[I] = 0.120000
Var[I]= 0.001150
σ[I]= 0.033912
V(I) = 0.282597

E[ln I] = -2.158680
σ [ln I] = 0.277187

Ic= 0.80
ln(I crit) = -0.223144

β =	-7.787820
F(z) =	1.000000
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: MA 3

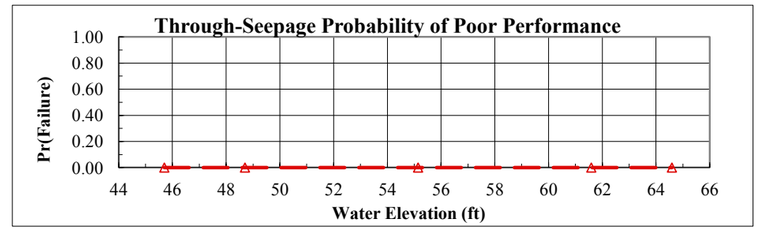
Levee Mile: 4.92
River Mile: 2106963.58 N; 6679261.24E
Analysis Case Infinite landside blanket

Crest Elev.: 64.59
L/S Toe Elev.: 45.70
W/S Toe Elev.: 45.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 09/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	45.70	0.0000
Toe+3ft	3.00	48.70	0.000000
Half Height	9.45	55.15	0.000000
Crest-3ft	15.89	61.59	0.000000
Crest	18.89	64.59	0.000000

Crest | **Head =** 18.89 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 15.89 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 9.45 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

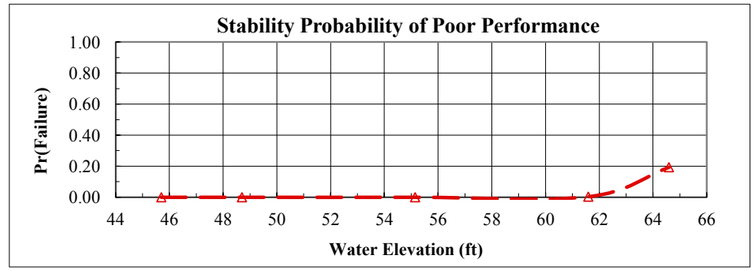
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: MA 3

Levee Mile: 4.92
River Mile: 2106963.58 N; 6679261.24E
Analysis Case Infinite landside blanket

Crest Elev.: 64.59
L/S Toe Elev.: 45.70
W/S Toe Elev.: 45.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 09/12/2012

Random Variables				
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %	
Levee ϕ'	29	1	5.00	
Levee γ	120	6	5.00	
Foundation c'	150	17	11.50	
Foundation γ	120	6	5.00	
Foundation ϕ'	31	4	11.50	



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	45.70	0.0000
Toe+3ft	3.00	48.70	0.000000
Half Height	9.45	55.15	0.000000
Crest-3ft	15.89	61.59	0.003757
Crest	18.89	64.59	0.193409

Crest	Head =	18.89	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.09		
2	28	120	150	120	31	1.20	0.010816	93.19
3	30	120	150	120	31	0.99		
4	29	114	150	120	31	1.07	0.000306	2.64
5	29	126	150	120	31	1.11		
6	29	120	133	120	31	1.09	0.000484	4.17
7	29	120	167	120	31	1.05		
8	29	120	150	114	31	1.09	0.000000	0.00
9	29	120	150	126	31	1.09		
10	29	120	150	120	27	1.09	0.000000	0.00
11	29	120	150	120	35	1.09		

E[FS] = 1.094000 E[ln FS] = 0.085015 Total 0.011606 100.00
Var[FS]= 0.011606
σ[FS]= 0.107732 σ[ln FS]= 0.098238
V(FS) = 0.098476
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	0.865401
F(z) =	0.193409
Pr(f) % =	19.340941

Crest-3ft	Head =	15.89	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.25		
2	28	120	150	120	31	1.35	0.009604	90.64
3	30	120	150	120	31	1.16		
4	29	114	150	120	31	1.24	0.000144	1.36
5	29	126	150	120	31	1.26		
6	29	120	133	120	31	1.25	0.000784	7.40
7	29	120	167	120	31	1.19		
8	29	120	150	114	31	1.25	0.000064	0.60
9	29	120	150	126	31	1.23		
10	29	120	150	120	27	1.25	0.000000	0.00
11	29	120	150	120	35	1.25		

E[FS] = 1.250000 E[ln FS] = 0.219764 Total 0.010596 100.00
Var[FS]= 0.010596
σ[FS]= 0.102937 σ[ln FS]= 0.082210
V(FS) = 0.082349
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	2.673193
F(z) =	0.003757
Pr(f) % =	0.375665

Half Height	Head =	9.45	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

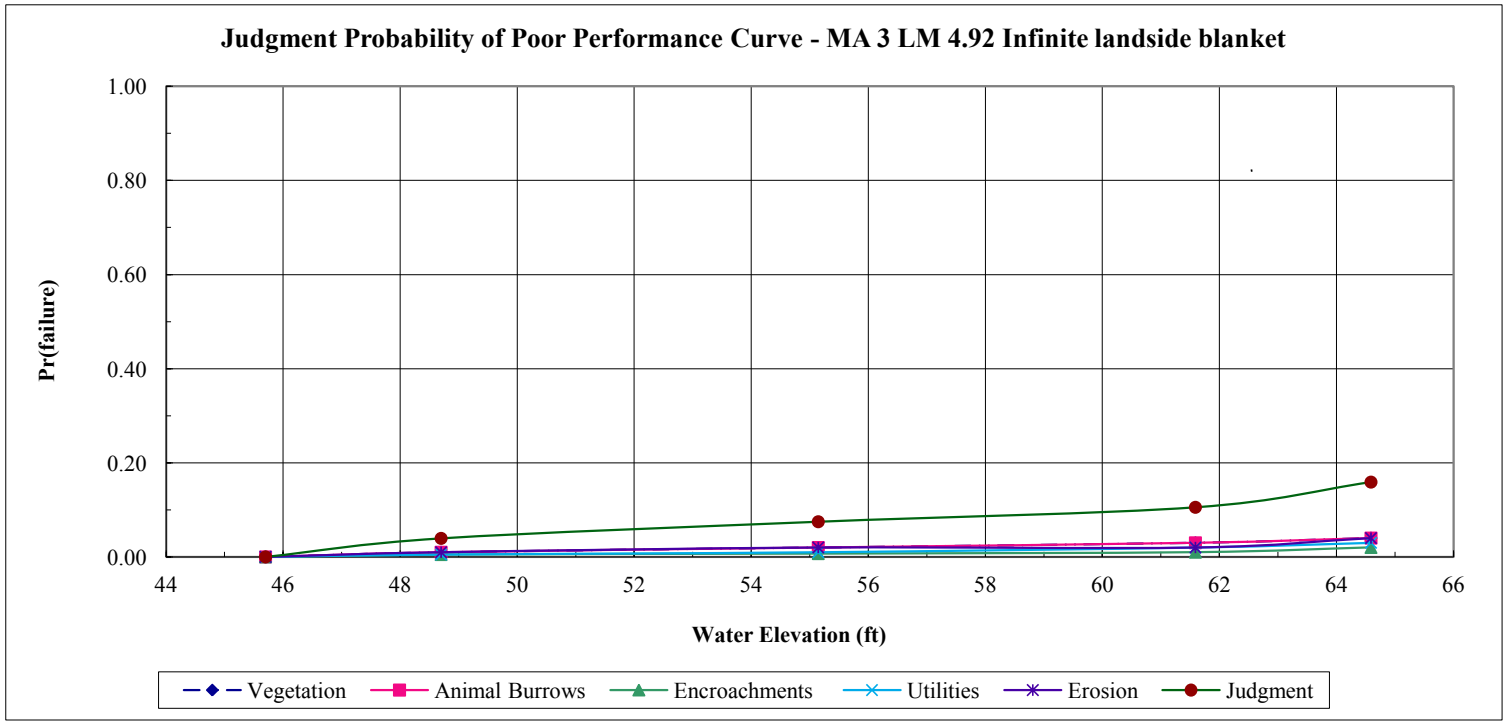
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: MA 3

Levee Mile: 4.92
River Mile: 2106963.58 N
Analysis Case: Infinite landside blanket

Crest Elev.: 64.59
L/S Toe Elev.: 45.70
W/S Toe Elev.: 45.00

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 09/12

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
45.70	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
48.70	0.0100	0.9900	0.0100	0.9900	0.0050	0.9950	0.0050	0.9950	0.0100	0.9900	0.0394	0.9606
55.15	0.0200	0.9800	0.0200	0.9800	0.0070	0.9930	0.0100	0.9900	0.0200	0.9800	0.0747	0.9253
61.59	0.0300	0.9700	0.0300	0.9700	0.0100	0.9900	0.0200	0.9800	0.0200	0.9800	0.1054	0.8946
64.59	0.0400	0.9600	0.0400	0.9600	0.0200	0.9800	0.0300	0.9700	0.0400	0.9600	0.1590	0.8410



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

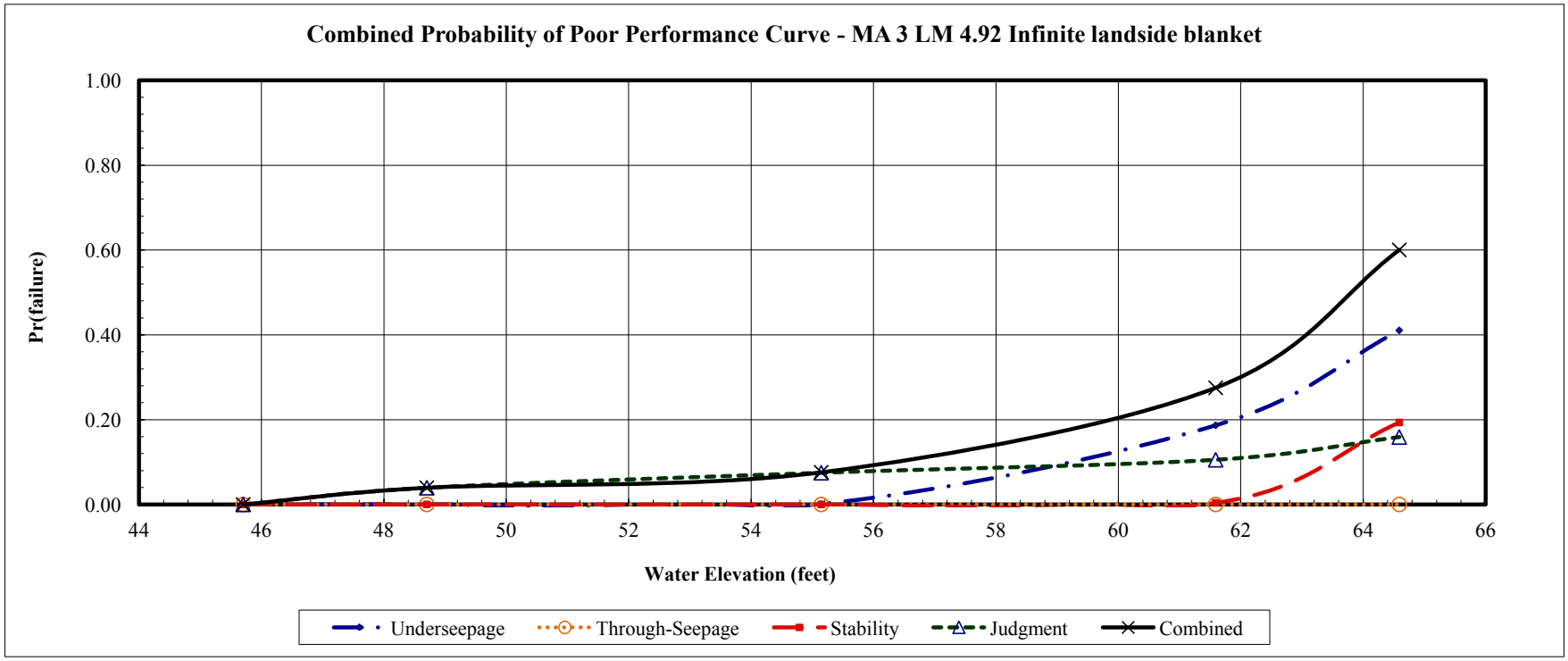
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: MA 3

Levee Mile: 4.92
River Mile: 2106963.58 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 64.59
L/S Toe Elev.: 45.70
W/S Toe Elev.: 45.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 09/12/2(

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
45.70	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
48.70	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0394	0.9606
55.15	0.0011	0.9989	0.0000	1.0000	0.0000	1.0000	0.0747	0.9253	0.0758	0.9242
61.59	0.1867	0.8133	0.0000	1.0000	0.0038	0.9962	0.1054	0.8946	0.2751	0.7249
64.59	0.4106	0.5894	0.0000	1.0000	0.1934	0.8066	0.1590	0.8410	0.6002	0.3998



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Feather River South
Basin and Reach: LD 1

Levee Mile: 3.99
Coordinates: 2127081.8143 N; 6676331.1294E
Analysis Case Infinite landside blanket

Crest Elev.: 68.40
L/S Toe Elev.: 49.10
W/S Toe Elev.: 40.00

Analysis By: T. Huynh
Checked By: E.W. James\J.M. Bolton
Date: Updated 09/26/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WL0001_033B	5.29					3					CH/SM	0.01	SM	2.8	280				
WL0001_005S	10.35					97					CL,CLs/sML	0.007	M,SW,SP-SM, S	10	1429				
WL0001_039B	24.04					35.5					, CL, sCL, CH/s	0.001	SM,SW,SW-SM	70	70000				
WL0001_006S	6.2					28					CL/SC/ML	0.007	M, SW, GW,GW	70	10000				
2F-97-1	13					11					CL, CLs	0.01	SC, SM, SP-SM	1	100				
WL0001_041B	11					5					CL,sMH	0.01	SM	1.2	120				
WL0001_007S	25.5					11					CLs,CL, CLs	0.007	SM, SP-SM	14	2000				
WL0001_046B	25.18					16					sCLs,sML,MH/	0.01	SP-SM	2.8	280				
		14	9	84	66		26	31	767	98						10526	24260	244824623	98

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WL0001_033B	CH	5	0.01	SM	4	0.14	5.29	SM	3	2.8							2.8
WL0001_005S	CL,CLs	10	0.007	sML	7	0.14	10.35	M,SW,SP-SM, S	97	10							10
WL0001_039B	Ls, CL, sCL, C	24	0.001	sML	4	0.1	24.04	SM,SW,SW-SM	35.5	70							70
WL0001_006S	CL	6	0.007	SC/ML	4	0.14	6.2	M, SW, GW,GW	28	70							70
2F-97-1	CL, CLs	13	0.01				13	SC, SM, SP-SM	11	1							1
WL0001_041B	CL,sMH	11	0.01				11	SM	5	1.2							1.2
WL0001_007S	CLs,CL, CLs	25.5	0.007				25.5	SM, SP-SM	11	14							14

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

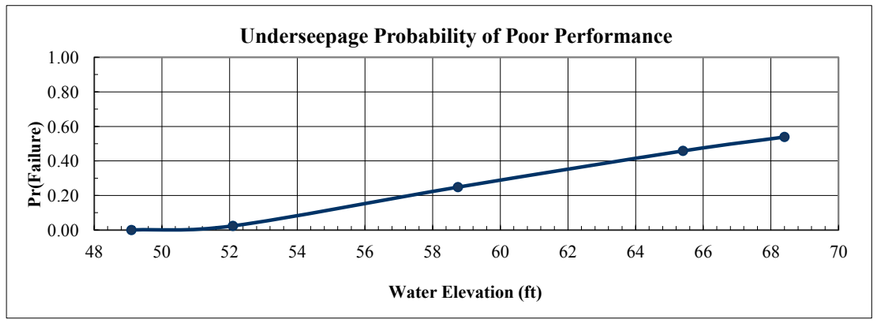
Levee Mile: 3.99
River Mile: 2127081.8143 N; 6676331.1294E
Analysis Case Infinite landside blanket

Crest Elev.: 68.40
L/S Toe Elev.: 49.10
W/S Toe Elev.: 40.00

Analysis By: T. Huynh
Checked By: E.W. James\J.M. Bolton
Date: Updated 09/26/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	10526	10315	98
Blanket Thickness (z)	14	9	66
Aquifer Thickness (d)	26	25	98

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	50	130	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	49.10	0.0000
Toe+3ft	3.00	52.10	0.0240
Half Height	9.65	58.75	0.2485
Crest-3ft	16.30	65.40	0.4584
Crest	19.30	68.40	0.5390

Crest	Rh
Head = 19.30	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	10526	13.63	26.00	49.99	1931.07	0.0123	17.65	1.30		
2	20841	13.63	26.00	49.99	2717.26	0.0090	18.10	1.33	0.055225	2.69
3	211	13.63	26.00	49.45	273.09	0.0575	11.65	0.86		
4	10526	22.62	26.00	49.99	2488.01	0.0097	18.00	0.80	1.946025	94.63
5	10526	4.63	26.00	49.97	1126.00	0.0199	16.64	3.59		
6	10526	13.63	51.48	49.99	2717.26	0.0178	18.10	1.33	0.055225	2.69
7	10526	13.63	0.52	49.45	273.09	0.0011	11.65	0.86		
								Total	2.056475	100.00

E[I] = 1.300000
Var[I]= 2.056475
σ[I]= 1.434041
V(I) = 1.103109

E[ln I] = -0.135679
σ [ln I] = 0.892237

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.152066
F(z) =	0.460955
Pr(f) % =	53.904505

Crest-3ft	Rh
Head = 16.30	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	10526	13.63	26.00	49.99	1931.07	0.0123	14.91	1.09		
2	20841	13.63	26.00	49.99	2717.26	0.0090	15.29	1.12	0.040000	2.72
3	211	13.63	26.00	49.45	273.09	0.0575	9.84	0.72		
4	10526	22.62	26.00	49.99	2488.01	0.0097	15.20	0.67	1.392400	94.57
5	10526	4.63	26.00	49.97	1126.00	0.0199	14.05	3.03		
6	10526	13.63	51.48	49.99	2717.26	0.0178	15.29	1.12	0.040000	2.72
7	10526	13.63	0.52	49.45	273.09	0.0011	9.84	0.72		
								Total	1.472400	100.00

E[I] = 1.090000
Var[I]= 1.472400
σ[I]= 1.213425
V(I) = 1.113234

E[ln I] = -0.316902
σ [ln I] = 0.897863

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.352951
F(z) =	0.541583
Pr(f) % =	45.841661

Half Height	Rh
Head = 9.65	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	10526	13.63	26.00	49.99	1931.07	0.0123	8.83	0.65		
2	20841	13.63	26.00	49.99	2717.26	0.0090	9.05	0.66	0.013225	2.56
3	211	13.63	26.00	49.45	273.09	0.0575	5.82	0.43		
4	10526	22.62	26.00	49.99	2488.01	0.0097	9.00	0.40	0.490000	94.88
5	10526	4.63	26.00	49.97	1126.00	0.0199	8.32	1.80		
6	10526	13.63	51.48	49.99	2717.26	0.0178	9.05	0.66	0.013225	2.56
7	10526	13.63	0.52	49.45	273.09	0.0011	5.82	0.43		
								Total	0.516450	100.00

E[I] = 0.650000
Var[I]= 0.516450
σ[I]= 0.718645
V(I) = 1.105607

E[ln I] = -0.830069
σ [ln I] = 0.893629

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.928875
F(z) =	0.751485
Pr(f) % =	24.851517

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	10526	13.63	26.00	49.99	1931.07	0.0123	2.74	0.20		
2	20841	13.63	26.00	49.99	2717.26	0.0090	2.81	0.21	0.001600	3.10
3	211	13.63	26.00	49.45	273.09	0.0575	1.81	0.13		
4	10526	22.62	26.00	49.99	2488.01	0.0097	2.80	0.12	0.048400	93.80
5	10526	4.63	26.00	49.97	1126.00	0.0199	2.59	0.56		
6	10526	13.63	51.48	49.99	2717.26	0.0178	2.81	0.21	0.001600	3.10
7	10526	13.63	0.52	49.45	273.09	0.0011	1.81	0.13		
								Total	0.051600	100.00

E[I] = 0.200000
Var[I]= 0.051600
σ[I]= 0.227156
V(I) = 1.135782

E[ln I] = -2.023714
σ [ln I] = 0.910248

Ic= 0.80
ln(I crit) = -0.223144

β =	-2.223255
F(z) =	0.976042
Pr(f) % =	2.395820

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

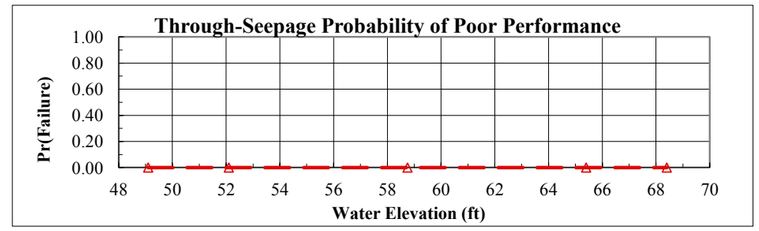
Levee Mile: 3.99
River Mile: 2127081.8143 N; 6676331.1294E
Analysis Case Infinite landside blanket

Crest Elev.: 68.40
L/S Toe Elev.: 49.10
W/S Toe Elev.: 40.00

Analysis By: T. Huynh
Checked By: E.W. James\J.M. Bolton
Date: Updated 09/26/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	49.10	0.0000
Toe+3ft	3.00	52.10	0.000000
Half Height	9.65	58.75	0.000000
Crest-3ft	16.30	65.40	0.000000
Crest	19.30	68.40	0.000000

Crest | **Head =** 19.30 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 16.30 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 9.65 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

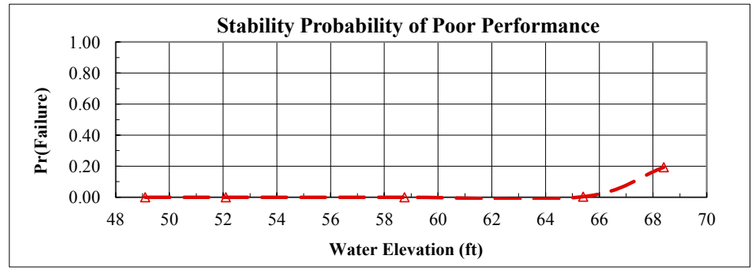
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

Levee Mile: 3.99
River Mile: 2127081.8143 N; 6676331.1294E
Analysis Case Infinite landside blanket

Crest Elev.: 68.40
L/S Toe Elev.: 49.10
W/S Toe Elev.: 40.00

Analysis By: T. Huynh
Checked By: E.W. James\J.M. Bolton
Date: Updated 09/26/2012

Random Variables				
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %	
Levee ϕ'	29	1	5.00	
Levee γ	120	6	5.00	
Foundation c'	150	17	11.50	
Foundation γ	120	6	5.00	
Foundation ϕ'	31	4	11.50	



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	49.10	0.0000
Toe+3ft	3.00	52.10	0.000000
Half Height	9.65	58.75	0.000000
Crest-3ft	16.30	65.40	0.003757
Crest	19.30	68.40	0.193409

Crest	Head =	19.30	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.09		
2	28	120	150	120	31	1.20	0.010816	93.19
3	30	120	150	120	31	0.99		
4	29	114	150	120	31	1.07	0.000306	2.64
5	29	126	150	120	31	1.11		
6	29	120	133	120	31	1.09	0.000484	4.17
7	29	120	167	120	31	1.05		
8	29	120	150	114	31	1.09	0.000000	0.00
9	29	120	150	126	31	1.09		
10	29	120	150	120	27	1.09	0.000000	0.00
11	29	120	150	120	35	1.09		

E[FS] = 1.094000
Var[FS]= 0.011606
σ[FS]= 0.107732
V(FS) = 0.098476
FS req'd = 1.00

E[ln FS] = 0.085015
σ[ln FS]= 0.098238
ln(FS req'd) = 0.000000

Total 0.011606 100.00

β = 0.865401
F(z) = 0.193409
Pr(f) % = 19.340941

Crest-3ft	Head =	16.30	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.25		
2	28	120	150	120	31	1.35	0.009604	90.64
3	30	120	150	120	31	1.16		
4	29	114	150	120	31	1.24	0.000144	1.36
5	29	126	150	120	31	1.26		
6	29	120	133	120	31	1.25	0.000784	7.40
7	29	120	167	120	31	1.19		
8	29	120	150	114	31	1.25	0.000064	0.60
9	29	120	150	126	31	1.23		
10	29	120	150	120	27	1.25	0.000000	0.00
11	29	120	150	120	35	1.25		

E[FS] = 1.250000
Var[FS]= 0.010596
σ[FS]= 0.102937
V(FS) = 0.082349
FS req'd = 1.00

E[ln FS] = 0.219764
σ[ln FS]= 0.082210
ln(FS req'd) = 0.000000

Total 0.010596 100.00

β = 2.673193
F(z) = 0.003757
Pr(f) % = 0.375665

Half Height	Head =	9.65	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

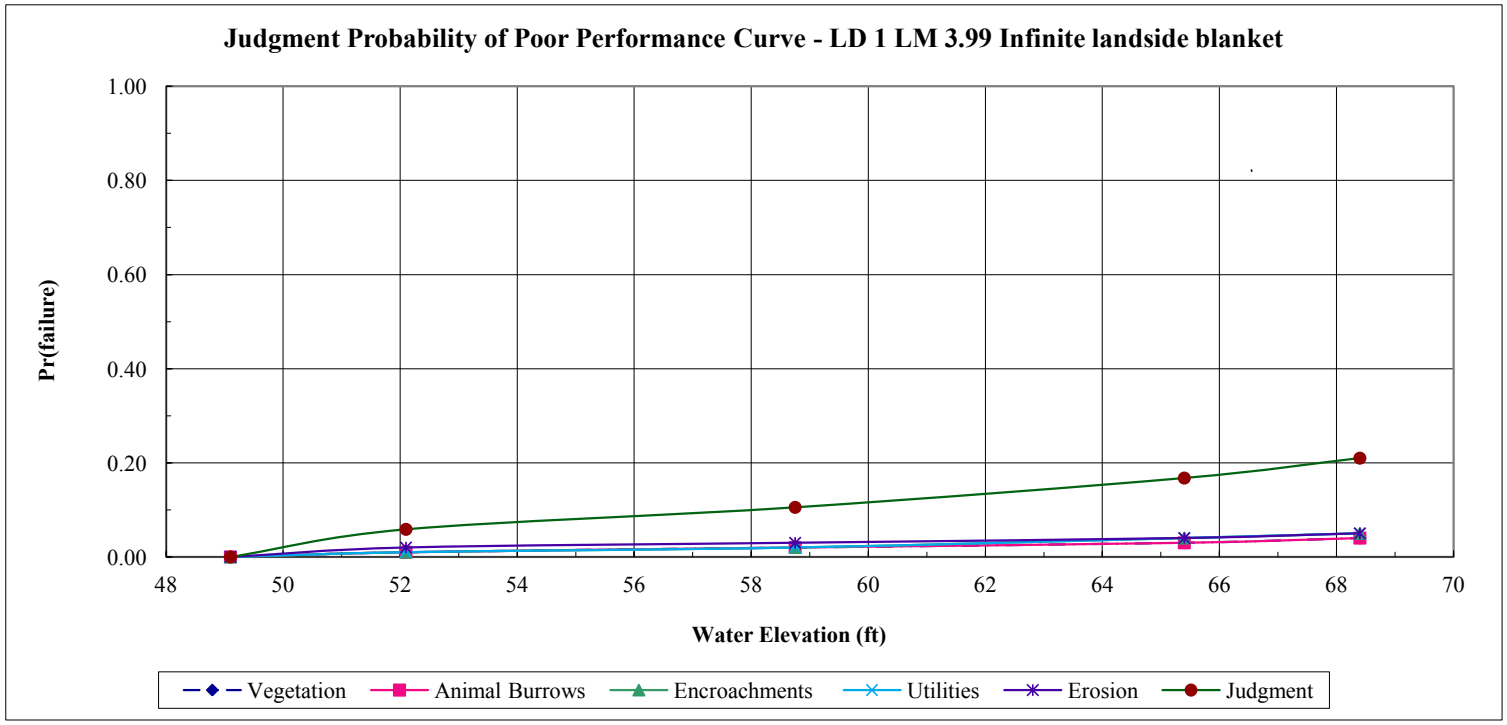
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

Levee Mile: 3.99
River Mile: 2127081.8143
Analysis Case: Infinite landside blanket

Crest Elev.: 68.40
L/S Toe Elev.: 49.10
W/S Toe Elev.: 40.00

Analysis By: T. Huynh
Checked By: E.W. James\J.
Date: Updated 09/26

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
49.10	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
52.10	0.0100	0.9900	0.0100	0.9900	0.0100	0.9900	0.0100	0.9900	0.0200	0.9800	0.0586	0.9414
58.75	0.0200	0.9800	0.0200	0.9800	0.0200	0.9800	0.0200	0.9800	0.0300	0.9700	0.1053	0.8947
65.40	0.0300	0.9700	0.0300	0.9700	0.0400	0.9600	0.0400	0.9600	0.0400	0.9600	0.1676	0.8324
68.40	0.0400	0.9600	0.0400	0.9600	0.0500	0.9500	0.0500	0.9500	0.0500	0.9500	0.2098	0.7902



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

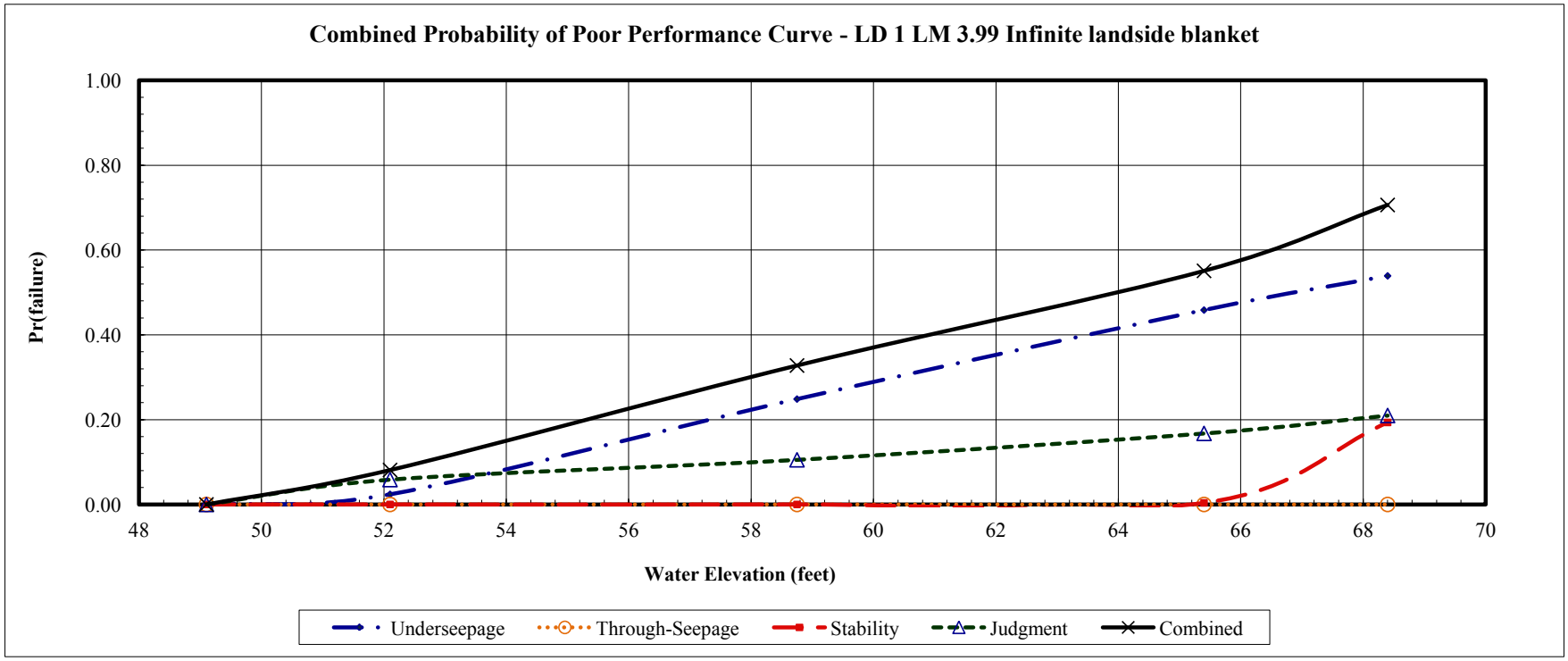
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

Levee Mile: 3.99
River Mile: 2127081.8143 N
Analysis Case: Infinite landside blanket

Crest Elev.: 68.40
L/S Toe Elev.: 49.10
W/S Toe Elev.: 40.00

Analysis By: T. Huynh
Checked By: E.W. James\J.M.
Date: Updated 09/26/2(

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
49.10	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
52.10	0.0240	0.9760	0.0000	1.0000	0.0000	1.0000	0.0586	0.9414	0.0812	0.9188
58.75	0.2485	0.7515	0.0000	1.0000	0.0000	1.0000	0.1053	0.8947	0.3276	0.6724
65.40	0.4584	0.5416	0.0000	1.0000	0.0038	0.9962	0.1676	0.8324	0.5509	0.4491
68.40	0.5390	0.4610	0.0000	1.0000	0.1934	0.8066	0.2098	0.7902	0.7062	0.2938



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Feather River South
Basin and Reach: LD 1

Levee Mile: 9.31
Coordinates: 2156078.18 N; 6673804.98 E
Analysis Case Infinite landside blanket

Crest Elev.: 78.50
L/S Toe Elev.: 51.40
W/S Toe Elev.: 53.70

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
SL0001_001B	20					14					CL, ML	0.007	SP-SM	14	2000				
WL0001_059B	25					14.9					CL, CH, sML	0.01	SM	1.2	120				
WL0001_012S	31					16.5					CL, sML	0.01	/GW-GM, GP-(	5.73	573				
2F-07-05	8.5					2.5					sML	0.14	SM	1.2	9				
2F-07-06	12					5					sML	0.14	SM	1.2	9				
2F-07-01	10					40					CL, ML	0.01	/SW-SM, GM S	13	1300				
WL0001_064B	12										ML, CL	0.01	SP-SM	14	1400				
		17	9	92	53		15	13	162	87						773	797	343652	98

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
SL0001_001B	CL, ML	20	0.007				20	SP-SM	14	14							14
WL0001_059B	CL, CH, sML	25	0.01				25	SM	14.9	1.2							1.2
WL0001_012S	CL, sML	31	0.01				31	SM	8	1.2	GW-GM, GP-GM	8.5	10				5.73
2F-07-05	sML	8.5	0.14				8.5	SM	2.5	1.2							1.2
2F-07-06	sML	12	0.14				12	SM	5	1.2							1.2
2F-07-01	CL, ML	10	0.01				10	SP	30	14	SW-SM, GM SW	10	10				13
WL0001_064B	ML, CL	12	0.01				12	SP-SM	9	14							14

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

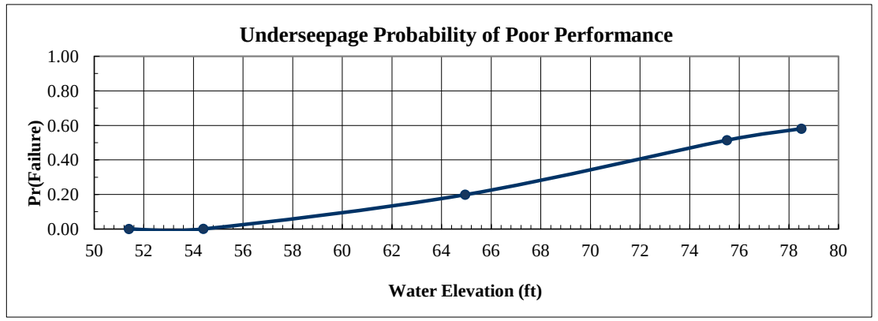
Levee Mile: 9.31
River Mile: 2156078.18 N; 6673804.98 E
Analysis Case Infinite landside blanket

Crest Elev.: 78.50
L/S Toe Elev.: 51.40
W/S Toe Elev.: 53.70

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	773	758	98
Blanket Thickness (z)	17	9	53
Aquifer Thickness (d)	15	13	87

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	50	130	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	51.40	0.0000
Toe+3ft	3.00	54.40	0.0008
Half Height	13.55	64.95	0.1986
Crest-3ft	24.10	75.50	0.5140
Crest	27.10	78.50	0.5805

Crest		Rh
Head =	27.10	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	773	17.00	15.00	49.79	443.98	0.0240	19.29	1.13		
2	1531	17.00	15.00	49.89	624.73	0.0186	21.04	1.24	0.164025	24.22
3	15	17.00	15.00	41.56	62.79	0.0640	7.26	0.43		
4	773	26.01	15.00	49.86	549.17	0.0206	20.41	0.78	0.455625	67.28
5	773	7.99	15.00	49.56	304.37	0.0310	17.04	2.13		
6	773	17.00	28.05	49.89	607.13	0.0356	20.91	1.23	0.057600	8.50
7	773	17.00	1.95	48.44	160.08	0.0058	12.82	0.75		
								Total	0.677250	100.00

E[I] = 1.130000
Var[I]= 0.677250
σ[I]= 0.822952
V(I) = 0.728276

E[ln I] = -0.090542
σ [ln I] = 0.652319

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.138801
F(z) =	0.419459
Pr(f) % =	58.054056

Crest-3ft		Rh
Head =	24.10	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	773	17.00	15.00	49.79	443.98	0.0240	17.15	1.01		
2	1531	17.00	15.00	49.89	624.73	0.0186	18.71	1.10	0.129600	24.28
3	15	17.00	15.00	41.56	62.79	0.0640	6.46	0.38		
4	773	26.01	15.00	49.86	549.17	0.0206	18.15	0.70	0.360000	67.45
5	773	7.99	15.00	49.56	304.37	0.0310	15.16	1.90		
6	773	17.00	28.05	49.89	607.13	0.0356	18.59	1.09	0.044100	8.26
7	773	17.00	1.95	48.44	160.08	0.0058	11.40	0.67		
								Total	0.533700	100.00

E[I] = 1.010000
Var[I]= 0.533700
σ[I]= 0.730548
V(I) = 0.723315

E[ln I] = -0.200451
σ [ln I] = 0.648693

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.309008
F(z) =	0.486047
Pr(f) % =	51.395286

Half Height		Rh
Head =	13.55	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	773	17.00	15.00	49.79	443.98	0.0240	9.64	0.57		
2	1531	17.00	15.00	49.89	624.73	0.0186	10.52	0.62	0.042025	24.60
3	15	17.00	15.00	41.56	62.79	0.0640	3.63	0.21		
4	773	26.01	15.00	49.86	549.17	0.0206	10.21	0.39	0.115600	67.66
5	773	7.99	15.00	49.56	304.37	0.0310	8.52	1.07		
6	773	17.00	28.05	49.89	607.13	0.0356	10.45	0.61	0.013225	7.74
7	773	17.00	1.95	48.44	160.08	0.0058	6.41	0.38		
								Total	0.170850	100.00

E[I] = 0.570000
Var[I]= 0.170850
σ[I]= 0.413340
V(I) = 0.725158

E[ln I] = -0.773396
σ [ln I] = 0.650042

Ic= 0.80
ln(I crit) = -0.223144

β =	-1.189764
F(z) =	0.801360
Pr(f) % =	19.864030

Toe+3ft		Rh
Head =	3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	773	17.00	15.00	49.79	443.98	0.0240	2.14	0.13		
2	1531	17.00	15.00	49.89	624.73	0.0186	2.33	0.14	0.002025	23.68
3	15	17.00	15.00	41.56	62.79	0.0640	0.80	0.05		
4	773	26.01	15.00	49.86	549.17	0.0206	2.26	0.09	0.005625	65.79
5	773	7.99	15.00	49.56	304.37	0.0310	1.89	0.24		
6	773	17.00	28.05	49.89	607.13	0.0356	2.31	0.14	0.000900	10.53
7	773	17.00	1.95	48.44	160.08	0.0058	1.42	0.08		
								Total	0.008550	100.00

E[I] = 0.130000
Var[I]= 0.008550
σ[I]= 0.092466
V(I) = 0.711279

E[ln I] = -2.244922
σ [ln I] = 0.639845

Ic= 0.80
ln(I crit) = -0.223144

β =	-3.508538
F(z) =	0.999211
Pr(f) % =	0.078941

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

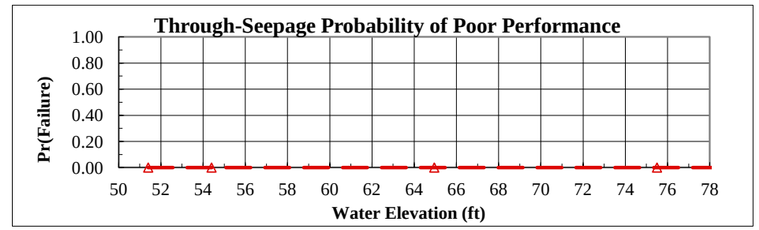
Levee Mile: 9.31
River Mile: 2156078.18 N; 6673804.98 E
Analysis Case Infinite landside blanket

Crest Elev.: 78.50
L/S Toe Elev.: 51.40
W/S Toe Elev.: 53.70

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	51.40	0.0000
Toe+3ft	3.00	54.40	0.000000
Half Height	13.55	64.95	0.000000
Crest-3ft	24.10	75.50	0.000000
Crest	27.10	78.50	0.000000

Crest | **Head =** 27.10 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 24.10 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 13.55 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

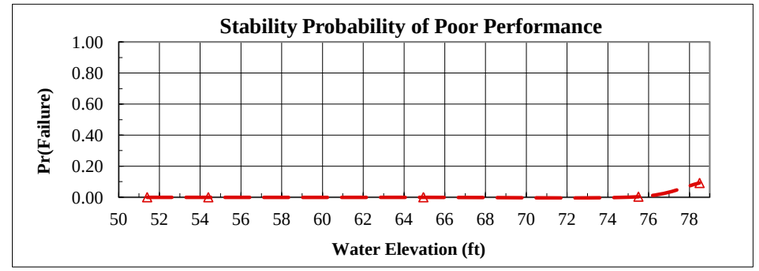
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

Levee Mile: 9.31
River Mile: 2156078.18 N; 6673804.98 E
Analysis Case Infinite landside blanket

Crest Elev.: 78.50
L/S Toe Elev.: 51.40
W/S Toe Elev.: 53.70

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Random Variables				
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %	
Levee ϕ'	29	1	5.00	
Levee γ	120	6	5.00	
Foundation c'	150	17	11.50	
Foundation γ	120	6	5.00	
Foundation ϕ'	31	4	11.50	



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	51.40	0.0000
Toe+3ft	3.00	54.40	0.000000
Half Height	13.55	64.95	0.000000
Crest-3ft	24.10	75.50	0.003757
Crest	27.10	78.50	0.091721

Crest	Head =	27.10	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.50		
2	28	120	150	120	31	1.69	0.024806	13.98
3	30	120	150	120	31	1.37		
4	29	114	150	120	31	1.46	0.001560	0.88
5	29	126	150	120	31	1.54		
6	29	120	133	120	31	1.70	0.136530	76.92
7	29	120	167	120	31	0.96		
8	29	120	150	114	31	1.53	0.003782	2.13
9	29	120	150	126	31	1.41		
10	29	120	150	120	27	1.58	0.010816	6.09
11	29	120	150	120	35	1.37		

E[FS] = 1.499000 E[ln FS] = 0.366785 Total 0.177495 100.00
Var[FS]= 0.177495
σ[FS]= 0.421302 σ[ln FS]= 0.275730
V(FS) = 0.281055
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	1.330229
F(z) =	0.091721
Pr(f) % =	9.172136

Crest-3ft	Head =	24.10	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.25		
2	28	120	150	120	31	1.35	0.009604	90.64
3	30	120	150	120	31	1.16		
4	29	114	150	120	31	1.24	0.000144	1.36
5	29	126	150	120	31	1.26		
6	29	120	133	120	31	1.25	0.000784	7.40
7	29	120	167	120	31	1.19		
8	29	120	150	114	31	1.25	0.000064	0.60
9	29	120	150	126	31	1.23		
10	29	120	150	120	27	1.25	0.000000	0.00
11	29	120	150	120	35	1.25		

E[FS] = 1.250000 E[ln FS] = 0.219764 Total 0.010596 100.00
Var[FS]= 0.010596
σ[FS]= 0.102937 σ[ln FS]= 0.082210
V(FS) = 0.082349
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	2.673193
F(z) =	0.003757
Pr(f) % =	0.375665

Half Height	Head =	13.55	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

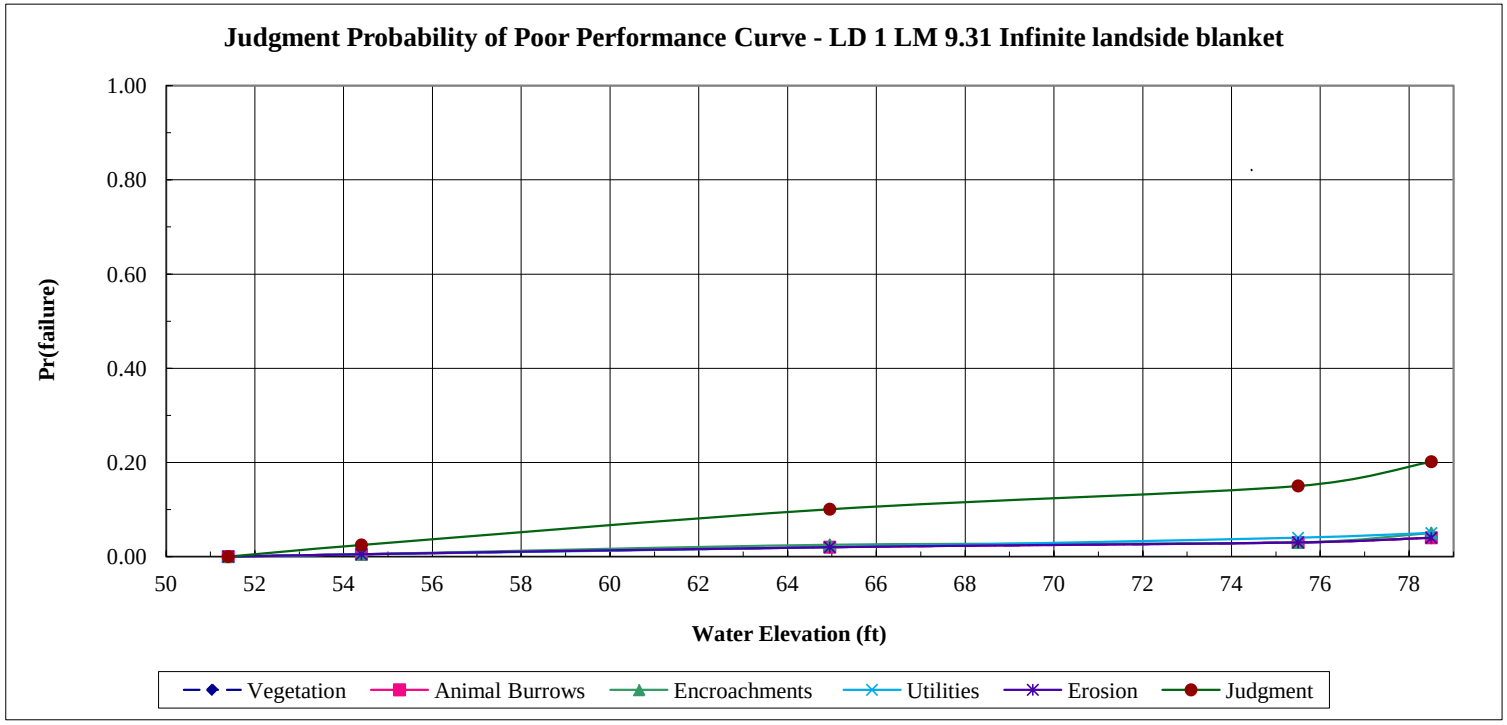
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

Levee Mile: 9.31
River Mile: 2156078.18 N
Analysis Case: Infinite landside blanket

Crest Elev.: 78.50
L/S Toe Elev.: 51.40
W/S Toe Elev.: 53.70

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 2/21/

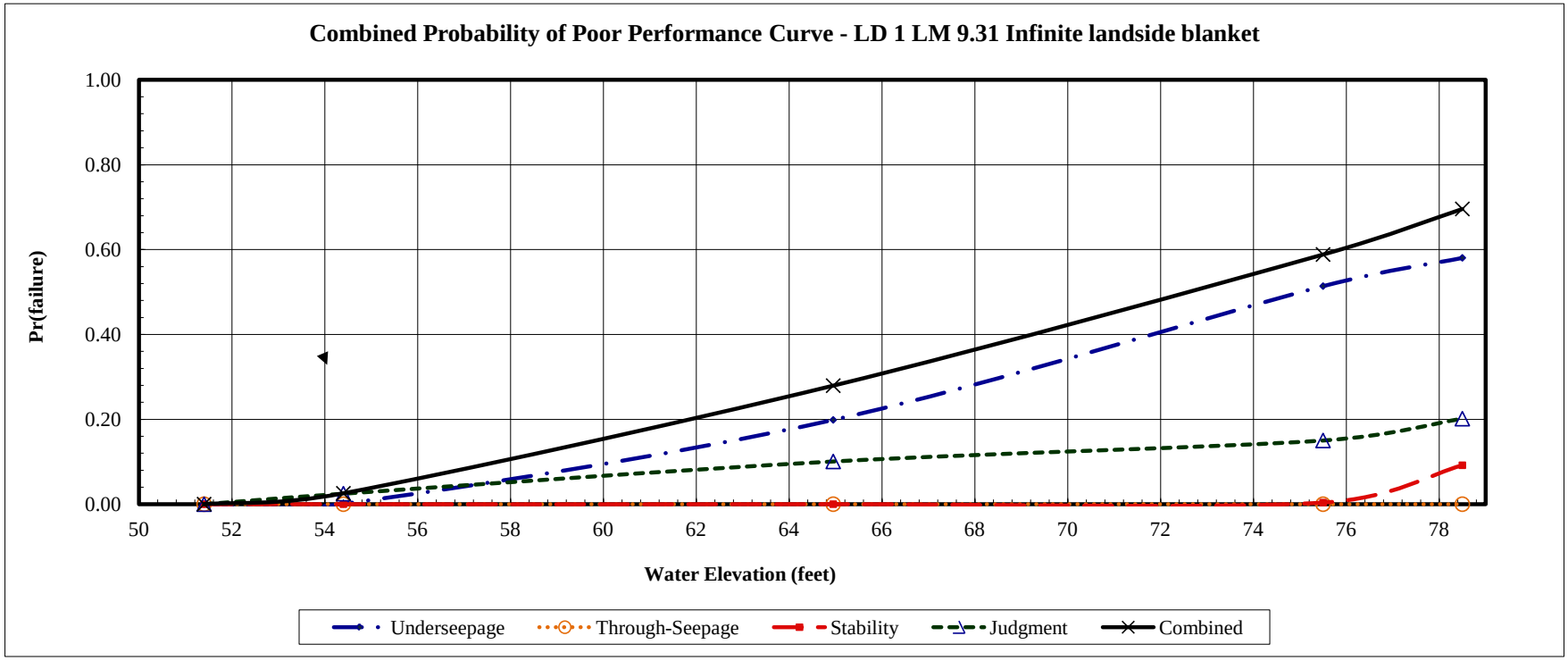
Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
51.40	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
54.40	0.0050	0.9950	0.0050	0.9950	0.0050	0.9950	0.0050	0.9950	0.0050	0.9950	0.0248	0.9752
64.95	0.0200	0.9800	0.0200	0.9800	0.0250	0.9750	0.0200	0.9800	0.0200	0.9800	0.1007	0.8993
75.50	0.0300	0.9700	0.0300	0.9700	0.0300	0.9700	0.0400	0.9600	0.0300	0.9700	0.1501	0.8499
78.50	0.0400	0.9600	0.0400	0.9600	0.0500	0.9500	0.0500	0.9500	0.0400	0.9600	0.2015	0.7985



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	Sutter Feasibility Study	**Levee Mile:**	9.31	**Crest Elev.:**	78.50	**Analysis By:**	T. Huynh
Study Area:	Feather River South	**River Mile:**	2156078.18 N; (	**L/S Toe Elev.:**	51.40	**Checked By:**	E.W. James/J.M.
River Section:	LD 1	**Analysis Case:**	Infinite landside blanket	**W/S Toe Elev.:**	53.70	**Date:**	Updated 2/21/20

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
51.40	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
54.40	0.0008	0.9992	0.0000	1.0000	0.0000	1.0000	0.0248	0.9752	0.0255	0.9745
64.95	0.1986	0.8014	0.0000	1.0000	0.0000	1.0000	0.1007	0.8993	0.2793	0.7207
75.50	0.5140	0.4860	0.0000	1.0000	0.0038	0.9962	0.1501	0.8499	0.5885	0.4115
78.50	0.5805	0.4195	0.0000	1.0000	0.0917	0.9083	0.2015	0.7985	0.6958	0.3042



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Feather River South
Basin and Reach: LD 9

Levee Mile: 0.52
Coordinates: 2188213.88 N; 6668679.41 E
Analysis Case Infinite landside blanket

Crest Elev.: 86.52
L/S Toe Elev.: 66.50
W/S Toe Elev.: 58.90

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WL0009_001S	19.5					52.5					CL	0.007	SP-SM/SP-SC	14	2000				
WL0009_007A	10					50.8					CL, CLs	0.007	SM, SP, SM/SW	17.94	2563				
WL0009_007A	7.5					27.5					CL, ML	0.007	SP-SM, SP-SC	14	2000				
WL0009_12B	13					10.8					CL-ML	0.007	SP-SM/SW	23.46	3351				
2F-07-7	10	13	5	55	38	17.5	28	17	383	61	ML	0.14	SW/SP-SM	26	186	1730	1217	1685521	70
SL0009_001B	10					24					SC, CL, ML	1.4	SP-SM/SP-SC	14	10				
WL0009_009B	20					11					ML, CL	0.007	SM, SP-SM	14	2000				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WL0009_001S	CL	19.5	0.007				19.5	SP-SM	47	14	SP-SC	5.5	14				14
WL0009_007A	CL, CLs	10	0.007				10	SP-SM, SP, SM	36.5	14	SW-SM	14.3	28				17.94
WL0009_007A	CL, ML	7.5	0.007				7.5	SP-SM, SP-SC	27.5	14							14
WL0009_12B	CL-ML	13	0.007				13	SP-SM	3.5	14	SW	7.3	28				23.46
2F-07-7	ML	10	0.14				10	SW	15	28	SP-SM	2.5	14				26
SL0009_001B	SC, CL, ML	10	1.4				10	SP-SM	12	14	SP-SC	12	14				14
WL0009_009B	ML, CL	20	0.007				20	SM, SP-SM	11	14							14

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 9

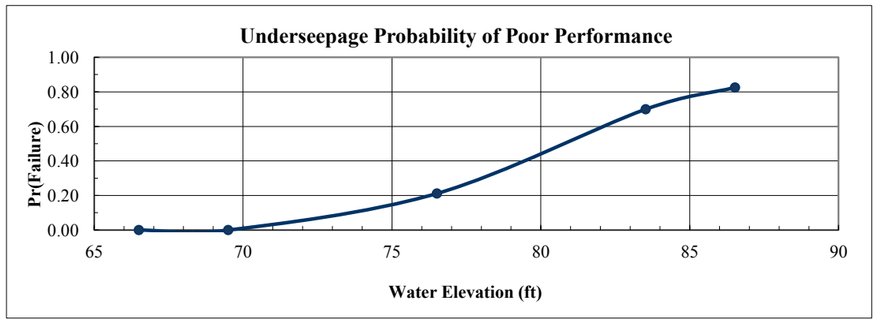
Levee Mile: 0.52
River Mile: 2188213.88 N; 6668679.41 E
Analysis Case Infinite landside blanket

Crest Elev.: 86.52
L/S Toe Elev.: 66.50
W/S Toe Elev.: 58.90

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	1730	1217	70
Blanket Thickness (z)	13	5	38
Aquifer Thickness (d)	28	17	61

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	50	130	∞	112



Analysis Case	Head	Elevation	Pr(f) Stability
Toe	0.00	66.50	0.0000
Toe+3ft	3.00	69.50	0.0001
Half Height	10.01	76.51	0.2117
Crest-3ft	17.02	83.52	0.6995
Crest	20.02	86.52	0.8254

Crest	Rh
Head = 20.02	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1730	13.00	28.00	49.93	793.55	0.0288	16.32	1.26		
2	2947	13.00	28.00	49.96	1035.72	0.0230	17.06	1.31	0.012100	4.40
3	513	13.00	28.00	49.78	432.12	0.0458	14.14	1.09		
4	1730	18.00	28.00	49.95	933.77	0.0251	16.79	0.93	0.255025	92.66
5	1730	8.00	28.00	49.89	622.51	0.0349	15.53	1.94		
6	1730	13.00	45.00	49.96	1006.01	0.0379	16.98	1.31	0.008100	2.94
7	1730	13.00	11.00	49.83	497.38	0.0162	14.70	1.13		
								Total	0.275225	100.00

E[I] = 1.260000
Var[I]= 0.275225
σ[I]= 0.524619
V(I) = 0.416364

E[ln I] = 0.151176
σ [ln I] = 0.399838

Ic= 0.80
ln(I crit) = -0.223144

β =	0.378094
F(z) =	0.174591
Pr(f) % =	82.540925

Crest-3ft	Rh
Head = 17.02	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1730	13.00	28.00	49.93	793.55	0.0288	13.87	1.07		
2	2947	13.00	28.00	49.96	1035.72	0.0230	14.50	1.12	0.010000	4.99
3	513	13.00	28.00	49.78	432.12	0.0458	12.02	0.92		
4	1730	18.00	28.00	49.95	933.77	0.0251	14.27	0.79	0.184900	92.21
5	1730	8.00	28.00	49.89	622.51	0.0349	13.20	1.65		
6	1730	13.00	45.00	49.96	1006.01	0.0379	14.44	1.11	0.005625	2.81
7	1730	13.00	11.00	49.83	497.38	0.0162	12.50	0.96		
								Total	0.200525	100.00

E[I] = 1.070000
Var[I]= 0.200525
σ[I]= 0.447800
V(I) = 0.418505

E[ln I] = -0.013038
σ [ln I] = 0.401737

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.032453
F(z) =	0.300489
Pr(f) % =	69.951062

Half Height	Rh
Head = 10.01	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1730	13.00	28.00	49.93	793.55	0.0288	8.16	0.63		
2	2947	13.00	28.00	49.96	1035.72	0.0230	8.53	0.66	0.003600	5.32
3	513	13.00	28.00	49.78	432.12	0.0458	7.07	0.54		
4	1730	18.00	28.00	49.95	933.77	0.0251	8.39	0.47	0.062500	92.32
5	1730	8.00	28.00	49.89	622.51	0.0349	7.77	0.97		
6	1730	13.00	45.00	49.96	1006.01	0.0379	8.49	0.65	0.001600	2.36
7	1730	13.00	11.00	49.83	497.38	0.0162	7.35	0.57		
								Total	0.067700	100.00

E[I] = 0.630000
Var[I]= 0.067700
σ[I]= 0.260192
V(I) = 0.413004

E[ln I] = -0.540782
σ [ln I] = 0.396853

Ic= 0.80
ln(I crit) = -0.223144

β =	-1.362674
F(z) =	0.788258
Pr(f) % =	21.174185

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1730	13.00	28.00	49.93	793.55	0.0288	2.45	0.19		
2	2947	13.00	28.00	49.96	1035.72	0.0230	2.56	0.20	0.000400	6.40
3	513	13.00	28.00	49.78	432.12	0.0458	2.12	0.16		
4	1730	18.00	28.00	49.95	933.77	0.0251	2.52	0.14	0.005625	90.00
5	1730	8.00	28.00	49.89	622.51	0.0349	2.33	0.29		
6	1730	13.00	45.00	49.96	1006.01	0.0379	2.54	0.20	0.000225	3.60
7	1730	13.00	11.00	49.83	497.38	0.0162	2.20	0.17		
								Total	0.006250	100.00

E[I] = 0.190000
Var[I]= 0.006250
σ[I]= 0.079057
V(I) = 0.416089

E[ln I] = -1.740569
σ [ln I] = 0.399594

Ic= 0.80
ln(I crit) = -0.223144

β =	-4.355841
F(z) =	0.999927
Pr(f) % =	0.007311

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 9

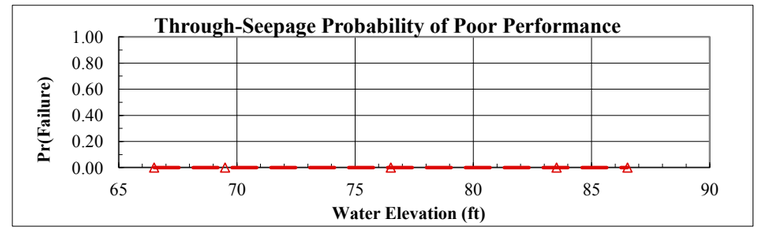
Levee Mile: 0.52
River Mile: 2188213.88 N; 6668679.41 E
Analysis Case Infinite landside blanket

Crest Elev.: 86.52
L/S Toe Elev.: 66.50
W/S Toe Elev.: 58.90

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f) Stability
Toe	0.00	66.50	0.0000
Toe+3ft	3.00	69.50	0.000000
Half Height	10.01	76.51	0.000000
Crest-3ft	17.02	83.52	0.000000
Crest	20.02	86.52	0.000000

Crest | **Head =** 20.02 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 17.02 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 10.01 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

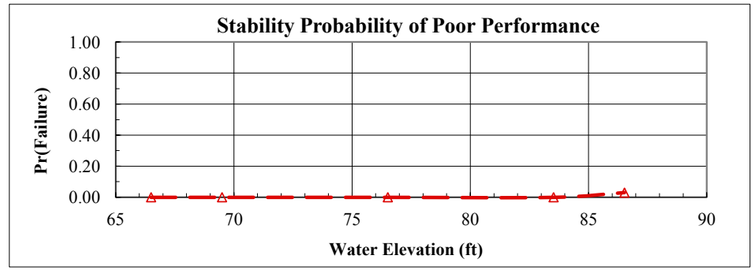
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 9

Levee Mile: 0.52
River Mile: 2188213.88 N; 6668679.41 E
Analysis Case Infinite landside blanket

Crest Elev.: 86.52
L/S Toe Elev.: 66.50
W/S Toe Elev.: 58.90

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee Φ	29	4	13.00
Levee γ	120	48	40.00
Foundation Cohesion	150	11	7.00
Foundation γ	120	16	13.00
Foundation Φ	31	12	40.00



Analysis Case	Head	Elevation	Pr(f) Stability
Toe	0.00	66.50	0.0000
Toe+3ft	3.00	69.50	0.000000
Half Height	10.01	76.51	0.000000
Crest-3ft	17.02	83.52	0.000000
Crest	20.02	86.52	0.029687

Crest	Head =	20.02	Pr(f)=0	NO

Run	Levee Φ	Levee γ	Foundation Cohesion	Foundation g	Foundation Φ	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.29		
2	25	120	150	120	31	1.22	0.000576	2.01
3	33	120	150	120	31	1.27		
4	29	72	150	120	31	1.30	0.003025	10.58
5	29	168	150	120	31	1.19		
6	29	120	139	120	31	1.23	0.000110	0.39
7	29	120	161	120	31	1.21		
8	29	120	150	104	31	1.33	0.013225	46.24
9	29	120	150	136	31	1.10		
10	29	120	150	120	19	1.36	0.011664	40.78
11	29	120	150	120	43	1.14		

E[FS] = 1.290000 E[ln FS] = 0.246122 Total 0.028600 100.00
Var[FS]= 0.028600
σ[FS]= 0.169116 σ[ln FS]= 0.130540
V(FS) = 0.131098
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	1.885419
F(z) =	0.029687
Pr(f) % =	2.968665

Crest-3ft	Head =	17.02	Pr(f)=0	YES

Run	Levee Φ	Levee γ	Foundation Cohesion	Foundation g	Foundation Φ	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.25		
2	25	120	150	120	31	1.35	0.009604	90.64
3	33	120	150	120	31	1.16		
4	29	72	150	120	31	1.24	0.000144	1.36
5	29	168	150	120	31	1.26		
6	29	120	139	120	31	1.25	0.000784	7.40
7	29	120	161	120	31	1.19		
8	29	120	150	104	31	1.25	0.000064	0.60
9	29	120	150	136	31	1.23		
10	29	120	150	120	19	1.25	0.000000	0.00
11	29	120	150	120	43	1.25		

E[FS] = E[ln FS] = Total 0.010596 100.00
Var[FS]= 0.010596
σ[FS]= 0.102937 σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	10.01	Pr(f)=0	YES

Run	Levee Φ	Levee γ	Foundation Cohesion	Foundation g	Foundation Φ	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	25	120	150	120	31			
3	33	120	150	120	31			
4	29	72	150	120	31			
5	29	168	150	120	31			
6	29	120	139	120	31			
7	29	120	161	120	31			
8	29	120	150	104	31			
9	29	120	150	136	31			
10	29	120	150	120	19			
11	29	120	150	120	43			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee γ	Foundation Cohesion	Foundation g	Foundation Φ	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	25	120	150	120	31			
3	33	120	150	120	31			
4	29	72	150	120	31			
5	29	168	150	120	31			
6	29	120	139	120	31			
7	29	120	161	120	31			
8	29	120	150	104	31			
9	29	120	150	136	31			
10	29	120	150	120	19			
11	29	120	150	120	43			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

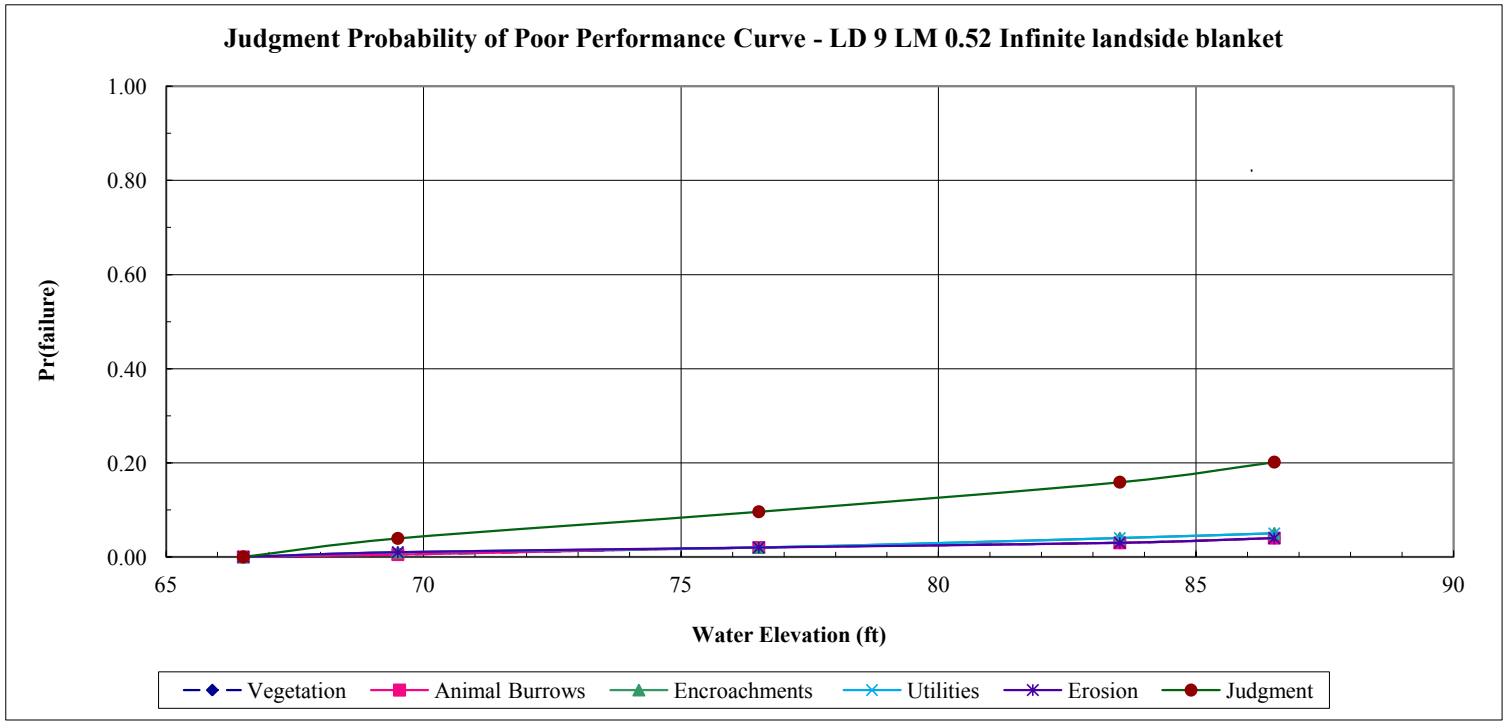
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 9

Levee Mile: 0.52
River Mile: 2188213.88 N
Analysis Case: Infinite landside blanket

Crest Elev.: 86.52
L/S Toe Elev.: 66.50
W/S Toe Elev.: 58.90

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 9/12/

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
66.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
69.50	0.0050	0.9950	0.0050	0.9950	0.0100	0.9900	0.0100	0.9900	0.0100	0.9900	0.0394	0.9606
76.51	0.0200	0.9800	0.0200	0.9800	0.0200	0.9800	0.0200	0.9800	0.0200	0.9800	0.0961	0.9039
83.52	0.0300	0.9700	0.0300	0.9700	0.0400	0.9600	0.0400	0.9600	0.0300	0.9700	0.1589	0.8411
86.52	0.0400	0.9600	0.0400	0.9600	0.0500	0.9500	0.0500	0.9500	0.0400	0.9600	0.2015	0.7985



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

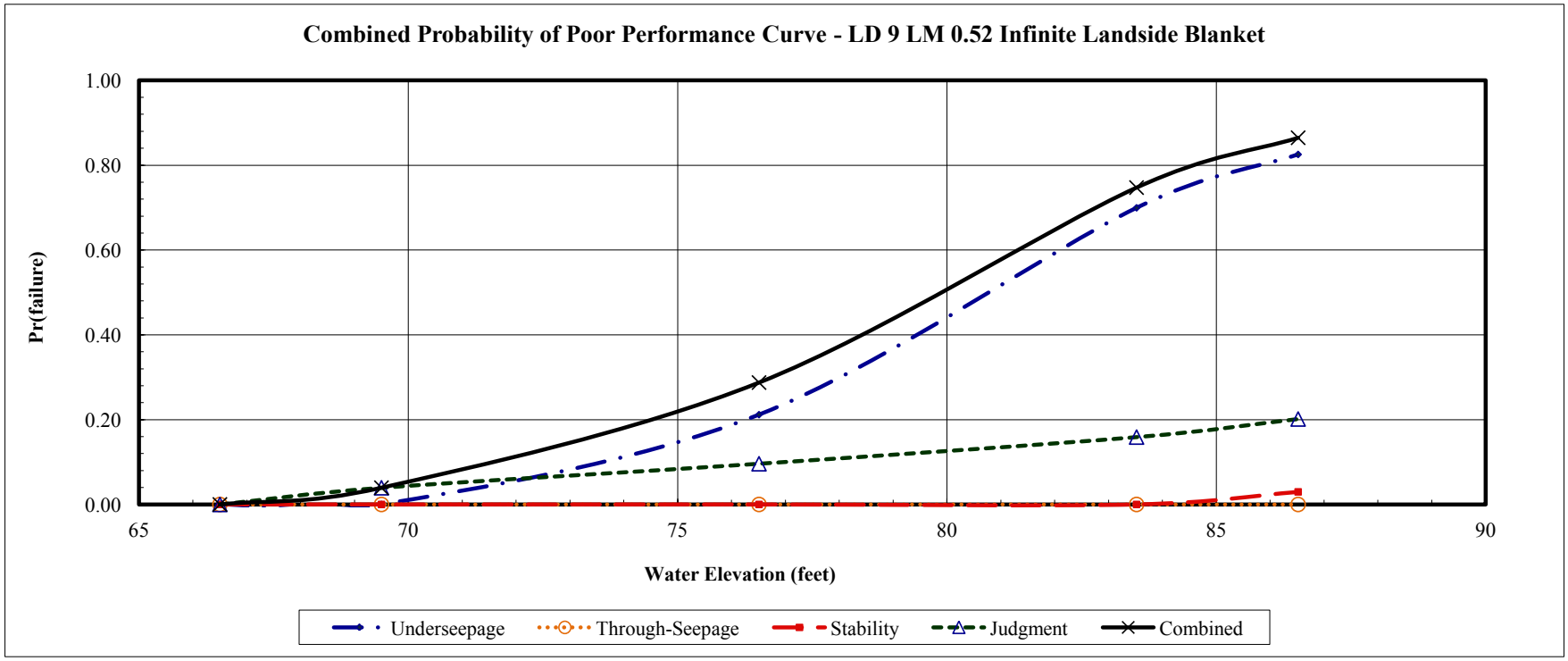
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 9

Levee Mile: 0.52
River Mile: 2188213.88 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 86.52
L/S Toe Elev.: 66.50
W/S Toe Elev.: 58.90

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/12/20

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
66.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
69.50	0.0001	0.9999	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0394	0.9606
76.51	0.2117	0.7883	0.0000	1.0000	0.0000	1.0000	0.0961	0.9039	0.2875	0.7125
83.52	0.6995	0.3005	0.0000	1.0000	0.0000	1.0000	0.1589	0.8411	0.7473	0.2527
86.52	0.8254	0.1746	0.0000	1.0000	0.0297	0.9703	0.2015	0.7985	0.8647	0.1353



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Feather River North
Basin and Reach: MA 16

Levee Mile: 0.90
Coordinates: 2224154.37 N; 6664999.34 E
Analysis Case Infinite landside blanket

Crest Elev.: 91.02
L/S Toe Elev.: 79.30
W/S Toe Elev.: 77.30

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WM0016_011B	5					9.5					CL-ML	0.007	SP-SM/SP	25.79	3684				
WM0016_010C	15					30					CL-ML	0.007	SP	28	4000				
WM0016_012C	5					10					CL-ML	0.007	SP	28	4000				
WM0016_009C	3					14					CL-ML	0.0284	SP	28	986				
WM0016_001A	4	6	5	24	76	15	16	8	70	53	CL	0.0284	SW-SM	14	493	2633	1742	3033812	66

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WM0016_011B	CL-ML	5	0.007				5	SP-SM	1.5	14	SP	8	28				25.79
WM0016_010C	CL-ML	18	0.007				18	SP	30	28							28
WM0016_012C	CL-ML	5	0.007				5	SP	10	28							28
WM0016_009C	CL-ML	3	0.0284				3	SP	14	28							28
WM0016_001A	CL	4	0.0284				4	SW-SM	15	14							14

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

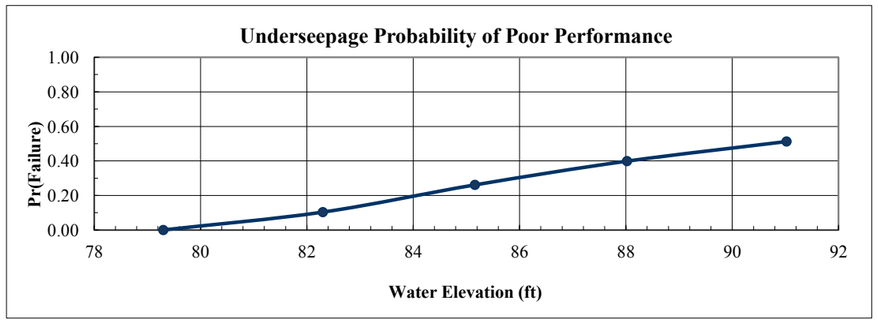
Levee Mile: 0.90
River Mile: 2224154.37 N; 6664999.34 E
Analysis Case Infinite landside blanket

Crest Elev.: 91.02
L/S Toe Elev.: 79.30
W/S Toe Elev.: 77.30

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	2633	1742	66
Blanket Thickness (z)	6	5	76
Aquifer Thickness (d)	16	8	53

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	15	130	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	79.30	0.0000
Toe+3ft	3.00	82.30	0.1036
Half Height	5.86	85.16	0.2614
Crest-3ft	8.72	88.02	0.3990
Crest	11.72	91.02	0.5127

Crest	Rh
Head = 11.72	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	2633	6.40	15.70	15.00	514.32	0.0238	9.14	1.43		
2	4374	6.40	15.70	15.00	662.98	0.0194	9.62	1.50	0.018225	0.45
3	891	6.40	15.70	14.99	299.19	0.0353	7.89	1.23		
4	2633	11.28	15.70	15.00	682.76	0.0190	9.67	0.86	4.040100	99.33
5	2633	1.52	15.70	14.98	250.77	0.0397	7.43	4.88		
6	2633	6.40	24.05	15.00	636.55	0.0308	9.55	1.49	0.009025	0.22
7	2633	6.40	7.35	14.99	351.94	0.0148	8.30	1.30		
								Total	4.067350	100.00

E[I] = 1.430000
Var[I]= 4.067350
σ[I]= 2.016767
V(I) = 1.410327

E[ln I] = -0.189799
σ [ln I] = 1.046397

Ic= 0.80
ln(I crit) = -0.223144

β = -0.181383
F(z) = 0.487289
Pr(f) % = 51.271073

Crest-3ft	Rh
Head = 8.72	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	2633	6.40	15.70	15.00	514.32	0.0238	6.80	1.06		
2	4374	6.40	15.70	15.00	662.98	0.0194	7.16	1.12	0.010000	0.44
3	891	6.40	15.70	14.99	299.19	0.0353	5.87	0.92		
4	2633	11.28	15.70	15.00	682.76	0.0190	7.19	0.64	2.235025	99.34
5	2633	1.52	15.70	14.98	250.77	0.0397	5.53	3.63		
6	2633	6.40	24.05	15.00	636.55	0.0308	7.10	1.11	0.004900	0.22
7	2633	6.40	7.35	14.99	351.94	0.0148	6.18	0.97		
								Total	2.249925	100.00

E[I] = 1.060000
Var[I]= 2.249925
σ[I]= 1.499975
V(I) = 1.415071

E[ln I] = -0.491441
σ [ln I] = 1.048532

Ic= 0.80
ln(I crit) = -0.223144

β = -0.468694
F(z) = 0.600978
Pr(f) % = 39.902203

Half Height	Rh
Head = 5.86	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	2633	6.40	15.70	15.00	514.32	0.0238	4.57	0.71		
2	4374	6.40	15.70	15.00	662.98	0.0194	4.81	0.75	0.004225	0.42
3	891	6.40	15.70	14.99	299.19	0.0353	3.95	0.62		
4	2633	11.28	15.70	15.00	682.76	0.0190	4.83	0.43	1.010025	99.34
5	2633	1.52	15.70	14.98	250.77	0.0397	3.71	2.44		
6	2633	6.40	24.05	15.00	636.55	0.0308	4.77	0.75	0.002500	0.25
7	2633	6.40	7.35	14.99	351.94	0.0148	4.15	0.65		
								Total	1.016750	100.00

E[I] = 0.710000
Var[I]= 1.016750
σ[I]= 1.008340
V(I) = 1.420197

E[ln I] = -0.894615
σ [ln I] = 1.050833

Ic= 0.80
ln(I crit) = -0.223144

β = -0.851339
F(z) = 0.738585
Pr(f) % = 26.141473

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	2633	6.40	15.70	15.00	514.32	0.0238	2.34	0.37		
2	4374	6.40	15.70	15.00	662.98	0.0194	2.46	0.38	0.000900	0.34
3	891	6.40	15.70	14.99	299.19	0.0353	2.02	0.32		
4	2633	11.28	15.70	15.00	682.76	0.0190	2.47	0.22	0.265225	99.43
5	2633	1.52	15.70	14.98	250.77	0.0397	1.90	1.25		
6	2633	6.40	24.05	15.00	636.55	0.0308	2.44	0.38	0.000625	0.23
7	2633	6.40	7.35	14.99	351.94	0.0148	2.12	0.33		
								Total	0.266750	100.00

E[I] = 0.370000
Var[I]= 0.266750
σ[I]= 0.516478
V(I) = 1.395888

E[ln I] = -1.534901
σ [ln I] = 1.039855

Ic= 0.80
ln(I crit) = -0.223144

β = -1.476073
F(z) = 0.896432
Pr(f) % = 10.356768

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

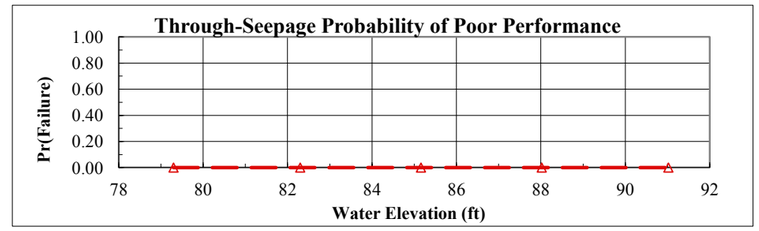
Levee Mile: 0.90
River Mile: 2224154.37 N; 6664999.34 E
Analysis Case Infinite landside blanket

Crest Elev.: 91.02
L/S Toe Elev.: 79.30
W/S Toe Elev.: 77.30

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	15	1.5	10.00
Initial Porosity (n)	45	4.50	10.00
Initial Permeability (Ko)	1.00E-10	3.00E-11	30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	79.30	0.0000
Toe+3ft	3.00	82.30	0.000000
Half Height	5.86	85.16	0.000000
Crest-3ft	8.72	88.02	0.000000
Crest	11.72	91.02	0.000000

Crest | **Head =** 11.72 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 8.72 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 5.86 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

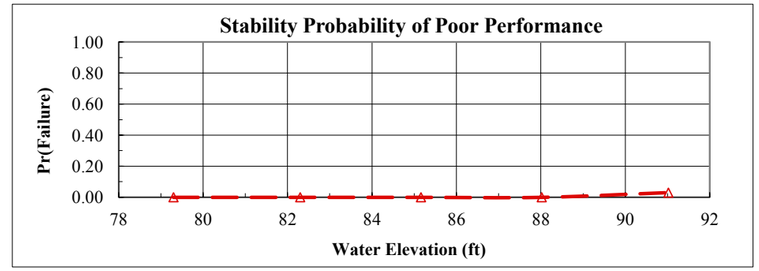
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 0.90
River Mile: 2224154.37 N; 6664999.34 E
Analysis Case Infinite landside blanket

Crest Elev.: 91.02
L/S Toe Elev.: 79.30
W/S Toe Elev.: 77.30

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee ϕ'	31	4	12.00
Levee γ	125	6	5.00
Foundation c'	150	50	33.00
Foundation γ	115	6	5.00
Foundation ϕ'	28	3	12.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	79.30	0.0000
Toe+3ft	3.00	82.30	0.000000
Half Height	5.86	85.16	0.000000
Crest-3ft	8.72	88.02	0.000000
Crest	11.72	91.02	0.029687

Crest	Head =	11.72	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28	1.29		
2	27	125	150	115	28	1.22	0.000576	2.01
3	35	125	150	115	28	1.27		
4	31	119	150	115	28	1.30	0.003025	10.58
5	31	131	150	115	28	1.19		
6	31	125	100	115	28	1.23	0.000110	0.39
7	31	125	200	115	28	1.21		
8	31	125	150	109	28	1.33	0.013225	46.24
9	31	125	150	121	28	1.10		
10	31	125	150	115	25	1.36	0.011664	40.78
11	31	125	150	115	31	1.14		

E[FS] = 1.290000 E[ln FS] = 0.246122 Total 0.028600 100.00
Var[FS]= 0.028600
σ[FS]= 0.169116 σ[ln FS]= 0.130540
V(FS) = 0.131098
FS req'd = 1.00 ln(FS req'd) = 0.000000

β = 1.885419
F(z) = 0.029687
Pr(f) % = 2.968665

Crest-3ft	Head =	8.72	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28	1.25		
2	27	125	150	115	28	1.35	0.009604	90.64
3	35	125	150	115	28	1.16		
4	31	119	150	115	28	1.24	0.000144	1.36
5	31	131	150	115	28	1.26		
6	31	125	100	115	28	1.25	0.000784	7.40
7	31	125	200	115	28	1.19		
8	31	125	150	109	28	1.25	0.000064	0.60
9	31	125	150	121	28	1.23		
10	31	125	150	115	25	1.25	0.000000	0.00
11	31	125	150	115	31	1.25		

E[FS] = E[ln FS] = Total 0.010596 100.00
Var[FS]= 0.010596
σ[FS]= 0.102937 σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height	Head =	5.86	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

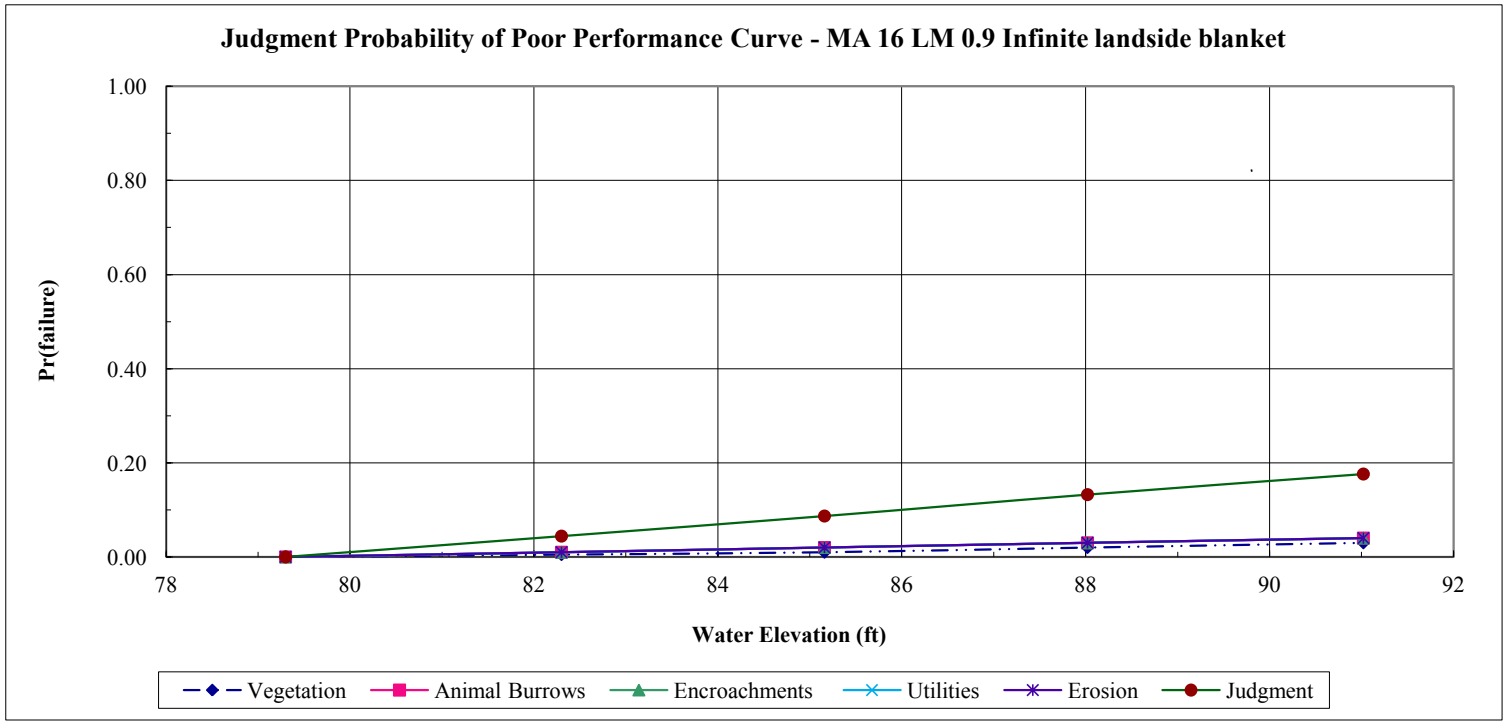
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 0.90
River Mile: 2224154.37 N
Analysis Case: Infinite landside blanket

Crest Elev.: 91.02
L/S Toe Elev.: 79.30
W/S Toe Elev.: 77.30

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 9/12/

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
79.30	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
82.30	0.0050	0.9950	0.0100	0.9900	0.0100	0.9900	0.0100	0.9900	0.0100	0.9900	0.0442	0.9558
85.16	0.0100	0.9900	0.0200	0.9800	0.0200	0.9800	0.0200	0.9800	0.0200	0.9800	0.0869	0.9131
88.02	0.0200	0.9800	0.0300	0.9700	0.0300	0.9700	0.0300	0.9700	0.0300	0.9700	0.1324	0.8676
91.02	0.0300	0.9700	0.0400	0.9600	0.0400	0.9600	0.0400	0.9600	0.0400	0.9600	0.1761	0.8239



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

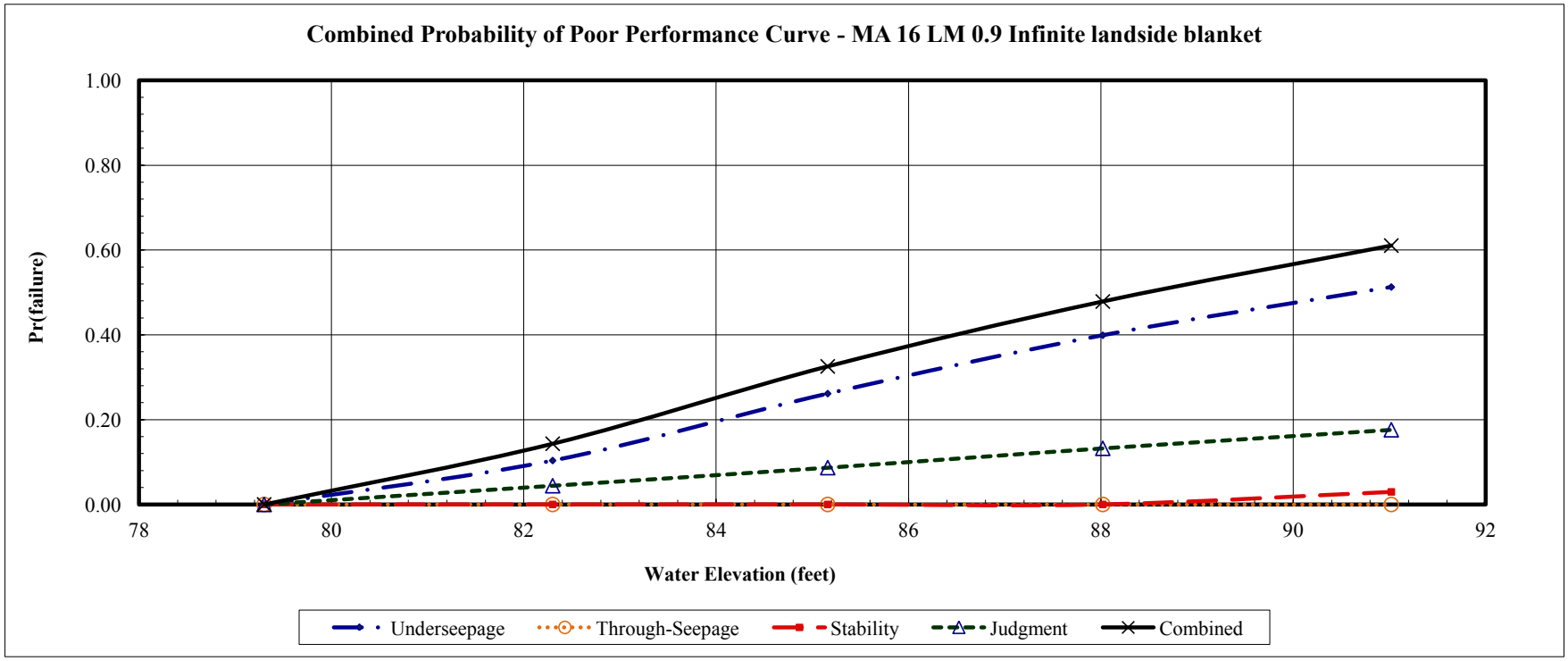
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 0.90
River Mile: 2224154.37 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 91.02
L/S Toe Elev.: 79.30
W/S Toe Elev.: 77.30

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/12/20

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
79.30	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
82.30	0.1036	0.8964	0.0000	1.0000	0.0000	1.0000	0.0442	0.9558	0.1432	0.8568
85.16	0.2614	0.7386	0.0000	1.0000	0.0000	1.0000	0.0869	0.9131	0.3256	0.6744
88.02	0.3990	0.6010	0.0000	1.0000	0.0000	1.0000	0.1324	0.8676	0.4786	0.5214
91.02	0.5127	0.4873	0.0000	1.0000	0.0297	0.9703	0.1761	0.8239	0.6105	0.3895



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Feather River North
Basin and Reach: MA 16

Levee Mile: 2.90
Coordinates: 2233626.25 N; 6664328.54 E
Analysis Case Infinite landside blanket

Crest Elev.: 93.73
L/S Toe Elev.: 81.50
W/S Toe Elev.: 79.40

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WM0016_011B	9					10					CL-ML	0.28	SP	28	100				
WM0016_014B	20					18					CL-ML	0.0071	SW, SM, SC	14	1972				
WM0016_018B	10					12					SC, SM	0.14	SP,SW,SM	28	200				
WM0016_019S	18					18					CL, ML	0.0071	SP	28	3944				
WM0016_020B	10					10					CL, ML	0.28	SW-SM	14	50				
WM0016_022S	8					4					CL	0.28	SP-SM	14	50				
		13	5	26	41		12	5	29	45						1053	1603	2569602	98

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)		Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)			Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WM0016_011B	CL-ML	9	0.28				9	9	SP	10	28							28
WM0016_014B	CL-ML	20	0.0071				20	20	SW, SM, SC	18	14							14
WM0016_018B	SC, SM	10	0.14				10	10	SP,SW,SM	12	28							28
WM0016_019S	CL, ML	18	0.0071				18	18	SP	18	28							28
WM0016_020B	CL, ML	10	0.28				10	10	SW-SM	10	14							14
WM0016_022S	CL	8	0.28				10	10	SP-SM	3	14							14

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

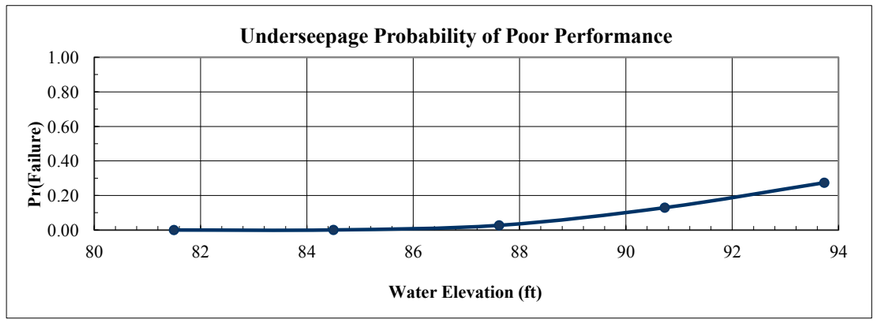
Levee Mile: 2.90
River Mile: 2233626.25 N; 6664328.54 E
Analysis Case Infinite landside blanket

Crest Elev.: 93.73
L/S Toe Elev.: 81.50
W/S Toe Elev.: 79.40

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	1053	1032	98
Blanket Thickness (z)	13	5	41
Aquifer Thickness (d)	12	5	45

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	50	130	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	81.50	0.0000
Toe+3ft	3.00	84.50	0.0005
Half Height	6.12	87.62	0.0271
Crest-3ft	9.23	90.73	0.1294
Crest	12.23	93.73	0.2738

Crest		Rh
Head =	12.23	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1053	12.50	12.00	49.74	397.35	0.0208	8.42	0.67		
2	2084	12.50	12.00	49.87	559.12	0.0162	9.25	0.74	0.062500	45.32
3	21	12.50	12.00	39.97	56.19	0.0531	3.04	0.24		
4	1053	17.63	12.00	49.81	471.87	0.0184	8.86	0.50	0.072900	52.86
5	1053	7.37	12.00	49.56	305.14	0.0248	7.70	1.04		
6	1053	12.50	17.37	49.82	478.01	0.0264	8.89	0.71	0.002500	1.81
7	1053	12.50	6.63	49.53	295.43	0.0140	7.61	0.61		
								Total	0.137900	100.00

E[I] = 0.670000
Var[I]= 0.137900
σ[I]= 0.371349
V(I) = 0.554252

E[ln I] = -0.534420
σ [ln I] = 0.517575

Ic= 0.80
ln(I crit) = -0.223144

β =	-1.032545
F(z) =	0.726217
Pr(f) % =	27.378272

Crest-3ft		Rh
Head =	9.23	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1053	12.50	12.00	49.74	397.35	0.0208	6.36	0.51		
2	2084	12.50	12.00	49.87	559.12	0.0162	6.98	0.56	0.036100	45.28
3	21	12.50	12.00	39.97	56.19	0.0531	2.29	0.18		
4	1053	17.63	12.00	49.81	471.87	0.0184	6.68	0.38	0.042025	52.71
5	1053	7.37	12.00	49.56	305.14	0.0248	5.81	0.79		
6	1053	12.50	17.37	49.82	478.01	0.0264	6.71	0.54	0.001600	2.01
7	1053	12.50	6.63	49.53	295.43	0.0140	5.74	0.46		
								Total	0.079725	100.00

E[I] = 0.510000
Var[I]= 0.079725
σ[I]= 0.282356
V(I) = 0.553640

E[ln I] = -0.807027
σ [ln I] = 0.517073

Ic= 0.80
ln(I crit) = -0.223144

β =	-1.560760
F(z) =	0.870595
Pr(f) % =	12.940497

Half Height		Rh
Head =	6.12	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1053	12.50	12.00	49.74	397.35	0.0208	4.21	0.34		
2	2084	12.50	12.00	49.87	559.12	0.0162	4.63	0.37	0.015625	44.96
3	21	12.50	12.00	39.97	56.19	0.0531	1.52	0.12		
4	1053	17.63	12.00	49.81	471.87	0.0184	4.43	0.25	0.018225	52.45
5	1053	7.37	12.00	49.56	305.14	0.0248	3.85	0.52		
6	1053	12.50	17.37	49.82	478.01	0.0264	4.44	0.36	0.000900	2.59
7	1053	12.50	6.63	49.53	295.43	0.0140	3.80	0.30		
								Total	0.034750	100.00

E[I] = 0.340000
Var[I]= 0.034750
σ[I]= 0.186414
V(I) = 0.548275

E[ln I] = -1.210225
σ [ln I] = 0.512669

Ic= 0.80
ln(I crit) = -0.223144

β =	-2.360633
F(z) =	0.972909
Pr(f) % =	2.709121

Toe+3ft		Rh
Head =	3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1053	12.50	12.00	49.74	397.35	0.0208	2.07	0.17		
2	2084	12.50	12.00	49.87	559.12	0.0162	2.27	0.18	0.003600	41.86
3	21	12.50	12.00	39.97	56.19	0.0531	0.75	0.06		
4	1053	17.63	12.00	49.81	471.87	0.0184	2.17	0.12	0.004900	56.98
5	1053	7.37	12.00	49.56	305.14	0.0248	1.89	0.26		
6	1053	12.50	17.37	49.82	478.01	0.0264	2.18	0.17	0.000100	1.16
7	1053	12.50	6.63	49.53	295.43	0.0140	1.87	0.15		
								Total	0.008600	100.00

E[I] = 0.170000
Var[I]= 0.008600
σ[I]= 0.092736
V(I) = 0.545507

E[ln I] = -1.902207
σ [ln I] = 0.510391

Ic= 0.80
ln(I crit) = -0.223144

β =	-3.726957
F(z) =	0.999499
Pr(f) % =	0.050137

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

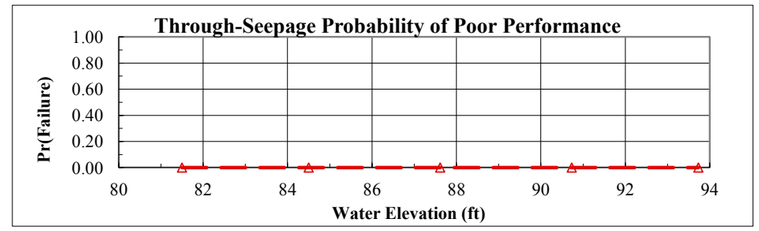
Levee Mile: 2.90
River Mile: 2233626.25 N; 6664328.54 E
Analysis Case Infinite landside blanket

Crest Elev.: 93.73
L/S Toe Elev.: 81.50
W/S Toe Elev.: 79.40

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	81.50	0.0000
Toe+3ft	3.00	84.50	0.000000
Half Height	6.12	87.62	0.000000
Crest-3ft	9.23	90.73	0.000000
Crest	12.23	93.73	0.000000

Crest	Head =	12.23	Horizontal Gradient (Ix) =	

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Crest-3ft	Head =	9.23	Horizontal Gradient (Ix) =	

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	6.12	Horizontal Gradient (Ix) =	

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Horizontal Gradient (Ix) =	

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

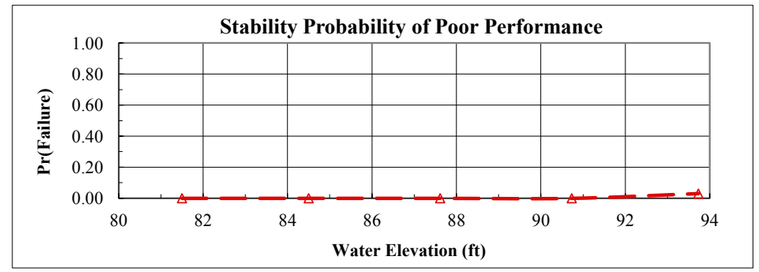
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 2.90
River Mile: 2233626.25 N; 6664328.54 E
Analysis Case Infinite landside blanket

Crest Elev.: 93.73
L/S Toe Elev.: 81.50
W/S Toe Elev.: 79.40

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables				
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %	
Levee ϕ'	29	1	5.00	
Levee γ	120	6	5.00	
Foundation c'	150	17	11.50	
Foundation γ	120	6	5.00	
Foundation ϕ'	31	4	11.50	



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	81.50	0.0000
Toe+3ft	3.00	84.50	0.000000
Half Height	6.12	87.62	0.000000
Crest-3ft	9.23	90.73	0.000000
Crest	12.23	93.73	0.029687

Crest	Head =	12.23	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.29		
2	28	120	150	120	31	1.22	0.000576	2.01
3	30	120	150	120	31	1.27		
4	29	114	150	120	31	1.30	0.003025	10.58
5	29	126	150	120	31	1.19		
6	29	120	133	120	31	1.23	0.000110	0.39
7	29	120	167	120	31	1.21		
8	29	120	150	114	31	1.33	0.013225	46.24
9	29	120	150	126	31	1.10		
10	29	120	150	120	27	1.36	0.011664	40.78
11	29	120	150	120	35	1.14		

E[FS] = 1.290000 E[ln FS] = 0.246122 Total 0.028600 100.00
Var[FS]= 0.028600
σ[FS]= 0.169116 σ[ln FS]= 0.130540
V(FS) = 0.131098
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	1.885419
F(z) =	0.029687
Pr(f) % =	2.968665

Crest-3ft	Head =	9.23	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.25		
2	28	120	150	120	31	1.35	0.009604	90.64
3	30	120	150	120	31	1.16		
4	29	114	150	120	31	1.24	0.000144	1.36
5	29	126	150	120	31	1.26		
6	29	120	133	120	31	1.25	0.000784	7.40
7	29	120	167	120	31	1.19		
8	29	120	150	114	31	1.25	0.000064	0.60
9	29	120	150	126	31	1.23		
10	29	120	150	120	27	1.25	0.000000	0.00
11	29	120	150	120	35	1.25		

E[FS] = E[ln FS] = Total 0.010596 100.00
Var[FS]= 0.010596
σ[FS]= 0.102937 σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	6.12	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

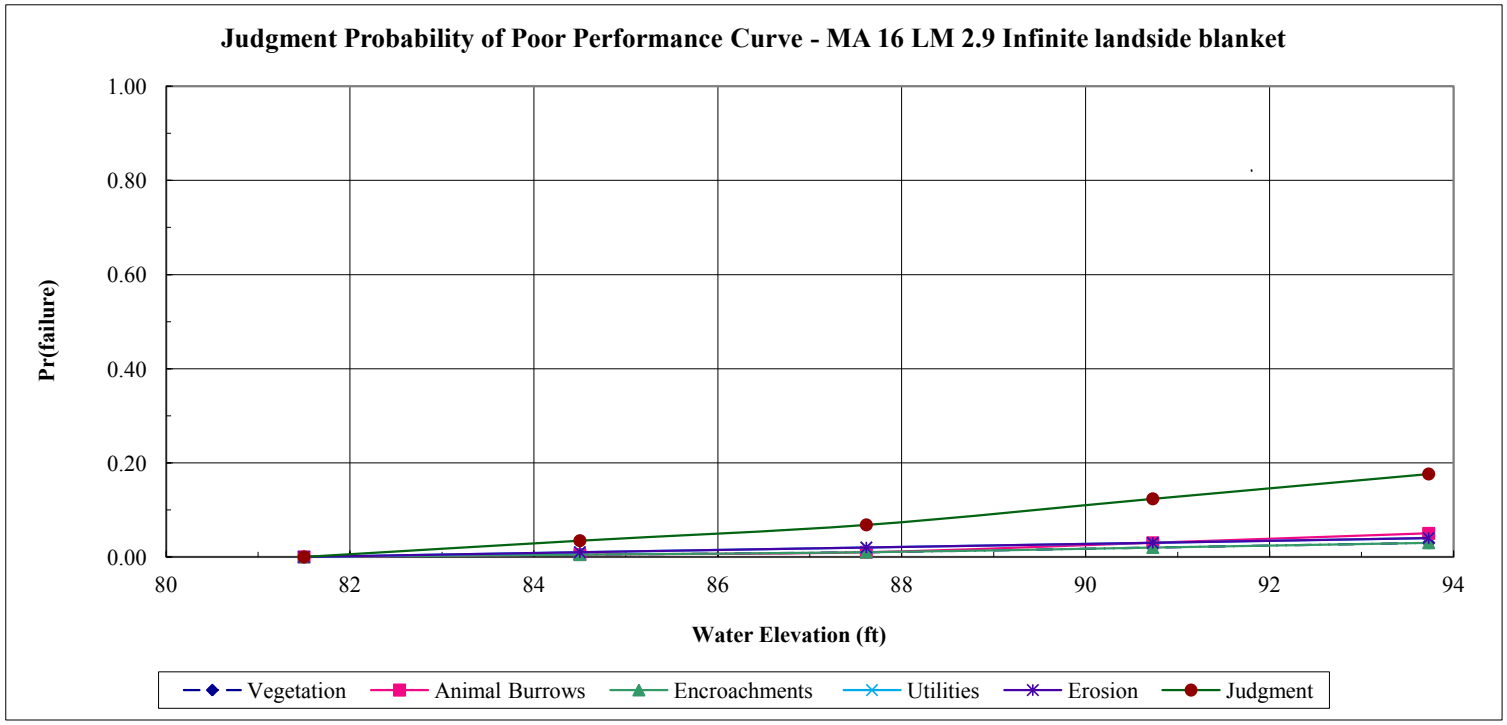
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 2.90
River Mile: 2233626.25 N
Analysis Case: Infinite landside blanket

Crest Elev.: 93.73
L/S Toe Elev.: 81.50
W/S Toe Elev.: 79.40

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 9/12/

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
81.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
84.50	0.0050	0.9950	0.0050	0.9950	0.0050	0.9950	0.0100	0.9900	0.0100	0.9900	0.0345	0.9655
87.62	0.0100	0.9900	0.0100	0.9900	0.0100	0.9900	0.0200	0.9800	0.0200	0.9800	0.0681	0.9319
90.73	0.0200	0.9800	0.0300	0.9700	0.0200	0.9800	0.0300	0.9700	0.0300	0.9700	0.1235	0.8765
93.73	0.0300	0.9700	0.0500	0.9500	0.0300	0.9700	0.0400	0.9600	0.0400	0.9600	0.1762	0.8238



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

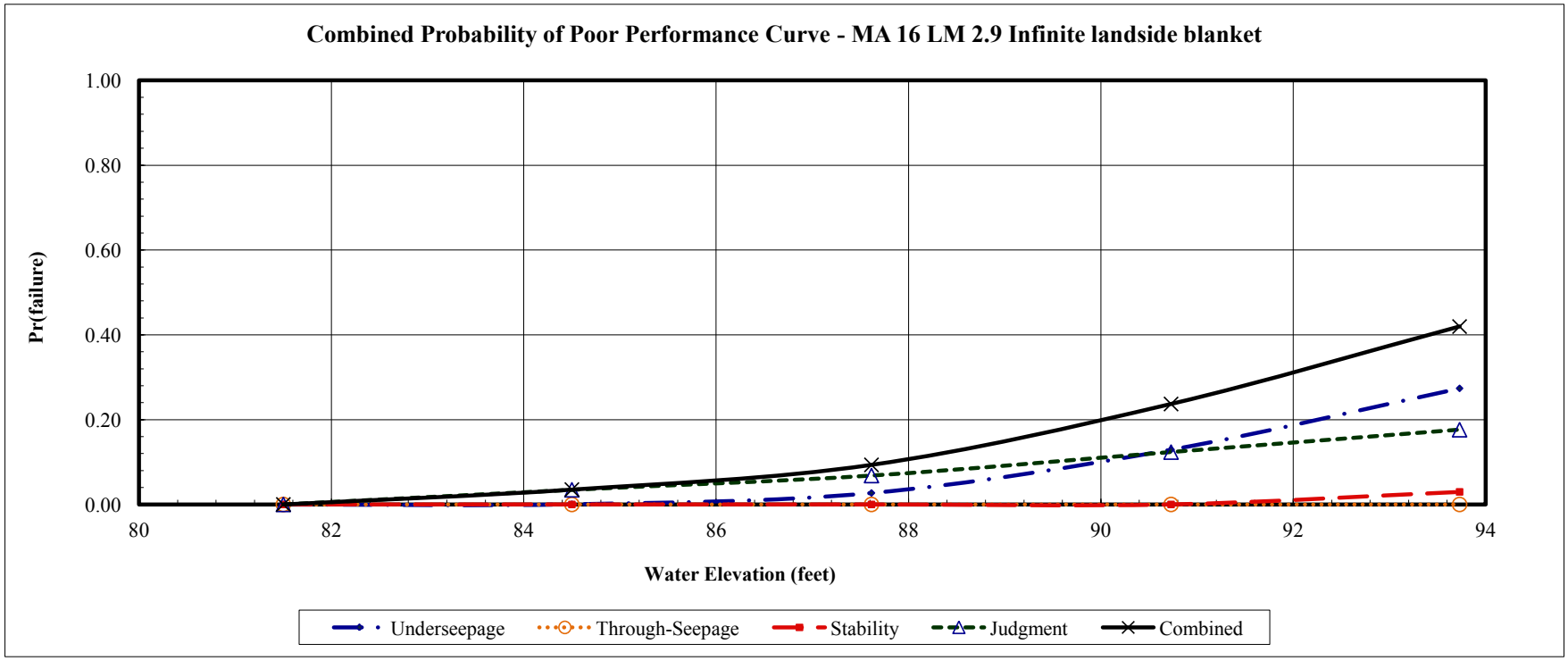
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 2.90
River Mile: 2233626.25 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 93.73
L/S Toe Elev.: 81.50
W/S Toe Elev.: 79.40

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/12/20

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
81.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
84.50	0.0005	0.9995	0.0000	1.0000	0.0000	1.0000	0.0345	0.9655	0.0350	0.9650
87.62	0.0271	0.9729	0.0000	1.0000	0.0000	1.0000	0.0681	0.9319	0.0934	0.9066
90.73	0.1294	0.8706	0.0000	1.0000	0.0000	1.0000	0.1235	0.8765	0.2369	0.7631
93.73	0.2738	0.7262	0.0000	1.0000	0.0297	0.9703	0.1762	0.8238	0.4195	0.5805



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Feather River North
Basin and Reach: Hamilton Bend (MA 7)

Levee Mile: 0.51
Coordinates: 2288660.96 N; 6662820.24 E
Analysis Case Infinite landside blanket

Crest Elev.: 136.00
L/S Toe Elev.: 118.00
W/S Toe Elev.: 118.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WM0007_069B	10					31.5					sML	0.14	GP-GM, GP,GV	560	4000				
WM0007_068S	9.02					49					L, CL-MLs/SP-	0.007	M,GW, GP-GM	70	10000				
WM0007_013S	8.71					60.5					CL-ML,sCL/MI	0.01	GW,GP,GC,SM	560	56000				
WM0007_067B/S	15					10					sML/SM	0.14	GP-GM	35	250				
WM0007_66S	16	12	3	10	26	13	30	21	482	70	ML, SC/CL-MI	0.14	SP	14	100	11742	20103	306195806	98
WM0007_65B/S	13.3					15.5					sML/SM	0.14	SW, SP-SM,GP-	14	100				

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Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WM0007_069B	sML	10	0.14				10	GP-GM, GP,GV	31.5	560							560
WM0007_068S	sML, CL-MLs	9	0.007	SP-SM	2	0.7	9.02	M,GW, GP-GM	49	70							70
WM0007_013S	CL-ML,sCL	8.5	0.01	ML	3	0.14	8.71	GW,GP,GC,SM	60.5	560							560
WM0007_067B/S	sML	11	0.14	SM	8	0.28	15	GP-GM	10	35							35
WM0007_66S	sML, SC	9	0.14	CL-ML	7	0.14	16	SP	13	14							14
WM0007_65B/S	sML	12	0.14	SM	6.5	0.7	13.3	SW, SP-SM,GP-	15.5	14							14

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: Hamilton Bend (MA 7)

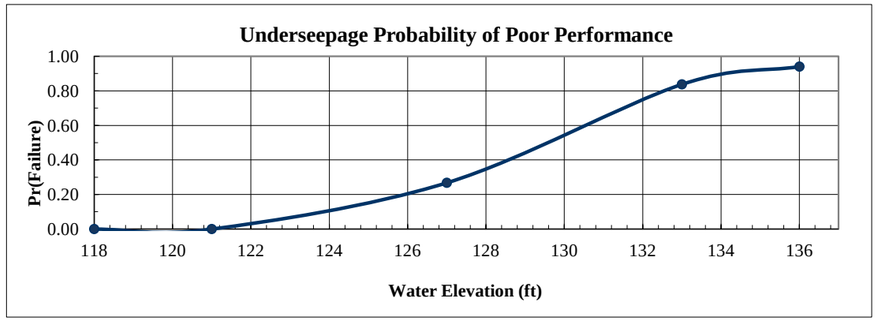
Levee Mile: 0.51
River Mile: 2288660.96 N; 6662820.24 E
Analysis Case Infinite landside blanket

Crest Elev.: 136.00
L/S Toe Elev.: 118.00
W/S Toe Elev.: 118.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	11742	11507	98
Blanket Thickness (z)	12	3	26
Aquifer Thickness (d)	30	21	70

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	50	130	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	118.00	0.0000
Toe+3ft	3.00	121.00	0.0000
Half Height	9.00	127.00	0.2678
Crest-3ft	15.00	133.00	0.8376
Crest	18.00	136.00	0.9405

Crest	Rh
Head = 18.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	11742	12.01	29.92	49.99	2053.54	0.0134	16.55	1.38		
2	23249	12.01	29.92	50.00	2889.58	0.0097	16.94	1.41	0.057600	28.54
3	235	12.01	29.92	49.51	290.41	0.0637	11.12	0.93		
4	11742	15.18	29.92	49.99	2309.16	0.0120	16.70	1.10	0.140625	69.68
5	11742	8.83	29.92	49.99	1761.20	0.0154	16.33	1.85		
6	11742	12.01	50.86	49.99	2677.48	0.0178	16.87	1.41	0.003600	1.78
7	11742	12.01	8.98	49.97	1124.79	0.0069	15.52	1.29		
								Total	0.201825	100.00

E[I] = 1.380000
Var[I]= 0.201825
σ[I]= 0.449249
V(I) = 0.325543

E[ln I] = 0.271718
σ [ln I] = 0.317380

Ic= 0.80
ln(I crit) = -0.223144

β =	0.856129
F(z) =	0.059474
Pr(f) % =	94.052644

Crest-3ft	Rh
Head = 15.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	11742	12.01	29.92	49.99	2053.54	0.0134	13.79	1.15		
2	23249	12.01	29.92	50.00	2889.58	0.0097	14.12	1.18	0.042025	29.99
3	235	12.01	29.92	49.51	290.41	0.0637	9.27	0.77		
4	11742	15.18	29.92	49.99	2309.16	0.0120	13.92	0.92	0.096100	68.57
5	11742	8.83	29.92	49.99	1761.20	0.0154	13.61	1.54		
6	11742	12.01	50.86	49.99	2677.48	0.0178	14.06	1.17	0.002025	1.44
7	11742	12.01	8.98	49.97	1124.79	0.0069	12.93	1.08		
								Total	0.140150	100.00

E[I] = 1.150000
Var[I]= 0.140150
σ[I]= 0.374366
V(I) = 0.325536

E[ln I] = 0.089399
σ [ln I] = 0.317374

Ic= 0.80
ln(I crit) = -0.223144

β =	0.281684
F(z) =	0.162367
Pr(f) % =	83.763344

Half Height	Rh
Head = 9.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	11742	12.01	29.92	49.99	2053.54	0.0134	8.27	0.69		
2	23249	12.01	29.92	50.00	2889.58	0.0097	8.47	0.71	0.015625	29.85
3	235	12.01	29.92	49.51	290.41	0.0637	5.56	0.46		
4	11742	15.18	29.92	49.99	2309.16	0.0120	8.35	0.55	0.036100	68.96
5	11742	8.83	29.92	49.99	1761.20	0.0154	8.17	0.93		
6	11742	12.01	50.86	49.99	2677.48	0.0178	8.43	0.70	0.000625	1.19
7	11742	12.01	8.98	49.97	1124.79	0.0069	7.76	0.65		
								Total	0.052350	100.00

E[I] = 0.690000
Var[I]= 0.052350
σ[I]= 0.228801
V(I) = 0.331596

E[ln I] = -0.423224
σ [ln I] = 0.322986

Ic= 0.80
ln(I crit) = -0.223144

β =	-1.310345
F(z) =	0.732196
Pr(f) % =	26.780357

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	11742	12.01	29.92	49.99	2053.54	0.0134	2.76	0.23		
2	23249	12.01	29.92	50.00	2889.58	0.0097	2.82	0.23	0.001600	27.35
3	235	12.01	29.92	49.51	290.41	0.0637	1.85	0.15		
4	11742	15.18	29.92	49.99	2309.16	0.0120	2.78	0.18	0.004225	72.22
5	11742	8.83	29.92	49.99	1761.20	0.0154	2.72	0.31		
6	11742	12.01	50.86	49.99	2677.48	0.0178	2.81	0.23	0.000025	0.43
7	11742	12.01	8.98	49.97	1124.79	0.0069	2.59	0.22		
								Total	0.005850	100.00

E[I] = 0.230000
Var[I]= 0.005850
σ[I]= 0.076485
V(I) = 0.332545

E[ln I] = -1.522120
σ [ln I] = 0.323864

Ic= 0.80
ln(I crit) = -0.223144

β =	-4.699875
F(z) =	0.999970
Pr(f) % =	0.003025

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: Hamilton Bend (MA 7)

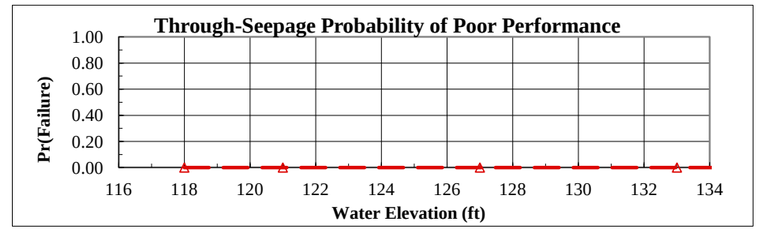
Levee Mile: 0.51
River Mile: 2288660.96 N; 6662820.24 E
Analysis Case Infinite landside blanket

Crest Elev.: 136.00
L/S Toe Elev.: 118.00
W/S Toe Elev.: 118.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	118.00	0.0000
Toe+3ft	3.00	121.00	0.000000
Half Height	9.00	127.00	0.000000
Crest-3ft	15.00	133.00	0.000000
Crest	18.00	136.00	0.000000

Crest | **Head =** 18.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 15.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 9.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

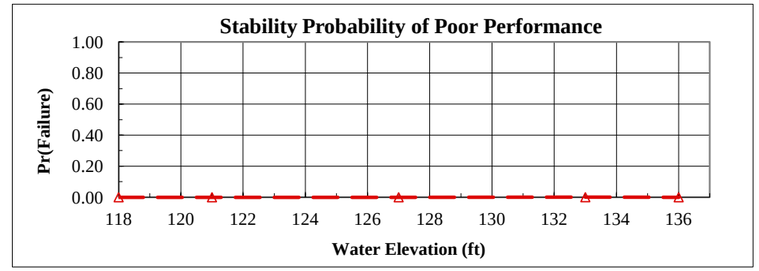
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: Hamilton Bend (MA 7)

Levee Mile: 0.51
River Mile: 2288660.96 N; 6662820.24 E
Analysis Case Infinite landside blanket

Crest Elev.: 136.00
L/S Toe Elev.: 118.00
W/S Toe Elev.: 118.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Random Variables				
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %	
Levee ϕ'	29	1	5.00	
Levee γ	120	6	5.00	
Foundation c'	150	17	11.50	
Foundation γ	120	6	5.00	
Foundation ϕ'	31	4	11.50	



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	118.00	0.0000
Toe+3ft	3.00	121.00	0.000000
Half Height	9.00	127.00	0.000000
Crest-3ft	15.00	133.00	0.000322
Crest	18.00	136.00	0.000000

Crest	Head =	18.00	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.67		
2	28	120	150	120	31	1.71	0.001892	10.54
3	30	120	150	120	31	1.62		
4	29	114	150	120	31	1.69	0.000240	1.34
5	29	126	150	120	31	1.66		
6	29	120	133	120	31	1.73	0.015006	83.59
7	29	120	167	120	31	1.48		
8	29	120	150	114	31	1.70	0.000812	4.52
9	29	120	150	126	31	1.64		
10	29	120	150	120	27	1.74	0.000002	0.01
11	29	120	150	120	35	1.75		

E[FS] = 1.671000 E[ln FS] = 0.510218 Total 0.017953 100.00
Var[FS]= 0.017953
σ[FS]= 0.133990 σ[ln FS]= 0.080057
V(FS) = 0.080185
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	6.373187
F(z) =	0.000000
Pr(f) % =	0.000000

Crest-3ft	Head =	15.00	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.80		
2	28	120	150	120	31	1.75	0.001936	2.11
3	30	120	150	120	31	1.84		
4	29	114	150	120	31	1.83	0.000812	0.88
5	29	126	150	120	31	1.77		
6	29	120	133	120	31	1.38	0.078400	85.41
7	29	120	167	120	31	1.94		
8	29	120	150	114	31	1.73	0.004556	4.96
9	29	120	150	126	31	1.86		
10	29	120	150	120	27	1.72	0.006084	6.63
11	29	120	150	120	35	1.87		

E[FS] = 1.796000 E[ln FS] = 0.571533 Total 0.091789 100.00
Var[FS]= 0.091789
σ[FS]= 0.302966 σ[ln FS]= 0.167507
V(FS) = 0.168689
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	3.411982
F(z) =	0.000322
Pr(f) % =	0.032246

Half Height	Head =	9.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

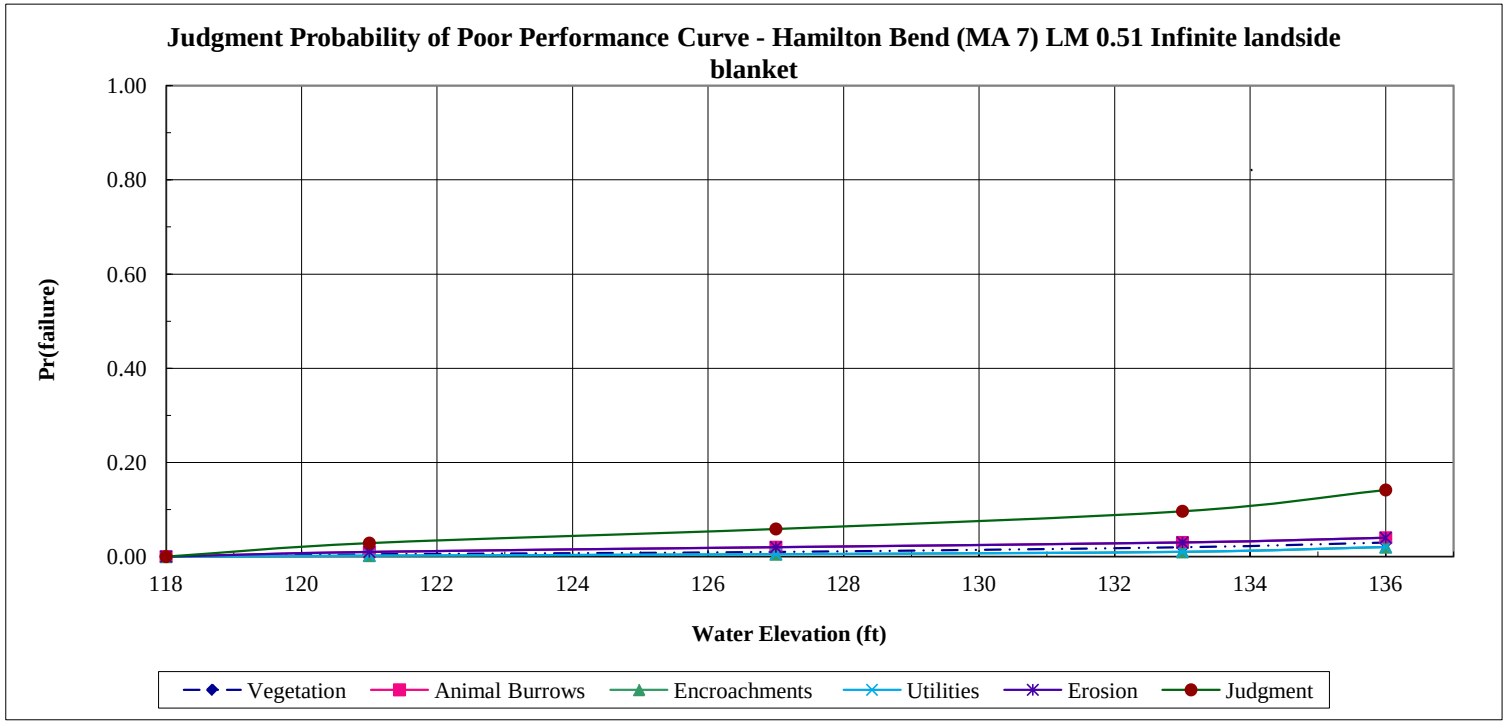
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: Hamilton Bend (MA 7)

Levee Mile: 0.51
River Mile: 2288660.96 N
Analysis Case: Infinite landside blanket

Crest Elev.: 136.00
L/S Toe Elev.: 118.00
W/S Toe Elev.: 118.00

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 2/21/

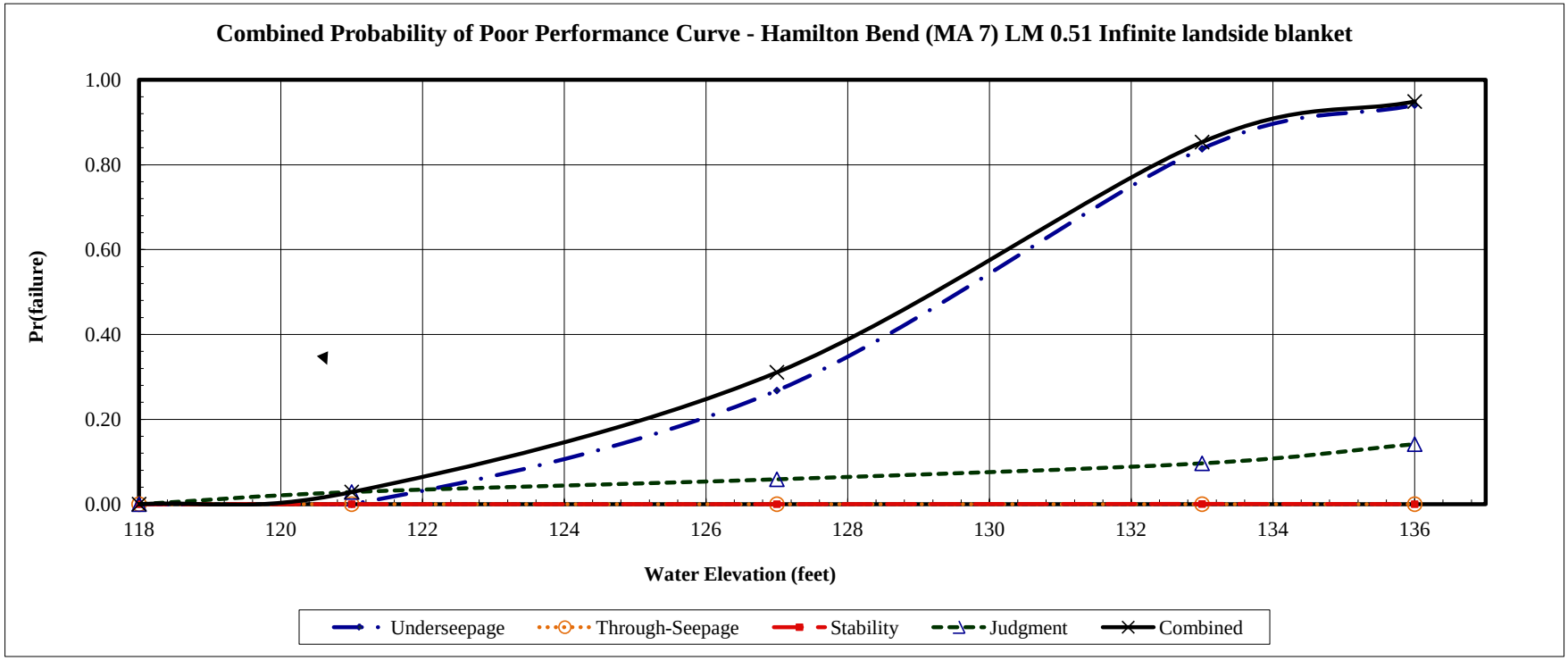
Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
118.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
121.00	0.0050	0.9950	0.0100	0.9900	0.0020	0.9980	0.0020	0.9980	0.0100	0.9900	0.0287	0.9713
127.00	0.0100	0.9900	0.0200	0.9800	0.0050	0.9950	0.0050	0.9950	0.0200	0.9800	0.0587	0.9413
133.00	0.0200	0.9800	0.0300	0.9700	0.0100	0.9900	0.0100	0.9900	0.0300	0.9700	0.0963	0.9037
136.00	0.0300	0.9700	0.0400	0.9600	0.0200	0.9800	0.0200	0.9800	0.0400	0.9600	0.1414	0.8586



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	Sutter Feasibility Study	**Levee Mile:**	0.51	**Crest Elev.:**	136.00	**Analysis By:**	T. Huynh
Study Area:	Feather River North	**River Mile:**	2288660.96 N; (	**L/S Toe Elev.:**	118.00	**Checked By:**	E.W. James/J.M.
River Section:	Hamilton Bend (MA 7)	**Analysis Case:**	Infinite landside blanket	**W/S Toe Elev.:**	118.00	**Date:**	Updated 2/21/20

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
118.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
121.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0287	0.9713	0.0287	0.9713
127.00	0.2678	0.7322	0.0000	1.0000	0.0000	1.0000	0.0587	0.9413	0.3108	0.6892
133.00	0.8376	0.1624	0.0000	1.0000	0.0003	0.9997	0.0963	0.9037	0.8533	0.1467
136.00	0.9405	0.0595	0.0000	1.0000	0.0000	1.0000	0.1414	0.8586	0.9489	0.0511



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Cherokee Canal
Basin and Reach: East Levee

Levee Mile: 9.50
Coordinates: 2301045.948 N: 6637006.261 E
Analysis Case Infinite landside blanket

Crest Elev.: 112.00
L/S Toe Elev.: 103.00
W/S Toe Elev.: 104.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/12

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
2F-08-34	7					9					CL-ML	0.01	SM, GC	3	300				
2F-08-35	3.2					8.3					CL-ML	0.01	SM	1.12	112				
2F-08-36	19					9.5					SC/CL	0.007	SW	10	1429				
2F-08-37	11					10.3					ML/SC/ML	0.1	SW	10	100				
2F-08-38	5	8	5	27	63	15.5	9	5	31	56	CL	0.007	SW	10	1429	417	578	313877	98
2F-08-39	10					13.3					ML/SM/ML	0.14	SM	10	71				
2F-08-40	5					1.5					MH	0.01	SC	1	100				
2F-08-41	9.5					1.5					CL	0.007	SC	1	143				
2F-08-42	6					14.5					sML	0.14	SW, SWg, ML	10	71				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
2F-08-34	CL-ML	7	0.01				7	SM, GC	9	3							3
2F-08-35	CL-ML	3.2	0.01				3.2	SM	8.3	1.12							1.12
2F-08-36	SC	10	0.007	CL	9	0.007	19	SW	9.5	10							10
2F-08-37	ML/SC/ML	11	0.1				11	SW	10.3	10							10
2F-08-38	CL	5	0.007				5	SW	15.5	10							10
2F-08-39	ML	8	0.14	SM/ML	8	0.56	10	SM	13.3	10							10
2F-08-40	MH	5	0.01				5	SC	1.5	1							1
2F-08-41	CL	9.5	0.007				9.5	SC	1.5	1							1
2F-08-42	sML	6	0.14				6	SW, SWg, ML	14.5	10							10

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Cherokee Canal
River Section: East Levee

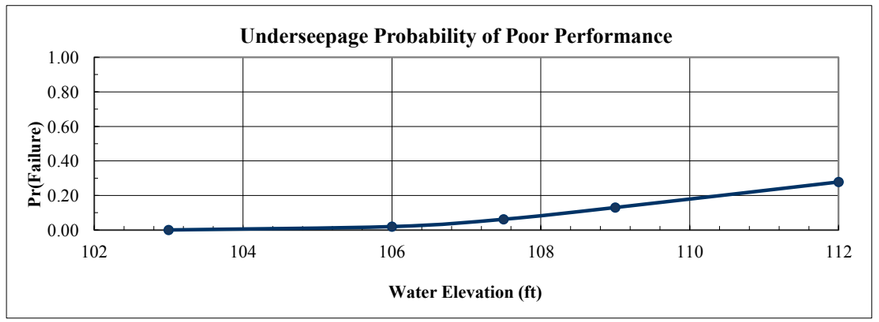
Levee Mile: 9.50
River Mile: 2301045.948 N: 6637006.261 E
Analysis Case Infinite landside blanket

Crest Elev.: 112.00
L/S Toe Elev.: 103.00
W/S Toe Elev.: 104.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/12

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	417	409	98
Blanket Thickness (z)	8	5	63
Aquifer Thickness (d)	9	5	56

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	49	65	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	103.00	0.0000
Toe+3ft	3.00	106.00	0.0195
Half Height	4.50	107.50	0.0620
Crest-3ft	6.00	109.00	0.1300
Crest	9.00	112.00	0.2780

Crest	Rh
Head = 9.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	417	8.00	9.00	47.73	173.27	0.0315	5.45	0.68		
2	826	8.00	9.00	48.35	243.82	0.0252	6.14	0.77	0.070225	21.12
3	8	8.00	9.00	23.62	24.50	0.0796	1.95	0.24		
4	417	13.00	9.00	48.21	220.88	0.0269	5.95	0.46	0.255025	76.71
5	417	3.00	9.00	45.79	106.11	0.0415	4.40	1.47		
6	417	8.00	14.00	48.18	216.11	0.0425	5.91	0.74	0.007225	2.17
7	417	8.00	4.00	46.26	115.52	0.0176	4.58	0.57		
								Total	0.332475	100.00

E[I] = 0.680000
Var[I]= 0.332475
σ[I]= 0.576606
V(I) = 0.847951

E[ln I] = -0.656540
σ [ln I] = 0.736040

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.891990
F(z) =	0.722010
Pr(f) % =	27.799044

Crest-3ft	Rh
Head = 6.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	417	8.00	9.00	47.73	173.27	0.0315	3.64	0.46		
2	826	8.00	9.00	48.35	243.82	0.0252	4.10	0.51	0.030625	20.99
3	8	8.00	9.00	23.62	24.50	0.0796	1.30	0.16		
4	417	13.00	9.00	48.21	220.88	0.0269	3.97	0.31	0.112225	76.93
5	417	3.00	9.00	45.79	106.11	0.0415	2.94	0.98		
6	417	8.00	14.00	48.18	216.11	0.0425	3.94	0.49	0.003025	2.07
7	417	8.00	4.00	46.26	115.52	0.0176	3.06	0.38		
								Total	0.145875	100.00

E[I] = 0.460000
Var[I]= 0.145875
σ[I]= 0.381936
V(I) = 0.830295

E[ln I] = -1.038713
σ [ln I] = 0.724132

Ic= 0.80
ln(I crit) = -0.223144

β =	-1.434424
F(z) =	0.869975
Pr(f) % =	13.002548

Half Height	Rh
Head = 4.50	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	417	8.00	9.00	47.73	173.27	0.0315	2.73	0.34		
2	826	8.00	9.00	48.35	243.82	0.0252	3.07	0.38	0.016900	20.86
3	8	8.00	9.00	23.62	24.50	0.0796	0.97	0.12		
4	417	13.00	9.00	48.21	220.88	0.0269	2.98	0.23	0.062500	77.16
5	417	3.00	9.00	45.79	106.11	0.0415	2.20	0.73		
6	417	8.00	14.00	48.18	216.11	0.0425	2.95	0.37	0.001600	1.98
7	417	8.00	4.00	46.26	115.52	0.0176	2.29	0.29		
								Total	0.081000	100.00

E[I] = 0.340000
Var[I]= 0.081000
σ[I]= 0.284605
V(I) = 0.837073

E[ln I] = -1.344327
σ [ln I] = 0.728722

Ic= 0.80
ln(I crit) = -0.223144

β =	-1.844775
F(z) =	0.938044
Pr(f) % =	6.195558

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	417	8.00	9.00	47.73	173.27	0.0315	1.82	0.23		
2	826	8.00	9.00	48.35	243.82	0.0252	2.05	0.26	0.008100	21.37
3	8	8.00	9.00	23.62	24.50	0.0796	0.65	0.08		
4	417	13.00	9.00	48.21	220.88	0.0269	1.98	0.15	0.028900	76.25
5	417	3.00	9.00	45.79	106.11	0.0415	1.47	0.49		
6	417	8.00	14.00	48.18	216.11	0.0425	1.97	0.25	0.000900	2.37
7	417	8.00	4.00	46.26	115.52	0.0176	1.53	0.19		
								Total	0.037900	100.00

E[I] = 0.230000
Var[I]= 0.037900
σ[I]= 0.194679
V(I) = 0.846431

E[ln I] = -1.739804
σ [ln I] = 0.735021

Ic= 0.80
ln(I crit) = -0.223144

β =	-2.367012
F(z) =	0.980464
Pr(f) % =	1.953616

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Cherokee Canal
River Section: East Levee

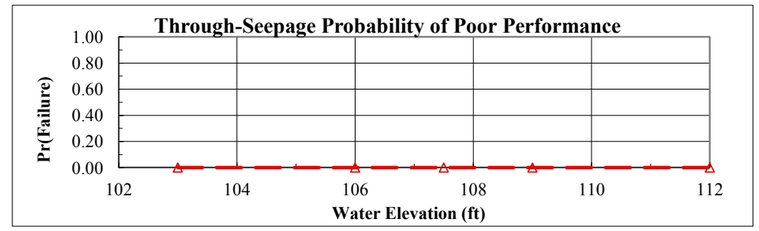
Levee Mile: 9.50
River Mile: 2301045.948 N: 6637006.261 E
Analysis Case Infinite landside blanket

Crest Elev.: 112.00
L/S Toe Elev.: 103.00
W/S Toe Elev.: 104.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/12

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	103.00	0.0000
Toe+3ft	3.00	106.00	0.000000
Half Height	4.50	107.50	0.000000
Crest-3ft	6.00	109.00	0.000000
Crest	9.00	112.00	0.000000

Crest	Head =	9.00	Horizontal Gradient (Ix) =	

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Crest-3ft	Head =	6.00	Horizontal Gradient (Ix) =	

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	4.50	Horizontal Gradient (Ix) =	

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Horizontal Gradient (Ix) =	

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

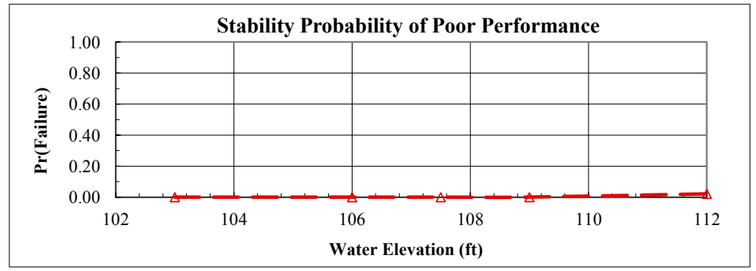
Project: Sutter Feasibility Study
Study Area: Cherokee Canal
River Section: East Levee

Levee Mile: 9.50
River Mile: 2301045.948 N: 6637006.261 E
Analysis Case Infinite landside blanket

Crest Elev.: 112.00
L/S Toe Elev.: 103.00
W/S Toe Elev.: 104.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/12

Random Variables				
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %	
Levee ϕ'	28	1	5.00	
Levee γ	120	6	5.00	
LEvee c'	150	17	11.50	
Foundation γ	115	6	5.00	
Foundation ϕ'	29	3	11.50	



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	103.00	0.0000
Toe+3ft	3.00	106.00	0.000000
Half Height	4.50	107.50	0.000000
Crest-3ft	6.00	109.00	0.000322
Crest	9.00	112.00	0.021343

Crest	Head =	9.00	Pr(f)=0	NO

Run	Levee φ'	Levee γ	LEvee c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	28	120	150	115	29	1.50		
2	27	120	150	115	29	1.48	0.001225	1.44
3	29	120	150	115	29	1.55		
4	28	114	150	115	29	1.52	0.000169	0.20
5	28	126	150	115	29	1.50		
6	28	120	133	115	29	1.11	0.074529	87.51
7	28	120	167	115	29	1.66		
8	28	120	150	109	29	1.44	0.005402	6.34
9	28	120	150	121	29	1.58		
10	28	120	150	115	26	1.45	0.003844	4.51
11	28	120	150	115	32	1.57		

E[FS] = 1.504000 E[ln FS] = 0.389648 Total 0.085169 100.00
Var[FS]= 0.085169
σ[FS]= 0.291838 σ[ln FS]= 0.192251
V(FS) = 0.194041
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	2.026769
F(z) =	0.021343
Pr(f) % =	2.134304

Crest-3ft	Head =	6.00	Pr(f)=0	NO

Run	Levee φ'	Levee γ	LEvee c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	28	120	150	115	29	1.80		
2	27	120	150	115	29	1.75	0.001936	2.11
3	29	120	150	115	29	1.84		
4	28	114	150	115	29	1.83	0.000812	0.88
5	28	126	150	115	29	1.77		
6	28	120	133	115	29	1.38	0.078400	85.41
7	28	120	167	115	29	1.94		
8	28	120	150	109	29	1.73	0.004556	4.96
9	28	120	150	121	29	1.86		
10	28	120	150	115	26	1.72	0.006084	6.63
11	28	120	150	115	32	1.87		

E[FS] = 1.796000 E[ln FS] = 0.571533 Total 0.091789 100.00
Var[FS]= 0.091789
σ[FS]= 0.302966 σ[ln FS]= 0.167507
V(FS) = 0.168689
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	3.411982
F(z) =	0.000322
Pr(f) % =	0.032246

Half Height	Head =	4.50	Pr(f)=0	YES

Run	Levee φ'	Levee γ	LEvee c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	28	120	150	115	29			
2	27	120	150	115	29			
3	29	120	150	115	29			
4	28	114	150	115	29			
5	28	126	150	115	29			
6	28	120	133	115	29			
7	28	120	167	115	29			
8	28	120	150	109	29			
9	28	120	150	121	29			
10	28	120	150	115	26			
11	28	120	150	115	32			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	LEvee c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	28	120	150	115	29			
2	27	120	150	115	29			
3	29	120	150	115	29			
4	28	114	150	115	29			
5	28	126	150	115	29			
6	28	120	133	115	29			
7	28	120	167	115	29			
8	28	120	150	109	29			
9	28	120	150	121	29			
10	28	120	150	115	26			
11	28	120	150	115	32			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

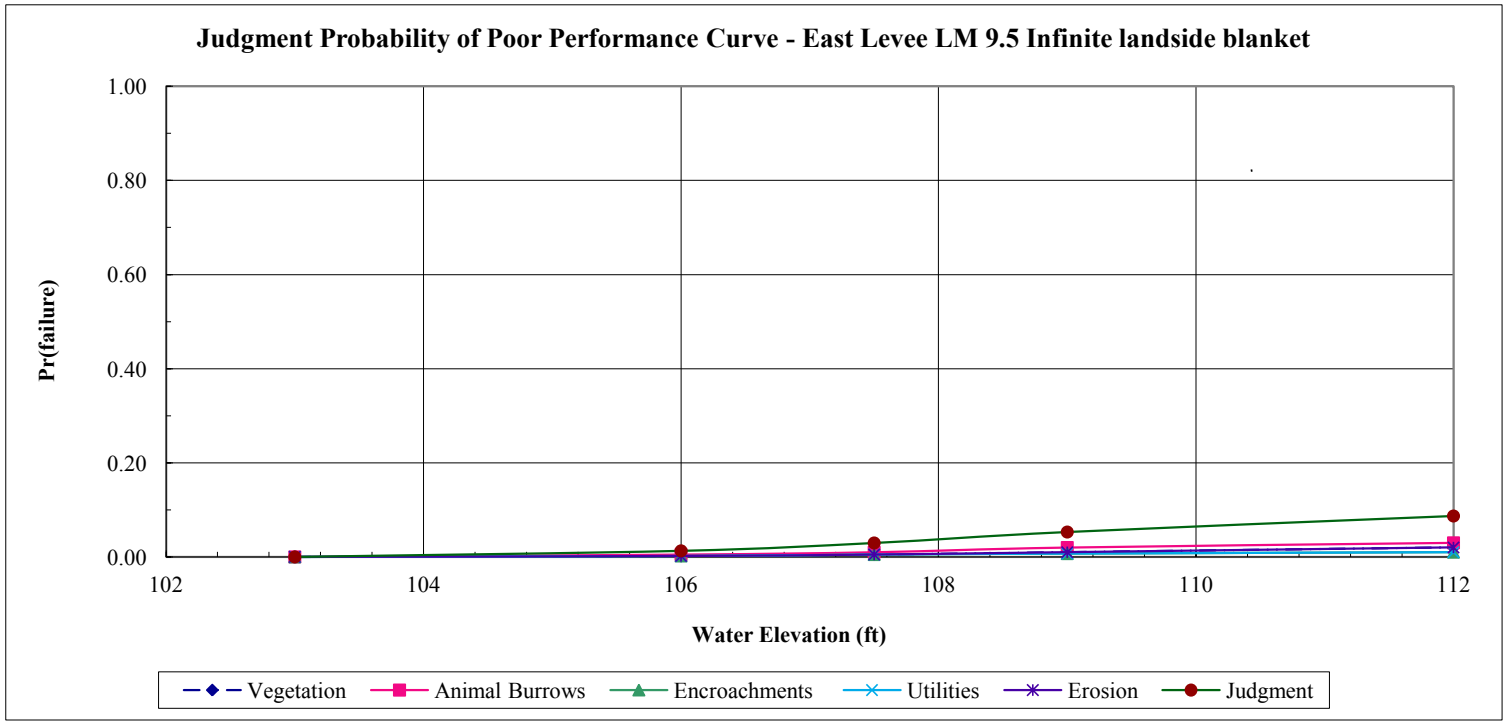
Project: Sutter Feasibility Study
Study Area: Cherokee Canal
River Section: East Levee

Levee Mile: 9.50
River Mile: 2301045.948
Analysis Case: Infinite landside blanket

Crest Elev.: 112.00
L/S Toe Elev.: 103.00
W/S Toe Elev.: 104.00

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 9/13/

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
103.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
106.00	0.0020	0.9980	0.0050	0.9950	0.0020	0.9980	0.0020	0.9980	0.0020	0.9980	0.0129	0.9871
107.50	0.0050	0.9950	0.0100	0.9900	0.0050	0.9950	0.0050	0.9950	0.0050	0.9950	0.0297	0.9703
109.00	0.0100	0.9900	0.0200	0.9800	0.0070	0.9930	0.0070	0.9930	0.0100	0.9900	0.0529	0.9471
112.00	0.0200	0.9800	0.0300	0.9700	0.0100	0.9900	0.0100	0.9900	0.0200	0.9800	0.0870	0.9130



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

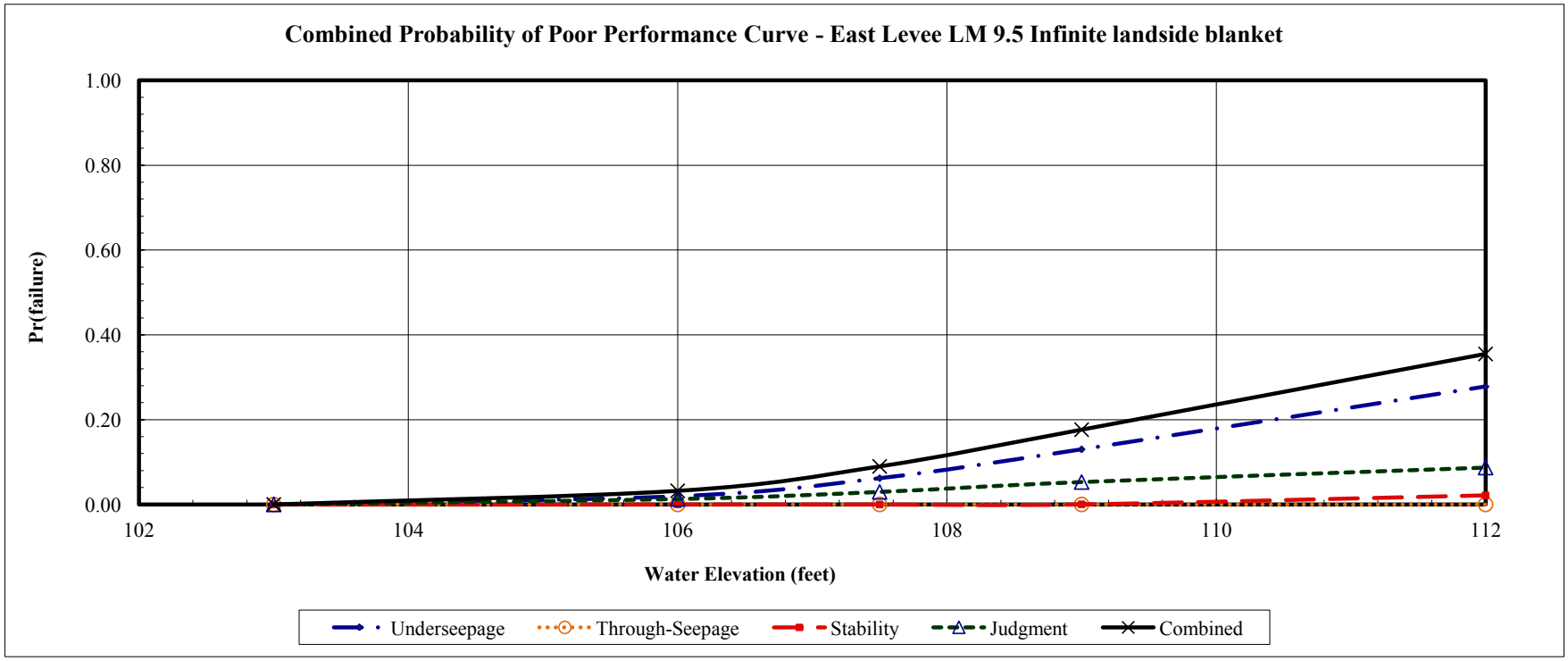
Project: Sutter Feasibility Study
Study Area: Cherokee Canal
River Section: East Levee

Levee Mile: 9.50
River Mile: 2301045.948 N:
Analysis Case: Infinite landside blanket

Crest Elev.: 112.00
L/S Toe Elev.: 103.00
W/S Toe Elev.: 104.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/13/12

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
103.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
106.00	0.0195	0.9805	0.0000	1.0000	0.0000	1.0000	0.0129	0.9871	0.0322	0.9678
107.50	0.0620	0.9380	0.0000	1.0000	0.0000	1.0000	0.0297	0.9703	0.0898	0.9102
109.00	0.1300	0.8700	0.0000	1.0000	0.0003	0.9997	0.0529	0.9471	0.1763	0.8237
112.00	0.2780	0.7220	0.0000	1.0000	0.0213	0.9787	0.0870	0.9130	0.3548	0.6452



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Wadsworth Canal - Right Bank
Basin and Reach:

Levee Mile: 0.50
Coordinates: 2168750 N; 6627910 E
Analysis Case

Crest Elev.: 60.30
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: E.W. James
Checked By: J.M. Bolton
Date: Updated 09/14/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
2F-00-01	6					13					CL	0.0071	SP-SC	10	1408				
2F-03-26	6					6					CL	0.0071	SP	28	3944				
2F-00-02	7.87					7					CL/ML/SC	0.0284	SP-SC	14	493				
2F-00-09	5.62					30					CL/ML	0.0284	SM/SP	2.8	99				
2F-00-10	8.41					30					CL/ML	0.0071	SP-SM/SP	10.27	1446				
2F-03-28	4.77	7	2	11	29	2.5	13	11	122	85	CL/SM	0.0284	SP	28	986	1244	1249	1489425	98
WSEWWC_001 A	10.5					11					CL, CH	0.0071	SM/SP-SM	11.14	1569				
WSEWWC_029 B	4					7					CL	0.28	SP-SM	2.8	10				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
2F-00-01	CL	6	0.0071				6.0	SP-SC	13	10							10
2F-03-26	CL	6	0.0071				6.0	SP	6	28							28
2F-00-02	CL	3	0.0284	ML/SC	6	0.035	7.9	SP-SC	7	14							14
2F-00-09	CL	4	0.0284	ML	2	0.035	5.6	SM	2	2.8	SP	28					2.8
2F-00-10	CL	8	0.0071	ML	2	0.035	8.4	SP-SM	2	14	SP	28	10				10.27
2F-03-28	CL	4	0.0284	SM	9.5	0.35	4.8	SP	2.5	28							28
WSEWWC_001 A	CL, CH	10.5	0.0071				10.5	SM	2.5	1.4	SP-SM	8.5	14				11.14
WSEWWC_029 B	CL	4	0.28				4	SP-SM	7	2.8							2.8

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Wadsworth Canal - Right Bank
River Section:

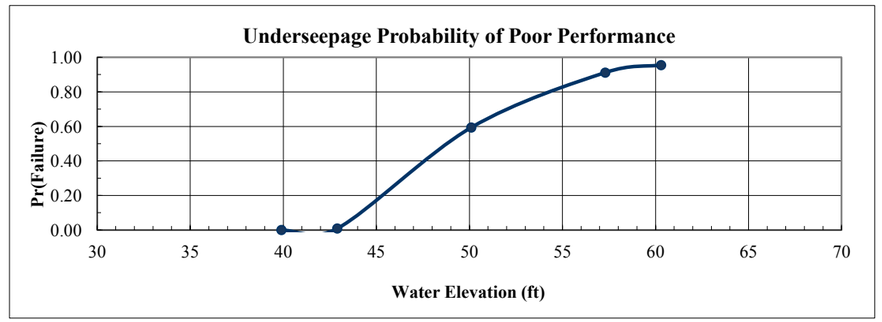
Levee Mile: 0.50
River Mile: 2168750 N; 6627910 E
Analysis Case

Crest Elev.: 60.30
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: E.W. James
Checked By: J.M. Bolton
Date: Updated 09/14/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	1244	1219	98
Blanket Thickness (z)	7	2	29
Aquifer Thickness (d)	13	11	85

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	25	130	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	39.90	0.0000
Toe+3ft	3.00	42.90	0.0088
Half Height	10.20	50.10	0.5935
Crest-3ft	17.40	57.30	0.9112
Crest	20.40	60.30	0.9547

Crest	Rh
Head = 20.40	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1244	7.00	13.00	24.95	336.46	0.0265	13.97	2.00		
2	2463	7.00	13.00	24.98	473.44	0.0207	15.37	2.20	0.570025	56.35
3	25	7.00	13.00	22.93	47.58	0.0648	4.84	0.69		
4	1244	9.00	13.00	24.96	381.51	0.0242	14.51	1.61	0.265225	26.22
5	1244	5.00	13.00	24.94	284.36	0.0296	13.20	2.64		
6	1244	7.00	24.00	24.98	457.16	0.0392	15.24	2.18	0.176400	17.44
7	1244	7.00	2.00	24.71	131.97	0.0070	9.39	1.34		
								Total	1.011650	100.00

E[I] = 2.000000
Var[I]= 1.011650
σ[I]= 1.005808
V(I) = 0.502904

E[ln I] = 0.580412
σ [ln I] = 0.474838

Ic= 0.80
ln(I crit) = -0.223144

β = 1.222337
F(z) = 0.045297
Pr(f) % = 95.470309

Crest-3ft	Rh
Head = 17.40	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1244	7.00	13.00	24.95	336.46	0.0265	11.91	1.70		
2	2463	7.00	13.00	24.98	473.44	0.0207	13.11	1.87	0.409600	55.90
3	25	7.00	13.00	22.93	47.58	0.0648	4.13	0.59		
4	1244	9.00	13.00	24.96	381.51	0.0242	12.37	1.37	0.193600	26.42
5	1244	5.00	13.00	24.94	284.36	0.0296	11.26	2.25		
6	1244	7.00	24.00	24.98	457.16	0.0392	12.99	1.86	0.129600	17.69
7	1244	7.00	2.00	24.71	131.97	0.0070	8.01	1.14		
								Total	0.732800	100.00

E[I] = 1.700000
Var[I]= 0.732800
σ[I]= 0.856037
V(I) = 0.503551

E[ln I] = 0.417633
σ [ln I] = 0.475385

Ic= 0.80
ln(I crit) = -0.223144

β = 0.878515
F(z) = 0.088843
Pr(f) % = 91.115651

Half Height	Rh
Head = 10.20	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1244	7.00	13.00	24.95	336.46	0.0265	6.98	1.00		
2	2463	7.00	13.00	24.98	473.44	0.0207	7.68	1.10	0.140625	56.31
3	25	7.00	13.00	22.93	47.58	0.0648	2.42	0.35		
4	1244	9.00	13.00	24.96	381.51	0.0242	7.25	0.81	0.065025	26.04
5	1244	5.00	13.00	24.94	284.36	0.0296	6.60	1.32		
6	1244	7.00	24.00	24.98	457.16	0.0392	7.62	1.09	0.044100	17.66
7	1244	7.00	2.00	24.71	131.97	0.0070	4.70	0.67		
								Total	0.249750	100.00

E[I] = 1.000000
Var[I]= 0.249750
σ[I]= 0.499750
V(I) = 0.499750

E[ln I] = -0.111472
σ [ln I] = 0.472169

Ic= 0.80
ln(I crit) = -0.223144

β = -0.236084
F(z) = 0.406519
Pr(f) % = 59.348079

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	1244	7.00	13.00	24.95	336.46	0.0265	2.05	0.29		
2	2463	7.00	13.00	24.98	473.44	0.0207	2.26	0.32	0.012100	56.74
3	25	7.00	13.00	22.93	47.58	0.0648	0.71	0.10		
4	1244	9.00	13.00	24.96	381.51	0.0242	2.13	0.24	0.005625	26.38
5	1244	5.00	13.00	24.94	284.36	0.0296	1.94	0.39		
6	1244	7.00	24.00	24.98	457.16	0.0392	2.24	0.32	0.003600	16.88
7	1244	7.00	2.00	24.71	131.97	0.0070	1.38	0.20		
								Total	0.021325	100.00

E[I] = 0.290000
Var[I]= 0.021325
σ[I]= 0.146031
V(I) = 0.503555

E[ln I] = -1.350871
σ [ln I] = 0.475387

Ic= 0.80
ln(I crit) = -0.223144

β = -2.841621
F(z) = 0.991159
Pr(f) % = 0.884059

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Wadsworth Canal - Right Bank
River Section:

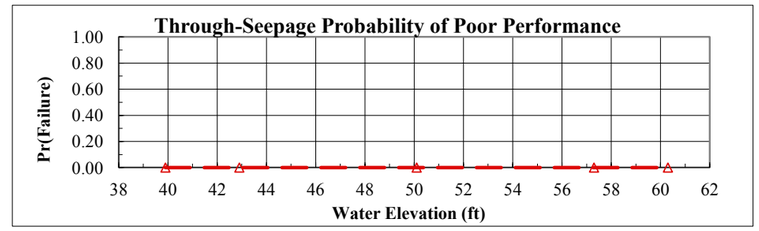
Levee Mile: 0.50
River Mile: 2168750 N; 6627910 E
Analysis Case

Crest Elev.: 60.30
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: E.W. James
Checked By: J.M. Bolton
Date: Updated 09/14/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	39.90	0.0000
Toe+3ft	3.00	42.90	0.000000
Half Height	10.20	50.10	0.000000
Crest-3ft	17.40	57.30	0.000000
Crest	20.40	60.30	0.000000

Crest | **Head =** 20.40 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 17.40 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 10.20 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

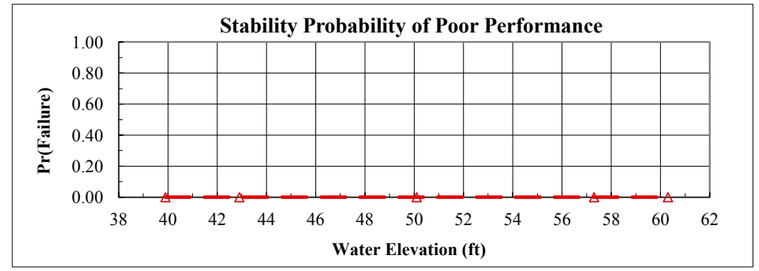
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal - Right Bank
River Section:

Levee Mile: 0.50
River Mile: 2168750 N; 6627910 E
Analysis Case

Crest Elev.: 60.30
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: E.W. James
Checked By: J.M. Bolton
Date: Updated 09/14/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee Φ	32	4	13.00
Levee Cohesion	10	4	40.00
Levee γ	125	9	7.00
Foundation Φ	28	4	13.00
Foundation Cohesion	100	40	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	39.90	0.0000
Toe+3ft	3.00	42.90	0.000000
Half Height	10.20	50.10	0.000000
Crest-3ft	17.40	57.30	0.000000
Crest	20.40	60.30	0.000026

Crest	Head =	20.40	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	32	10	125	28	100	1.49		
2	28	10	125	28	100	1.46	0.000930	4.37
3	36	10	125	28	100	1.52		
4	32	6	125	28	100	1.49	0.000020	0.10
5	32	14	125	28	100	1.50		
6	32	10	116	28	100	1.51	0.000342	1.61
7	32	10	134	28	100	1.47		
8	32	10	125	24	100	1.43	0.004489	21.09
9	32	10	125	32	100	1.56		
10	32	10	125	28	60	1.35	0.015500	72.83
11	32	10	125	28	140	1.60		

E[FS] = 1.491000 E[ln FS] = 0.394683 Total 0.021282 100.00
Var[FS]= 0.021282
σ[FS]= 0.145884 σ[ln FS]= 0.097610
V(FS) = 0.097843
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	4.043480
F(z) =	0.000026
Pr(f) % =	0.002633

Crest-3ft	Head =	17.40	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	32	10	125	28	100			
2	28	10	125	28	100			
3	36	10	125	28	100			
4	32	6	125	28	100			
5	32	14	125	28	100			
6	32	10	116	28	100			
7	32	10	134	28	100			
8	32	10	125	24	100			
9	32	10	125	32	100			
10	32	10	125	28	60			
11	32	10	125	28	140			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	10.20	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	32	10	125	28	100			
2	28	10	125	28	100			
3	36	10	125	28	100			
4	32	6	125	28	100			
5	32	14	125	28	100			
6	32	10	116	28	100			
7	32	10	134	28	100			
8	32	10	125	24	100			
9	32	10	125	32	100			
10	32	10	125	28	60			
11	32	10	125	28	140			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	32	10	125	28	100			
2	28	10	125	28	100			
3	36	10	125	28	100			
4	32	6	125	28	100			
5	32	14	125	28	100			
6	32	10	116	28	100			
7	32	10	134	28	100			
8	32	10	125	24	100			
9	32	10	125	32	100			
10	32	10	125	28	60			
11	32	10	125	28	140			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

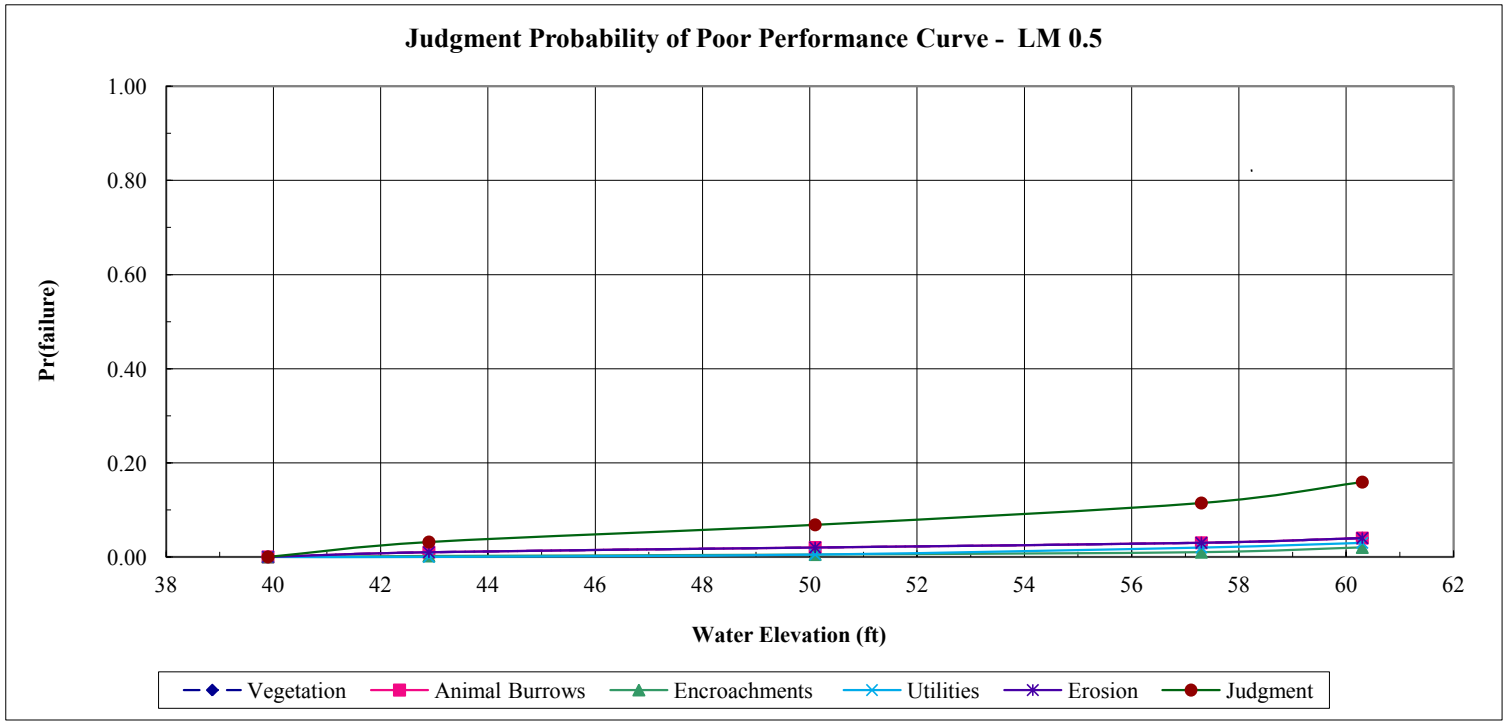
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal - Right Bank
River Section:

Levee Mile: 0.50
River Mile: 2168750 N; 6
Analysis Case:

Crest Elev.: 60.30
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: E.W. James
Checked By: J.M. Bolton
Date: Updated 09/1

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
39.90	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
42.90	0.0100	0.9900	0.0100	0.9900	0.0020	0.9980	0.0000	1.0000	0.0100	0.9900	0.0316	0.9684
50.10	0.0200	0.9800	0.0200	0.9800	0.0050	0.9950	0.0050	0.9950	0.0200	0.9800	0.0682	0.9318
57.30	0.0300	0.9700	0.0300	0.9700	0.0100	0.9900	0.0200	0.9800	0.0300	0.9700	0.1145	0.8855
60.30	0.0400	0.9600	0.0400	0.9600	0.0200	0.9800	0.0300	0.9700	0.0400	0.9600	0.1590	0.8410



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

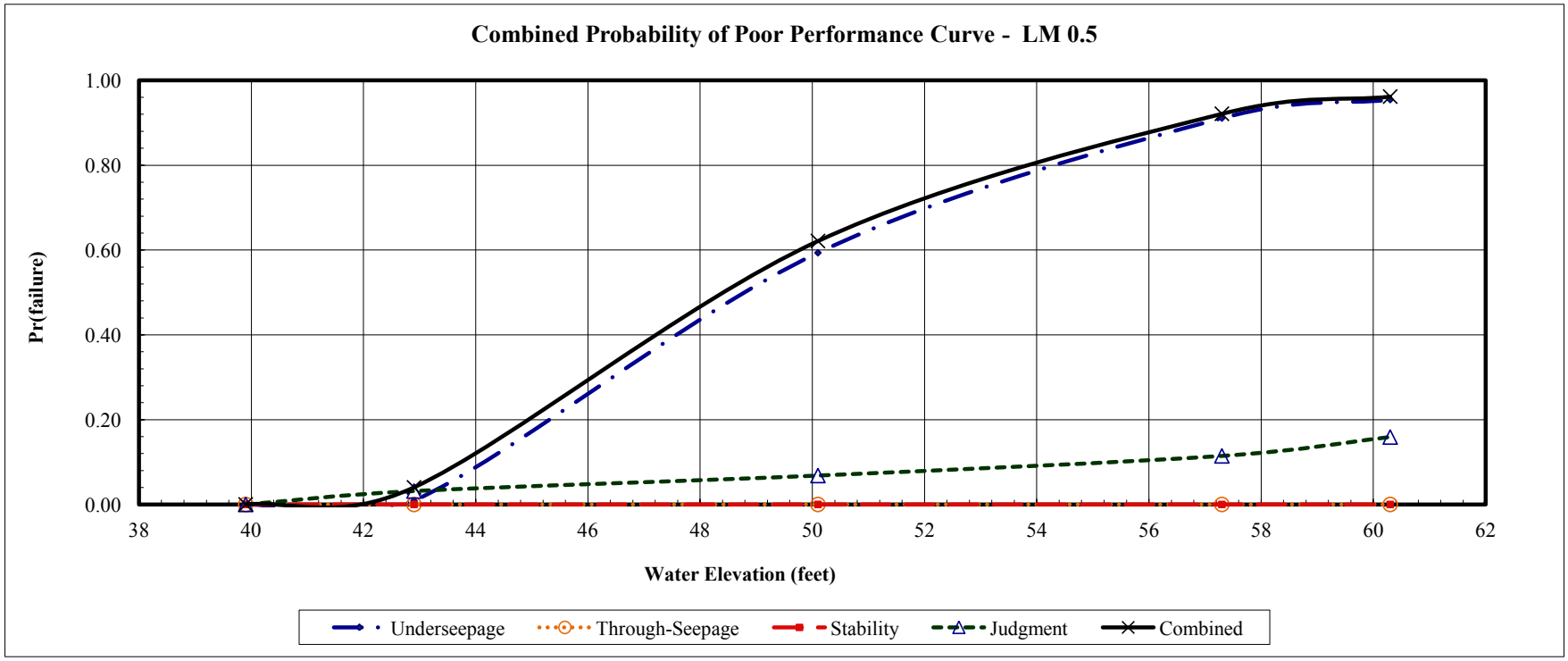
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal - Right Bank
River Section:

Levee Mile: 0.50
River Mile: 2168750 N; 662
Analysis Case:

Crest Elev.: 60.30
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: E.W. James
Checked By: J.M. Bolton
Date: Updated 09/14/

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
39.90	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
42.90	0.0088	0.9912	0.0000	1.0000	0.0000	1.0000	0.0316	0.9684	0.0402	0.9598
50.10	0.5935	0.4065	0.0000	1.0000	0.0000	1.0000	0.0682	0.9318	0.6212	0.3788
57.30	0.9112	0.0888	0.0000	1.0000	0.0000	1.0000	0.1145	0.8855	0.9213	0.0787
60.30	0.9547	0.0453	0.0000	1.0000	0.0000	1.0000	0.1590	0.8410	0.9619	0.0381



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Sutter Bypass
Basin and Reach: Left Levee

Levee Mile: 4.00
Coordinates: 2168110 N; 6626590 E
Analysis Case Infinite waterside/landside blanket

Crest Elev.: 60.60
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/14/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WSESBP_011B	14					9					sCL/CH	0.007	SP-SM	10	1429				
WSESBP_015B	9					16.5					CLs,CL,ML	0.1	SM	3	30				
WSESBP_016B	10.5					9					SM/CL	0.007	SP-SM	10	1429				
WSESBP_017B	8	10	4	25	40	2	10	6	43	60	CL,SM	0.3	SP-SM	10	33	725	650	427548	90
WSESBP_018B	14					8					CL,SM/CL	0.007	SP-SM,ML,sMI	3	429				
WSESBP_019B	4.8					17.5					CL/ML	0.01	SP-SM	10	1000				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WSESBP_011B	sCL	6	0.007	CH	8	0.007	14	SP-SM	9	10							10
WSESBP_015B	CLs,CL,ML	9	0.1				9	SM	16.5	3							3
WSESBP_016B	SM	2	0.007	CL	8.5	0.007	10.5	SP-SM	9	10							10
WSESBP_017B	CL,SM	8	0.3				8	SP-SM	2	10							10
WSESBP_018B	CL,SM	2.5	0.007	CL	11.5	0.007	14	SP-SM,ML,sMI	8	3							3
WSESBP_019B	CL	4.5	0.01	ML	3	0.1	4.8	SP-SM	17.5	10							10

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: Left Levee

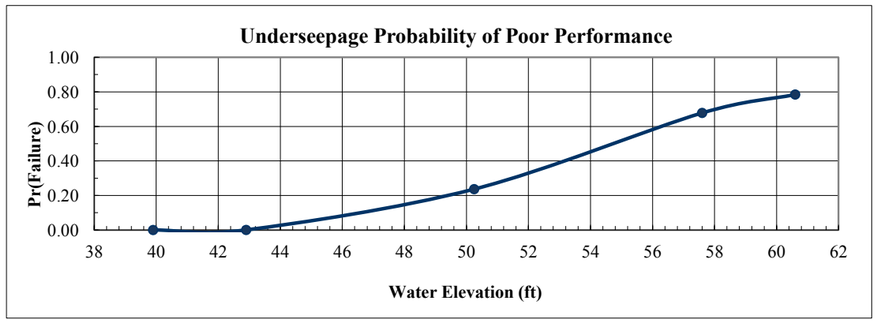
Levee Mile: 4.00
River Mile: 2168110 N; 6626590 E
Analysis Case Infinite waterside/landside blanket

Crest Elev.: 60.60
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/14/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	725	650	90
Blanket Thickness (z)	10	4	40
Aquifer Thickness (d)	10	6	60

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	15	150	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	39.90	0.0000
Toe+3ft	3.00	42.90	0.0004
Half Height	10.35	50.25	0.2366
Crest-3ft	17.70	57.60	0.6780
Crest	20.70	60.60	0.7846

Crest	Rh
Head = 20.70	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	12.84	1.28		
2	1375	10.00	10.00	14.99	370.81	0.0187	14.33	1.43	0.129600	33.32
3	75	10.00	10.00	14.85	86.60	0.0398	7.13	0.71		
4	725	14.00	10.00	14.99	318.59	0.0207	13.64	0.97	0.230400	59.24
5	725	6.00	10.00	14.97	208.57	0.0268	11.56	1.93		
6	725	10.00	16.00	14.99	340.59	0.0316	13.94	1.39	0.028900	7.43
7	725	10.00	4.00	14.96	170.29	0.0119	10.51	1.05		
								Total	0.388900	100.00

E[I] = 1.280000
Var[I]= 0.388900
σ[I]= 0.623618
V(I) = 0.487202

E[ln I] = 0.140368
σ [ln I] = 0.461503

Ic= 0.80
ln(I crit) = -0.223144

β = 0.304154
F(z) = 0.215445
Pr(f) % = 78.455479

Crest-3ft	Rh
Head = 17.70	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	10.98	1.10		
2	1375	10.00	10.00	14.99	370.81	0.0187	12.25	1.23	0.096100	33.69
3	75	10.00	10.00	14.85	86.60	0.0398	6.10	0.61		
4	725	14.00	10.00	14.99	318.59	0.0207	11.66	0.83	0.168100	58.94
5	725	6.00	10.00	14.97	208.57	0.0268	9.88	1.65		
6	725	10.00	16.00	14.99	340.59	0.0316	11.92	1.19	0.021025	7.37
7	725	10.00	4.00	14.96	170.29	0.0119	8.99	0.90		
								Total	0.285225	100.00

E[I] = 1.100000
Var[I]= 0.285225
σ[I]= 0.534065
V(I) = 0.485513

E[ln I] = -0.010518
σ [ln I] = 0.460061

Ic= 0.80
ln(I crit) = -0.223144

β = -0.022862
F(z) = 0.321980
Pr(f) % = 67.801956

Half Height	Rh
Head = 10.35	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	6.42	0.64		
2	1375	10.00	10.00	14.99	370.81	0.0187	7.16	0.72	0.032400	34.16
3	75	10.00	10.00	14.85	86.60	0.0398	3.56	0.36		
4	725	14.00	10.00	14.99	318.59	0.0207	6.82	0.49	0.055225	58.22
5	725	6.00	10.00	14.97	208.57	0.0268	5.78	0.96		
6	725	10.00	16.00	14.99	340.59	0.0316	6.97	0.70	0.007225	7.62
7	725	10.00	4.00	14.96	170.29	0.0119	5.26	0.53		
								Total	0.094850	100.00

E[I] = 0.640000
Var[I]= 0.094850
σ[I]= 0.307977
V(I) = 0.481214

E[ln I] = -0.550431
σ [ln I] = 0.456385

Ic= 0.80
ln(I crit) = -0.223144

β = -1.206066
F(z) = 0.763353
Pr(f) % = 23.664715

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	1.86	0.19		
2	1375	10.00	10.00	14.99	370.81	0.0187	2.08	0.21	0.003025	35.38
3	75	10.00	10.00	14.85	86.60	0.0398	1.03	0.10		
4	725	14.00	10.00	14.99	318.59	0.0207	1.98	0.14	0.004900	57.31
5	725	6.00	10.00	14.97	208.57	0.0268	1.68	0.28		
6	725	10.00	16.00	14.99	340.59	0.0316	2.02	0.20	0.000625	7.31
7	725	10.00	4.00	14.96	170.29	0.0119	1.52	0.15		
								Total	0.008550	100.00

E[I] = 0.190000
Var[I]= 0.008550
σ[I]= 0.092466
V(I) = 0.486664

E[ln I] = -1.767012
σ [ln I] = 0.461044

Ic= 0.80
ln(I crit) = -0.223144

β = -3.832633
F(z) = 0.999594
Pr(f) % = 0.040605

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: Left Levee

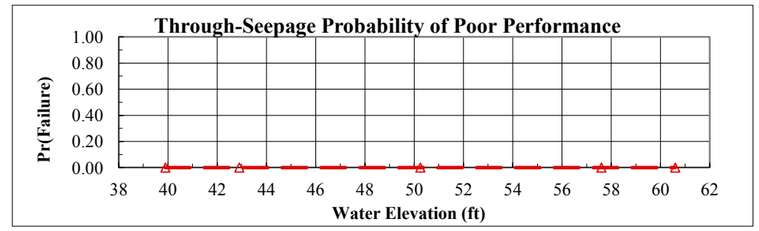
Levee Mile: 4.00
River Mile: 2168110 N; 6626590 E
Analysis Case Infinite waterside/landside blanket

Crest Elev.: 60.60
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/14/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	39.90	0.0000
Toe+3ft	3.00	42.90	0.000000
Half Height	10.35	50.25	0.000000
Crest-3ft	17.70	57.60	0.000000
Crest	20.70	60.60	0.000000

Crest | **Head =** 20.70 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 17.70 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 10.35 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =**

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

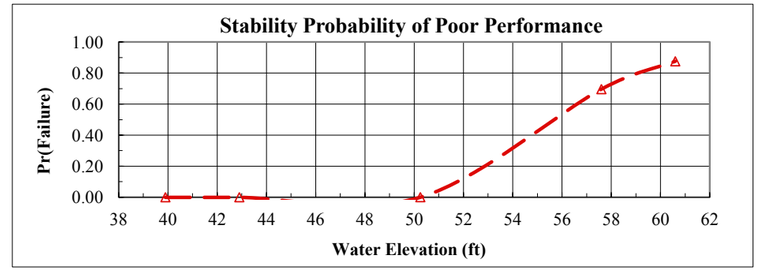
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: Left Levee

Levee Mile: 4.00
River Mile: 2168110 N; 6626590 E
Analysis Case Infinite waterside/landside blanket

Crest Elev.: 60.60
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/14/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee ϕ'	28	3	12.00
Levee γ	115	6	5.00
Foundation c'	200	66	33.00
Foundation γ	115	6	5.00
Foundation ϕ'	28	3	12.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	39.90	0.0000
Toe+3ft	3.00	42.90	0.000000
Half Height	10.35	50.25	0.000457
Crest-3ft	17.70	57.60	0.695853
Crest	20.70	60.60	0.875362

Crest	Head =	20.70	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	28	115	200	115	28	0.88		
2	25	115	200	115	28	0.79	0.008930	83.83
3	31	115	200	115	28	0.98		
4	28	109	200	115	28	0.84	0.001722	16.17
5	28	121	200	115	28	0.92		
6	28	115	134	115	28	0.88	0.000000	0.00
7	28	115	266	115	28	0.88		
8	28	115	200	109	28	0.88	0.000000	0.00
9	28	115	200	121	28	0.88		
10	28	115	200	115	25	0.88	0.000000	0.00
11	28	115	200	115	31	0.88		

E[FS] = 0.880000 E[ln FS] = -0.134664 Total 0.010653 100.00
Var[FS]= 0.010653
σ[FS]= 0.103211 σ[ln FS]= 0.116885
V(FS) = 0.117285
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	-1.152112
F(z) =	0.875362
Pr(f) % =	87.536249

Crest-3ft	Head =	17.70	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	28	115	200	115	28	0.95		
2	25	115	200	115	28	0.85	0.009604	70.29
3	31	115	200	115	28	1.05		
4	28	109	200	115	28	0.90	0.001560	11.42
5	28	121	200	115	28	0.98		
6	28	115	134	115	28	1.05	0.002500	18.30
7	28	115	266	115	28	0.95		
8	28	115	200	109	28	0.95	0.000000	0.00
9	28	115	200	121	28	0.95		
10	28	115	200	115	25	0.95	0.000000	0.00
11	28	115	200	115	31	0.95		

E[FS] = 0.946000 E[ln FS] = -0.063089 Total 0.013664 100.00
Var[FS]= 0.013664
σ[FS]= 0.116894 σ[ln FS]= 0.123099
V(FS) = 0.123567
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	-0.512509
F(z) =	0.695853
Pr(f) % =	69.585275

Half Height	Head =	10.35	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	28	115	200	115	28	1.48		
2	25	115	200	115	28	1.31	0.030102	99.21
3	31	115	200	115	28	1.66		
4	28	109	200	115	28	1.47	0.000240	0.79
5	28	121	200	115	28	1.50		
6	28	115	134	115	28	1.48	0.000000	0.00
7	28	115	266	115	28	1.48		
8	28	115	200	109	28	1.48	0.000000	0.00
9	28	115	200	121	28	1.48		
10	28	115	200	115	25	1.48	0.000000	0.00
11	28	115	200	115	31	1.48		

E[FS] = 1.484000 E[ln FS] = 0.387899 Total 0.030343 100.00
Var[FS]= 0.030343
σ[FS]= 0.174191 σ[ln FS]= 0.116978
V(FS) = 0.117379
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	3.316000
F(z) =	0.000457
Pr(f) % =	0.045658

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	28	115	200	115	28			
2	25	115	200	115	28			
3	31	115	200	115	28			
4	28	109	200	115	28			
5	28	121	200	115	28			
6	28	115	134	115	28			
7	28	115	266	115	28			
8	28	115	200	109	28			
9	28	115	200	121	28			
10	28	115	200	115	25			
11	28	115	200	115	31			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

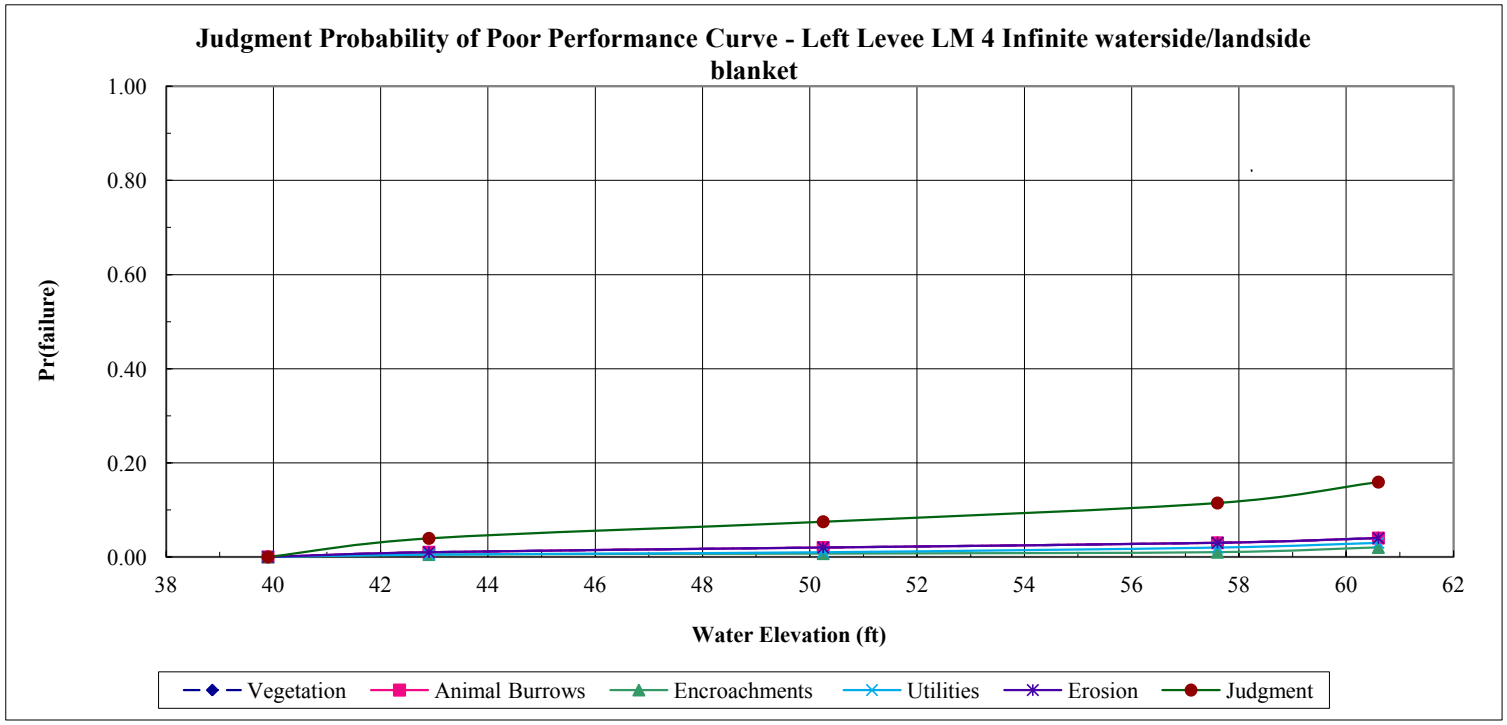
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: Left Levee

Levee Mile: 4.00
River Mile: 2168110 N; 6
Analysis Case: Infinite waterside/landside bl

Crest Elev.: 60.60
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 9/14/

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
39.90	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
42.90	0.0100	0.9900	0.0100	0.9900	0.0050	0.9950	0.0050	0.9950	0.0100	0.9900	0.0394	0.9606
50.25	0.0200	0.9800	0.0200	0.9800	0.0070	0.9930	0.0100	0.9900	0.0200	0.9800	0.0747	0.9253
57.60	0.0300	0.9700	0.0300	0.9700	0.0100	0.9900	0.0200	0.9800	0.0300	0.9700	0.1145	0.8855
60.60	0.0400	0.9600	0.0400	0.9600	0.0200	0.9800	0.0300	0.9700	0.0400	0.9600	0.1590	0.8410



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

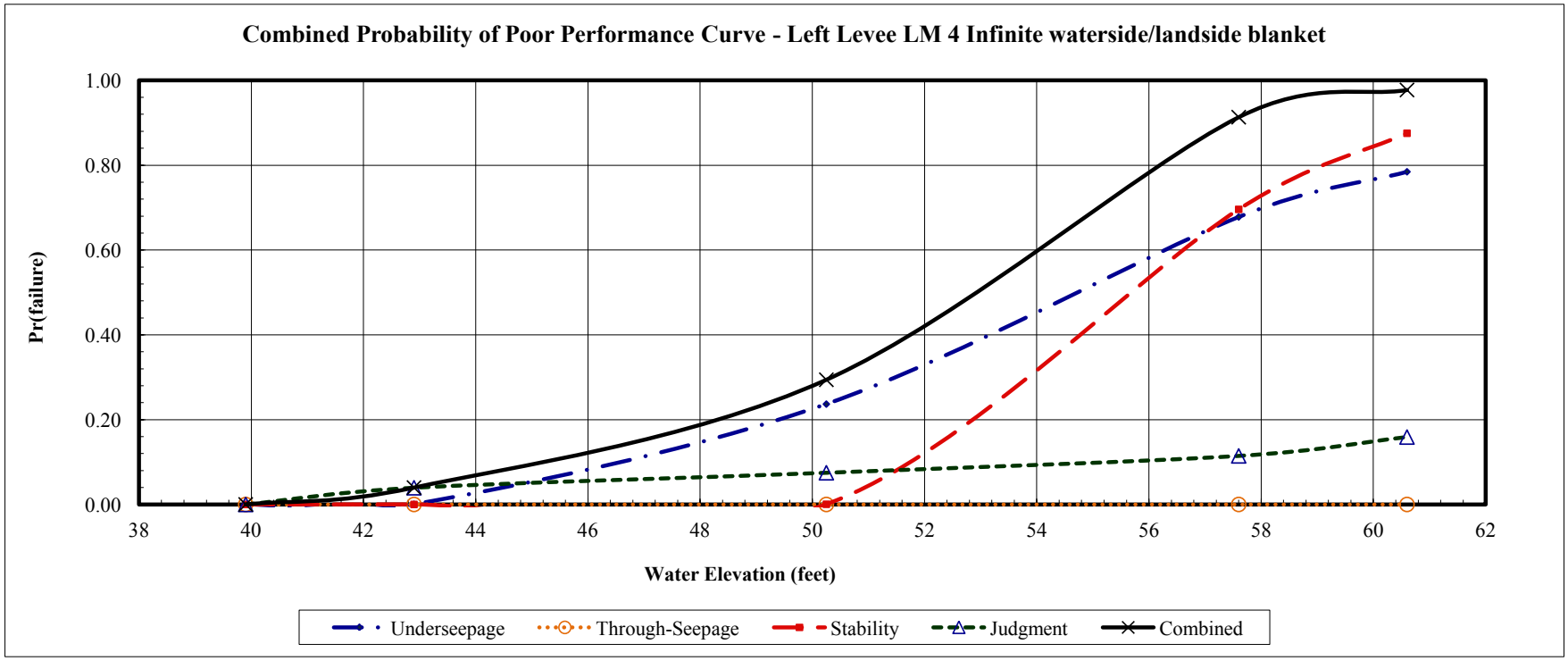
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: Left Levee

Levee Mile: 4.00
River Mile: 2168110 N; 662
Analysis Case: Infinite waterside/landside blanket

Crest Elev.: 60.60
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

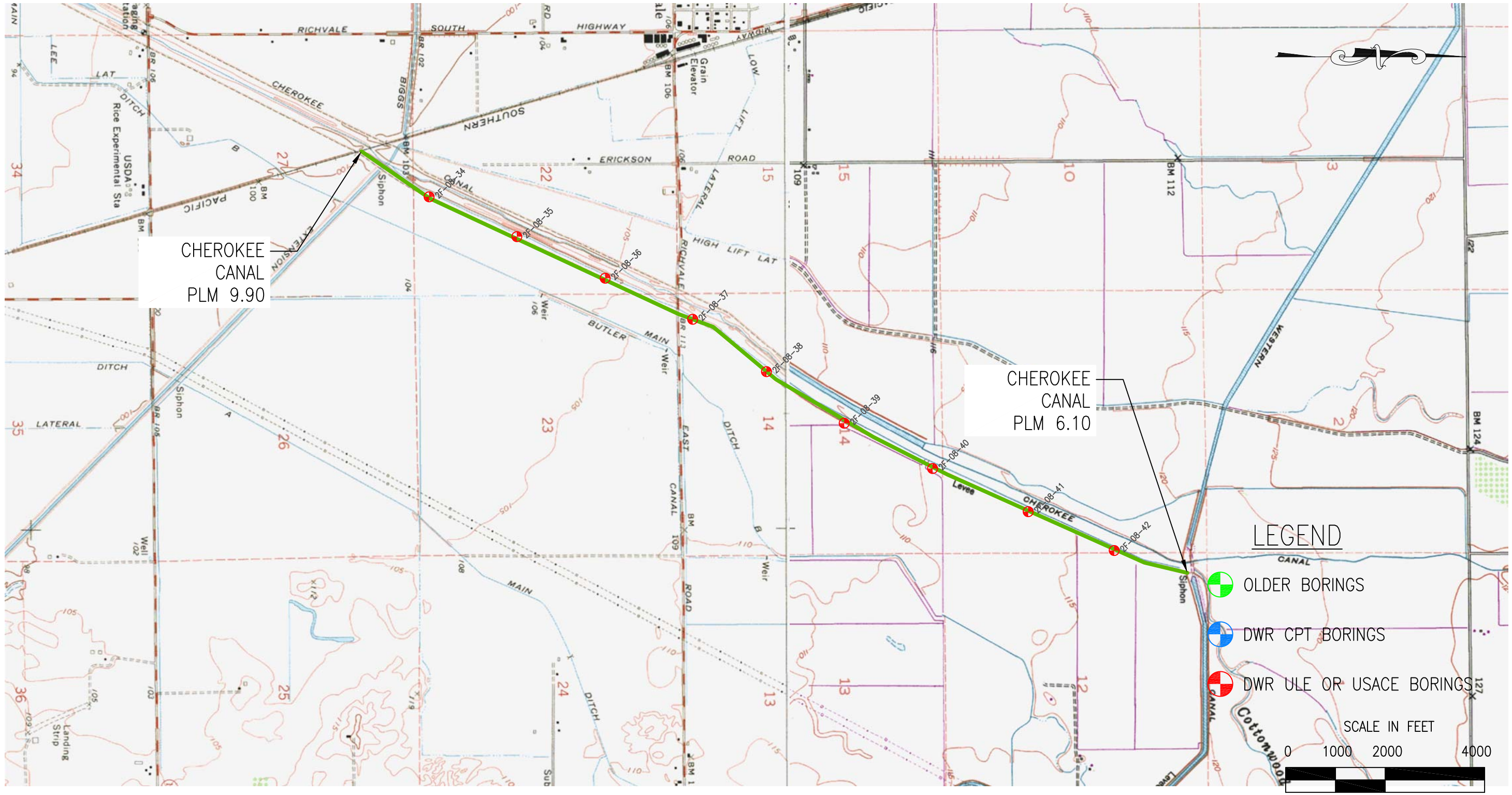
Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/14/20

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
39.90	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
42.90	0.0004	0.9996	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0398	0.9602
50.25	0.2366	0.7634	0.0000	1.0000	0.0005	0.9995	0.0747	0.9253	0.2940	0.7060
57.60	0.6780	0.3220	0.0000	1.0000	0.6959	0.3041	0.1145	0.8855	0.9133	0.0867
60.60	0.7846	0.2154	0.0000	1.0000	0.8754	0.1246	0.1590	0.8410	0.9774	0.0226



ENCLOSURE F

CHEROKEE CANAL LEFT LEVEE BORING LOGS



SUTTER BASIN FEASIBILITY STUDY – CHEROKEE CANAL

STUDY MAP SHOWING EXPLORATORY BORINGS

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER AND BUTTE COUNTY — CALIFORNIA

SUTTER FEASIBILITY STUDY

GEOTECHNICAL ENGINEERING APPENDIX
STUDY MAP SHOWING
GEOTECHNICAL EXPLORATIONS
CHEROKEE CANAL

DATE:	SCALE:
7 DEC 2012	1" = 2000'

DRILLING LOG

DIVISION	South Pacific
INSTALLATION	Sacramento District
SHEET	1 OF 2 SHEETS
1. PROJECT	Sutter Basin Feasibility Study Richvale, CA
9. COORDINATE SYSTEM	State Plane CA Zone 2
HORIZONTAL	NAD83
VERTICAL	NAVD88
10. SIZE AND TYPE OF BIT	8-inch HSA
2. HOLE NUMBER	2F-08-34
LOCATION COORDINATES	N 2,301,046.0 E 6,637,006.0
11. MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY	R&M Environmental
12. TOTAL SAMPLES	DISTURBED 3 / UNDISTURBED 11
4. NAME OF DRILLER	Kelin Jensen
13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG FROM VERTICAL	---
BEARING	
14. ELEVATION GROUND WATER	INITIAL 87.0 12/2/08 STATIC
15. DATE STARTED	12/2/08
DATE COMPLETED	12/2/08
6. THICKNESS OF OVERBURDEN	41.5
16. ELEVATION TOP OF BORING	112.0
7. DEPTH DRILLED INTO ROCK	0.0
17. TOTAL CORE RECOVERY FOR BORING	N/A
8. TOTAL DEPTH OF BORING	41.5
18. LOGGED BY	C. Payton
CHECKED BY	E. James

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							LEVEE FILL LEAN CLAY (CL); moist; dark grayish brown (10YR 4/2); trace sand; low plasticity fines; firm; PP = 2.25 tsf.										
108.0	4.0		5 6 7	13	9			83									
106.5	5.5		3 6 8	14	11		LEVEE FILL Silty CLAY (CL-ML); moist; yellowish brown (10YR 5/6); low plasticity fines; firm; PP = 2.0 tsf.	50	L1	0	30	70	41	25		CL	
			2 3 4	7	7		LEVEE FILL FAT CLAY with Sand (CH); moist; dark grayish brown (10YR 4/2); trace sand; low plasticity fines; firm; PP = 1.25 tsf.	60									
			4 7 7	14	9		Very dark gray (10YR 3/1); PP = 1.75 tsf.	60	L2						26		
			3 5 8	13	10		Very dark gray (5Y 3/1); PP = 1.25 tsf.	33	L3				49	35			
			4 6 8	14	14		Dark gray (10YR 4/1); low plasticity fines; hard; PP = 1.25 to 1.5 tsf.	67									
97.0	15.0							96	S-1	0	23	77	50	33		CH	
			7 14 21	35	30		Silty CLAY (CL-ML); moist; brown (10YR 5/3); PP = 4 to 4.5 tsf.	93	L4						24		
			8 10 12	22	23			100									
			12 14 15	29	25		PP > 4.5 tsf.	100									
							PP > 4.5 tsf.										

0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0

DRILLING LOG (Cont Sheet)

INSTALLATION	SHEET 2 OF 2 SHEETS
Sacramento District	

PROJECT	COORDINATE SYSTEM	HORIZONTAL	VERTICAL
Sutter Basin Feasibility Study Richvale, CA	State Plane CA Zone 2	NAD83	NAVD88

LOCATION COORDINATES	ELEVATION TOP OF BORING
N 2,301,046.0 E 6,637,006.0	112.0

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							Silty CLAY (CL-ML); moist; brown (10YR 5/3); PP = 4 to 4.5 tsf. *(continued)*										
90.0	22.0						SILTY SAND (SM); wet; brown (10YR 4/3); fine to coarse sand; 10% low plasticity fines; dense.										
			10 23 26	49	48			33	L5	0	75	26			23		
81.5	30.5		26 50 50/5"	R	R		Moist; yellowish brown (10YR 5/6).										
81.0	31.0						Clayey GRAVEL (GC); wet; yellowish brown (10YR 5/6); fine, subrounded gravel; 35% low plasticity fines; 10% fine to coarse sand; very dense.	33	L6						14		
							ELASTIC SILT (MH); moist; yellowish brown (10YR 5/4) light yellowish brown (10YR 6/4); low plasticity fines; hard; Well indurated. Mottled with iron oxide staining..										
			19 50/5"	R	R			67	L7				53	14			
73.7	38.3						SAND (SW); moist; dark yellowish brown (10YR 4/4); fine sand; dense; Silt lenses.										
70.5	41.5		7 20 26	46	45		Grayish brown (10YR 5/2); medium sand; 0% fines.	100	L8								

20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5 40.0

DRILLING LOG

DIVISION	South Pacific
INSTALLATION	Sacramento District
SHEET	1 OF 2 SHEETS
1. PROJECT	Sutter Basin Feasibility Study Richvale, CA
9. COORDINATE SYSTEM	State Plane CA Zone 2
HORIZONTAL	NAD83
VERTICAL	NAVD88
10. SIZE AND TYPE OF BIT	8-inch HSA
2. HOLE NUMBER	2F-08-35
LOCATION COORDINATES	N 2,302,812.0 E 6,637,807.0
11. MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY	R&M Environmental
12. TOTAL SAMPLES	DISTURBED 3 / UNDISTURBED 16
4. NAME OF DRILLER	Kelin Jensen
13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG FROM VERTICAL	---
BEARING	
14. ELEVATION GROUND WATER	INITIAL 97.5 12/3/08 STATIC 98.5 12/3/08
15. DATE STARTED	12/3/08
DATE COMPLETED	12/3/08
6. THICKNESS OF OVERBURDEN	41.5
16. ELEVATION TOP OF BORING	113.0
7. DEPTH DRILLED INTO ROCK	0.0
17. TOTAL CORE RECOVERY FOR BORING	N/A
8. TOTAL DEPTH OF BORING	41.5
18. LOGGED BY	C. Payton
CHECKED BY	E. James

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							LEVEE FILL LEAN CLAY (CL); moist; dark brown (10YR 3/3) yellowish brown (10YR 5/4); low plasticity fines; firm; Road base gravel.										
			4 6 8	14	9		Yellowish brown (10YR 5/4); PP = 1.25 tsf.	100	L1				34	19			
108.3	4.7		2 3 5	8	6		LEVEE FILL SILTY CLAY (CL-ML); moist; dark brown (10YR 3/3); low plasticity fines; firm; PP = 1.5 tsf.	93									
			2 4 4	8	8			100									
105.5	7.5																
			2 3 4	7	5		LEVEE FILL LEAN CLAY (CL); very dark gray (10YR 3/1); firm; PP = 0.7 tsf.	100									
			3 5 7	12	10		Dark gray (10YR 4/1); PP = 1.25 tsf, TV = 0.37 kg/cm^2.	100									
101.5	11.5		4 6 8	14	14		Dark gray (10YR 4/1).	100									
							SILTY CLAY (CL-ML); moist; yellowish brown (10YR 5/4); very hard; PP = 1.25 tsf.										
98.3	14.7							84	S-1								
			8 12 16	28	24		SILTY SAND (SM); wet; brown (10YR 4/3); 60% fine to medium sand; 40% low plasticity fines; medium dense.	100									
95.0	18.0		10 16 19	35	36			100	L2	0	69	32					
94.5	18.5		12 22 24	46	40		SANDY SILT (ML); moist; yellowish brown (10YR 5/4); dense. SANDY SILT with Gravel (SM); wet; dark yellowish brown (10YR 4/4); 30% fine sand; dense.	87									

0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0

DRILLING LOG (Cont Sheet)

INSTALLATION	SHEET 2 OF 2 SHEETS
Sacramento District	

PROJECT	COORDINATE SYSTEM	HORIZONTAL	VERTICAL
Sutter Basin Feasibility Study Richvale, CA	State Plane CA Zone 2	NAD83	NAVD88

LOCATION COORDINATES	ELEVATION TOP OF BORING
N 2,302,812.0 E 6,637,807.0	113.0

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
			26 36 40	76	74		SANDY SILT with Gravel (SM); wet; dark yellowish brown (10YR 4/4); 30% fine sand; dense. *(continued)* Very dense.	93	L3	2	86	12			14		
90.0	23.0						CLAYEY SAND (SC); moist; dark yellowish brown (10YR 4/4); 10% fine to medium sand; hard.										
			4 17 29	46	45			0									
			16 50	R	R			67	L4	0	51	49			25		
84.0	29.0						SANDY SILT (ML); yellowish brown (10YR 5/6); 40% fine sand; hard.										
			11 27 40	67	65			93	L5	0	61	39	38	19		SC	
77.2	35.8						SILTY SAND (SM); wet; yellowish brown (10YR 5/4); 40% fine to medium sand; 35% low plasticity fines; dense.										
			9 16 26	42	43			100	L6								
72.8	40.2						SILT (ML); moist; yellowish brown (10YR 5/8); trace sand; firm.										
71.5	41.5		3 7 24	31	32			67	L7								

20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5 40.0

DRILLING LOG

DIVISION	South Pacific
INSTALLATION	Sacramento District
SHEET	1 OF 2 SHEETS
1. PROJECT	Sutter Basin Feasibility Study Richvale, CA
9. COORDINATE SYSTEM	State Plane CA Zone 2
HORIZONTAL	NAD83
VERTICAL	NAVD88
10. SIZE AND TYPE OF BIT	8-inch HSA
2. HOLE NUMBER	2F-08-36
LOCATION COORDINATES	N 2,304,588.0 E 6,638,644.0
11. MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY	R&M Environmental
12. TOTAL SAMPLES	
DISTURBED	
UNDISTURBED	8
4. NAME OF DRILLER	Kelin Jensen
13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG FROM VERTICAL	---
BEARING	
14. ELEVATION GROUND WATER	INITIAL 84.5 12/4/08 STATIC
15. DATE STARTED	12/4/08
DATE COMPLETED	12/4/08
6. THICKNESS OF OVERBURDEN	39.5
16. ELEVATION TOP OF BORING	114.5
7. DEPTH DRILLED INTO ROCK	0.0
17. TOTAL CORE RECOVERY FOR BORING	N/A
8. TOTAL DEPTH OF BORING	39.5
18. LOGGED BY	C. Payton
CHECKED BY	E. James

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							LEAN CLAY (CL); ASTM D2488 used for field classifications. Sample decriptions were corrected to reflect lab results and reclassified using ASTM D2487 where applicable. Contacts are dashed where approximate or inferred, and solid where observed..										
			3 8 9	17				100					50	37	21		
			9 2 8	10				80									
			3 4 6	10				67									
								100					52	37			
								100									
103.5	11.0						SILT (ML).	100									
								84									
								100		0	51	49	32	18		SC	
							SILTY CLAY with Sand (ML). SILT (ML).	100									
							SILTY CLAY (ML).	87									

0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0

DRILLING LOG (Cont Sheet)

INSTALLATION	SHEET 2 OF 2 SHEETS
Sacramento District	

PROJECT	COORDINATE SYSTEM	HORIZONTAL	VERTICAL
Sutter Basin Feasibility Study Richvale, CA	State Plane CA Zone 2	NAD83	NAVD88

LOCATION COORDINATES	ELEVATION TOP OF BORING
N 2,304,588.0 E 6,638,644.0	114.5

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SILT (ML). *(continued)*	93					48	26			
								0									
								67		0	19	81	36	22		CL	
84.5	30.0						SAND (SW).										
								93									
								100									
76.5	38.0						SAND (SW).										
75.0	39.5																

20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5

DRILLING LOG

DIVISION	South Pacific
INSTALLATION	Sacramento District
SHEET	1 OF 2 SHEETS
1. PROJECT	Sutter Basin Feasibility Study Richvale, CA
9. COORDINATE SYSTEM	State Plane CA Zone 2
HORIZONTAL	NAD83
VERTICAL	NAVD88
10. SIZE AND TYPE OF BIT	8-inch HSA
2. HOLE NUMBER	2F-08-37
LOCATION COORDINATES	N 2,306,348.0 E 6,639,470.0
11. MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY	R&M Environmental
12. TOTAL SAMPLES	
DISTURBED	
UNDISTURBED	6
4. NAME OF DRILLER	Kelin Jensen
13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG FROM VERTICAL	---
BEARING	
14. ELEVATION GROUND WATER	INITIAL 96.5 12/4/08 STATIC 99.5 12/4/08
15. DATE STARTED	12/4/08
DATE COMPLETED	12/4/08
6. THICKNESS OF OVERBURDEN	40.5
16. ELEVATION TOP OF BORING	117.5
7. DEPTH DRILLED INTO ROCK	0.0
17. TOTAL CORE RECOVERY FOR BORING	N/A
8. TOTAL DEPTH OF BORING	40.5
18. LOGGED BY	C. Payton
CHECKED BY	E. James

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							ELASTIC SILT (MH); ASTM D2488 used for field classifications. Sample decriptions were corrected to reflect lab results and reclassified using ASTM D2487 where applicable. Contacts are dashed where approximate or inferred, and solid where observed..										
								83		2	22	76	42	23		CL	
								50									
								60									
108.8	8.7							60							23		
							FAT CLAY (CL).	33									
105.5	12.0							67									
							SANDY SILT (ML).										
								96					45	23			
101.6	15.9							93									
							CLAYEY SAND with Gravel (SC).	100									
99.1	18.4																
							SANDY SILT (ML).	100									

0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0

DRILLING LOG (Cont Sheet)

INSTALLATION	SHEET 2 OF 2 SHEETS
Sacramento District	

PROJECT	COORDINATE SYSTEM	HORIZONTAL	VERTICAL
Sutter Basin Feasibility Study Richvale, CA	State Plane CA Zone 2	NAD83	NAVD88

LOCATION COORDINATES	ELEVATION TOP OF BORING
N 2,306,348.0 E 6,639,470.0	117.5

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SANDY SILT (ML). *(continued)*			0	45	55			29		
94.5	23.0						SAND (SW).										
								33									
								33									
84.2	33.3						SILT (ML).										
								67									
77.0	40.5																

20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5 40.0

DRILLING LOG

DIVISION	South Pacific
INSTALLATION	Sacramento District
SHEET	1 OF 2 SHEETS
1. PROJECT	Sutter Basin Feasibility Study Richvale, CA
9. COORDINATE SYSTEM	State Plane CA Zone 2
HORIZONTAL	NAD83
VERTICAL	NAVD88
10. SIZE AND TYPE OF BIT	8-inch HSA
2. HOLE NUMBER	2F-08-38
LOCATION COORDINATES	N 2,307,833.0 E 6,640,524.0
11. MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY	R&M Environmental
12. TOTAL SAMPLES	
DISTURBED	
UNDISTURBED	9
4. NAME OF DRILLER	Kelin Jensen
13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG FROM VERTICAL	---
BEARING	
14. ELEVATION GROUND WATER	INITIAL 99.5 12/5/08 STATIC
15. DATE STARTED	12/5/08
DATE COMPLETED	12/5/08
6. THICKNESS OF OVERBURDEN	42.0
16. ELEVATION TOP OF BORING	119.0
7. DEPTH DRILLED INTO ROCK	0.0
17. TOTAL CORE RECOVERY FOR BORING	N/A
8. TOTAL DEPTH OF BORING	42.0
18. LOGGED BY	C. Payton
CHECKED BY	E. James

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SILT (ML); ASTM D2488 used for field classifications. Sample decriptions were corrected to reflect lab results and reclassified using ASTM D2487 where applicable. Contacts are dashed where approximate or inferred, and solid where observed..										
116.0	3.0																
115.5	3.5						LEAN CLAY (CL).	83		0	47	53	40	23		CL	
							ELASTIC SILT with Sand (MH).										
114.5	4.5																
114.0	5.0						LEAN CLAY (CL).	50									
113.7	5.3						ELASTIC SILT with Sand (MH).										
							LEAN CLAY (CL).										
112.9	6.1						ELASTIC SILT with Sand (MH).	60									
								60		0	38	62			27		
110.3	8.7																
							LEAN CLAY (CL).	33									
								67									
								96									
105.0	14.0						SANDY SILT (ML).										
								93		0	28	72	34	14		CL	
								100									
100.0	19.0							100									
							SAND (SW).										

0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0

DRILLING LOG (Cont Sheet)

INSTALLATION	SHEET 2 OF 2 SHEETS
Sacramento District	

PROJECT	COORDINATE SYSTEM	HORIZONTAL	VERTICAL
Sutter Basin Feasibility Study Richvale, CA	State Plane CA Zone 2	NAD83	NAVD88

LOCATION COORDINATES	ELEVATION TOP OF BORING
N 2,307,833.0 E 6,640,524.0	119.0

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SAND (SW). *(continued)*										
97.8	21.2														24		
							SANDY SILT (ML).										
95.7	23.3																
							SAND (SW).										
								33		0	73	27			25		
91.0	28.0																
							SANDY SILT (ML).										
								33					30	13			
87.9	31.1																
							SAND (SW).										
84.5	34.5																
							SILT (ML).										
								67									
										0	33	67			39		
								100									
77.0	42.0																

20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5 40.0

DRILLING LOG

DIVISION	South Pacific
INSTALLATION	Sacramento District
SHEET	1 OF 2 SHEETS
1. PROJECT	Sutter Basin Feasibility Study Richvale, CA
9. COORDINATE SYSTEM	State Plane CA Zone 2
HORIZONTAL	NAD83
VERTICAL	NAVD88
10. SIZE AND TYPE OF BIT	8-inch HSA
2. HOLE NUMBER	2F-08-39
LOCATION COORDINATES	N 2,309,396.0 E 6,641,562.0
11. MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY	R&M Environmental
12. TOTAL SAMPLES	DISTURBED: ; UNDISTURBED: 7
4. NAME OF DRILLER	Kelin Jensen
13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED; DEG FROM VERTICAL: ---; BEARING:
14. ELEVATION GROUND WATER	INITIAL 100.0 12/8/09; STATIC 103.0 12/8/09
15. DATE STARTED	12/8/09; DATE COMPLETED 12/8/09
6. THICKNESS OF OVERBURDEN	42.0
16. ELEVATION TOP OF BORING	121.0
7. DEPTH DRILLED INTO ROCK	0.0
17. TOTAL CORE RECOVERY FOR BORING	N/A
8. TOTAL DEPTH OF BORING	42.0
18. LOGGED BY	C. Payton
CHECKED BY	E. James

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SANDY SILT with Gravel (ML); ASTM D2488 used for field classifications. Sample decriptions were corrected to reflect lab results and reclassified using ASTM D2487 where applicable. Contacts are dashed where approximate or inferred, and solid where observed..										
							SILT (ML).	83		0	35	65	35	22		CL	
117.3	3.7						ELASTIC SILT (MH).										
116.5	4.5						Silty CLAY (CL).	50									
115.0	6.0																
114.5	6.5						ELASTIC SILT (MH).	60									
							LEAN CLAY (CL).										
							Silty CLAY (CL).	60					52	28			
								33									
								67									
108.5	12.5						SILT (ML).										
								96		0	37	63	41	26	25	CL	
								93		0	32	68	NV	NP		ML	
								100									
								100									

0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0

DRILLING LOG (Cont Sheet)

INSTALLATION	Sacramento District
SHEET	2 OF 2 SHEETS
PROJECT	Sutter Basin Feasibility Study Richvale, CA
COORDINATE SYSTEM	State Plane CA Zone 2
HORIZONTAL	NAD83
VERTICAL	NAVD88
LOCATION COORDINATES	N 2,309,396.0 E 6,641,562.0
ELEVATION TOP OF BORING	121.0

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
100.5	20.5						SILT (ML). *(continued)*										
							Silty SAND (SM).			0	72	28			24		
97.5	23.5						Sandy SILT (ML).										
								33									
92.5	28.5						SAND (SW).										
								33									
								67									
								100									
79.2	41.8																
79.0	42.0						SILT (ML).										

20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5 40.0

DRILLING LOG

DIVISION	South Pacific
INSTALLATION	Sacramento District
SHEET	1 OF 2 SHEETS
1. PROJECT	Sutter Basin Feasibility Study Richvale, CA
9. COORDINATE SYSTEM	State Plane CA Zone 2
HORIZONTAL	NAD83
VERTICAL	NAVD88
10. SIZE AND TYPE OF BIT	8-inch HSA
2. HOLE NUMBER	2F-08-40
LOCATION COORDINATES	N 2,311,175.0 E 6,642,474.0
11. MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY	R&M Environmental
12. TOTAL SAMPLES	DISTURBED: ; UNDISTURBED: 5
4. NAME OF DRILLER	Kelin Jensen
13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED; DEG FROM VERTICAL: ---; BEARING:
14. ELEVATION GROUND WATER	INITIAL 106.0 12/9/09; STATIC 107.5 12/9/09
15. DATE STARTED	12/9/09; DATE COMPLETED 12/9/09
6. THICKNESS OF OVERBURDEN	40.0
16. ELEVATION TOP OF BORING	122.5
7. DEPTH DRILLED INTO ROCK	0.0
17. TOTAL CORE RECOVERY FOR BORING	N/A
8. TOTAL DEPTH OF BORING	40.0
18. LOGGED BY	C. Payton
CHECKED BY	E. James

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							ELASTIC SILT (MH); ASTM D2488 used for field classifications. Sample decriptions were corrected to reflect lab results and reclassified using ASTM D2487 where applicable. Contacts are dashed where approximate or inferred, and solid where observed..										
119.7	2.8																
119.4	3.1						Silty SAND (SM).										
119.2	3.3						Sandy SILT (ML).	83		7	25	68	46	33		CL	
							LEAN CLAY (CL).										
								50									
								60									
							LEAN CLAY (CL).										
								60		0	38	62	34	19	34	CL	
113.5	9.0																
							ELASTIC SILT (MH).	33									
								67									
							ELASTIC SILT (MH).										
108.5	14.0							96									
							Clayey SAND (SC).										
107.0	15.5																
							ELASTIC SILT (MH).	93		8	41	51	43	16		ML	
								100									
								100									

0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0

DRILLING LOG (Cont Sheet)

INSTALLATION	SHEET 2 OF 2 SHEETS
Sacramento District	

PROJECT	COORDINATE SYSTEM	HORIZONTAL	VERTICAL
Sutter Basin Feasibility Study Richvale, CA	State Plane CA Zone 2	NAD83	NAVD88

LOCATION COORDINATES	ELEVATION TOP OF BORING
N 2,311,175.0 E 6,642,474.0	122.5

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
102.0	20.5						ELASTIC SILT (MH). *(continued)*										
101.3	21.2						SAND (SP).										
							Sandy SILT (ML).										
		■						33									
		■						33									
										0	27	73			24		
							SILT (ML).										
		■						67									
82.5	40.0																

20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5 40.0

DRILLING LOG

DIVISION	South Pacific
INSTALLATION	Sacramento District
SHEET	1 OF 2 SHEETS
1. PROJECT	Sutter Basin Feasibility Study Richvale, CA
9. COORDINATE SYSTEM	State Plane CA Zone 2
HORIZONTAL	NAD83
VERTICAL	NAVD88
10. SIZE AND TYPE OF BIT	8-inch HSA
2. HOLE NUMBER	2F-08-41
LOCATION COORDINATES	N 2,313,098.0 E 6,643,342.0
11. MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY	R&M Environmental
12. TOTAL SAMPLES	DISTURBED: ; UNDISTURBED: 7
4. NAME OF DRILLER	Kelin Jensen
13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED; DEG FROM VERTICAL: ---; BEARING:
14. ELEVATION GROUND WATER	INITIAL 107.0 12/9/09; STATIC 110.0 12/9/09
15. DATE STARTED	12/9/09; DATE COMPLETED 12/9/09
6. THICKNESS OF OVERBURDEN	40.5
16. ELEVATION TOP OF BORING	124.5
7. DEPTH DRILLED INTO ROCK	0.0
17. TOTAL CORE RECOVERY FOR BORING	N/A
8. TOTAL DEPTH OF BORING	40.5
18. LOGGED BY	C. Payton; CHECKED BY E. James

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SANDY LEAN CLAY (CL); ASTM D2488 used for field classifications. Sample decriptions were corrected to reflect lab results and reclassified using ASTM D2487 where applicable. Contacts are dashed where approximate or inferred, and solid where observed..										
							LEAN CLAY (CL).	83		1	27	73	36	25		CL	
								50									
119.0	5.5						ELASTIC SILT (MH).	60									
118.0	6.5						LEAN CLAY (CL).										
								60					48	33			
								33									
								67									
								96									
108.5	16.0							93									
							Clayey SAND (SC).										
107.2	17.3							100		0	32	68			32		
107.0	17.5						CLAYEY SAND (SC-SM).										
							ELASTIC SILT (MH).	100									

0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0

DRILLING LOG (Cont Sheet)

INSTALLATION	SHEET 2 OF 2 SHEETS
Sacramento District	

PROJECT	COORDINATE SYSTEM	HORIZONTAL	VERTICAL
Sutter Basin Feasibility Study Richvale, CA	State Plane CA Zone 2	NAD83	NAVD88

LOCATION COORDINATES	ELEVATION TOP OF BORING
N 2,313,098.0 E 6,643,342.0	124.5

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							ELASTIC SILT (MH). *(continued)*										
100.0	24.5						SILT (ML).						NV	NP			
								33									
								33									
							Sandy SILT (ML).										
								67							33		
							SILT (ML).										
84.0	40.5																

20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5 40.0

DRILLING LOG

DIVISION	South Pacific
INSTALLATION	Sacramento District
SHEET	1 OF 2 SHEETS
1. PROJECT	Sutter Basin Feasibility Study Richvale, CA
9. COORDINATE SYSTEM	State Plane CA Zone 2
HORIZONTAL	NAD83
VERTICAL	NAVD88
10. SIZE AND TYPE OF BIT	8-inch HSA
2. HOLE NUMBER	2F-08-42
LOCATION COORDINATES	N 2,314,828.0 E 6,644,123.0
11. MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY	R&M Environmental
12. TOTAL SAMPLES	DISTURBED: ; UNDISTURBED: 9
4. NAME OF DRILLER	Kelin Jensen
13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG FROM VERTICAL	---
BEARING	
14. ELEVATION GROUND WATER	INITIAL 110.0 12/10/08 STATIC
15. DATE STARTED	12/10/08
DATE COMPLETED	12/10/08
6. THICKNESS OF OVERBURDEN	41.6
16. ELEVATION TOP OF BORING	125.5
7. DEPTH DRILLED INTO ROCK	0.0
17. TOTAL CORE RECOVERY FOR BORING	N/A
8. TOTAL DEPTH OF BORING	41.6
18. LOGGED BY	C. Payton
CHECKED BY	E. James

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SILTY CLAY (CL); ASTM D2488 used for field classifications. Sample decriptions were corrected to reflect lab results and reclassified using ASTM D2487 where applicable. Contacts are dashed where approximate or inferred, and solid where observed..										
								83		0	21	80	49	33		CL	
							LEAN CLAY (CL).	50									
								60									
															24		
								60									
116.0	9.5						SANDY SILT (ML).	33									
								67									
								96									
110.0 ▽	15.5						SAND (SW).	93									
108.8	16.7						SAND with Gravel (SWG).										
108.2	17.3						SANDY SILT (ML).	100		25	64	11			21		
107.1	18.4						SAND (SW).	100									

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0

DRILLING LOG (Cont Sheet)

INSTALLATION	SHEET 2 OF 2 SHEETS
Sacramento District	

PROJECT	COORDINATE SYSTEM	HORIZONTAL	VERTICAL
Sutter Basin Feasibility Study Richvale, CA	State Plane CA Zone 2	NAD83	NAVD88

LOCATION COORDINATES	ELEVATION TOP OF BORING
N 2,314,828.0 E 6,644,123.0	125.5

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SAND (SW). *(continued)*										
104.1	21.4									1	50	49	40	16		SC	
							SILT (ML).										
102.0	23.5																
							SAND (SW).										
		▲						33		0	95	6			32		
95.5	30.0																
		▲					LEAN CLAY (CL).	33					78	51			
90.5	35.0																
		▲					SILT (ML).	67							36		
		▲						100									

Depth scale: 20.0, 22.5, 25.0, 27.5, 30.0, 32.5, 35.0, 37.5, 40.0

ENCLOSURE G

DETERMINISTIC ANALYSIS

Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Silty Sand & Clayey Sand Levee Fill, SM, SC	1.40	0.35	4	125	10	32
2	Clay Foundation, CH, CL, ML	0.028	0.028	1	115	100	28
3	Gravel or Sand Foundation, SM	2.800	0.710	4	125	0	34
4	Clay Interbed or Deep Layer, CL-ML	0.03	0.01	4	115	100	28
5	Gravel or Sand Foundation, SM	2.80	0.71	4	125	0	34
6	Clay Interbed or Deep Layer, CL	0.03	0.01	4	115	100	28

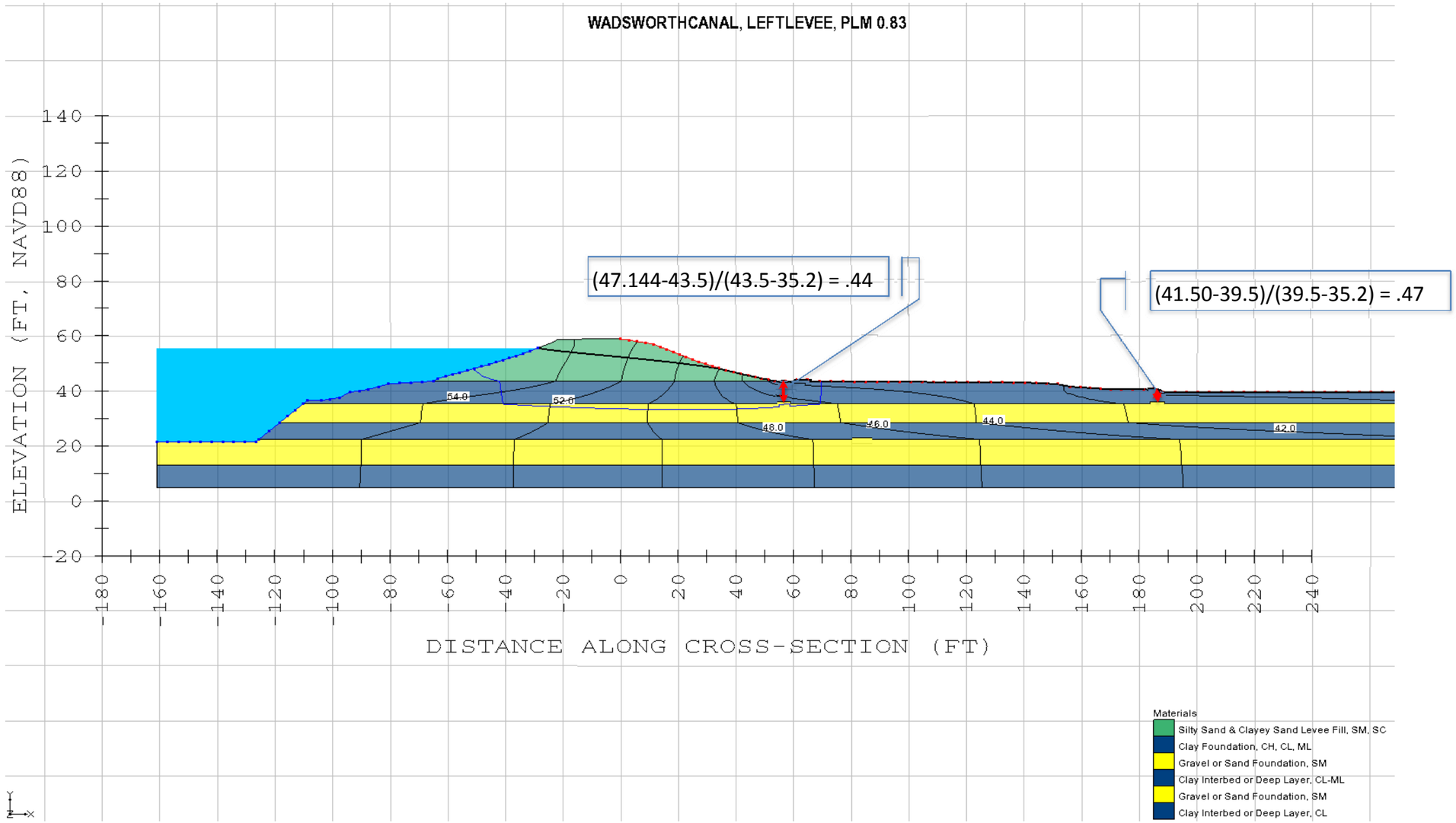
NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSEWWC_001B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 55.5 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER BASIN CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
WADSWORTH CANAL, LEFT LEVEE, LM0.83
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Silty Sand & Clayey Sand Levee Fill, SM, SC	1.40	0.35	4	125	10	32
2	Clay Foundation, CH, CL, ML	0.028	0.028	1	115	100	28
3	Gravel or Sand Foundation, SM	2.800	0.710	4	125	0	34
4	Clay Interbed or Deep Layer, CL-ML	0.03	0.01	4	115	100	28
5	Gravel or Sand Foundation, SM	2.80	0.71	4	125	0	34
6	Clay Interbed or Deep Layer, CL	0.03	0.01	4	115	100	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSEWWC_001B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 55.5 ft.

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SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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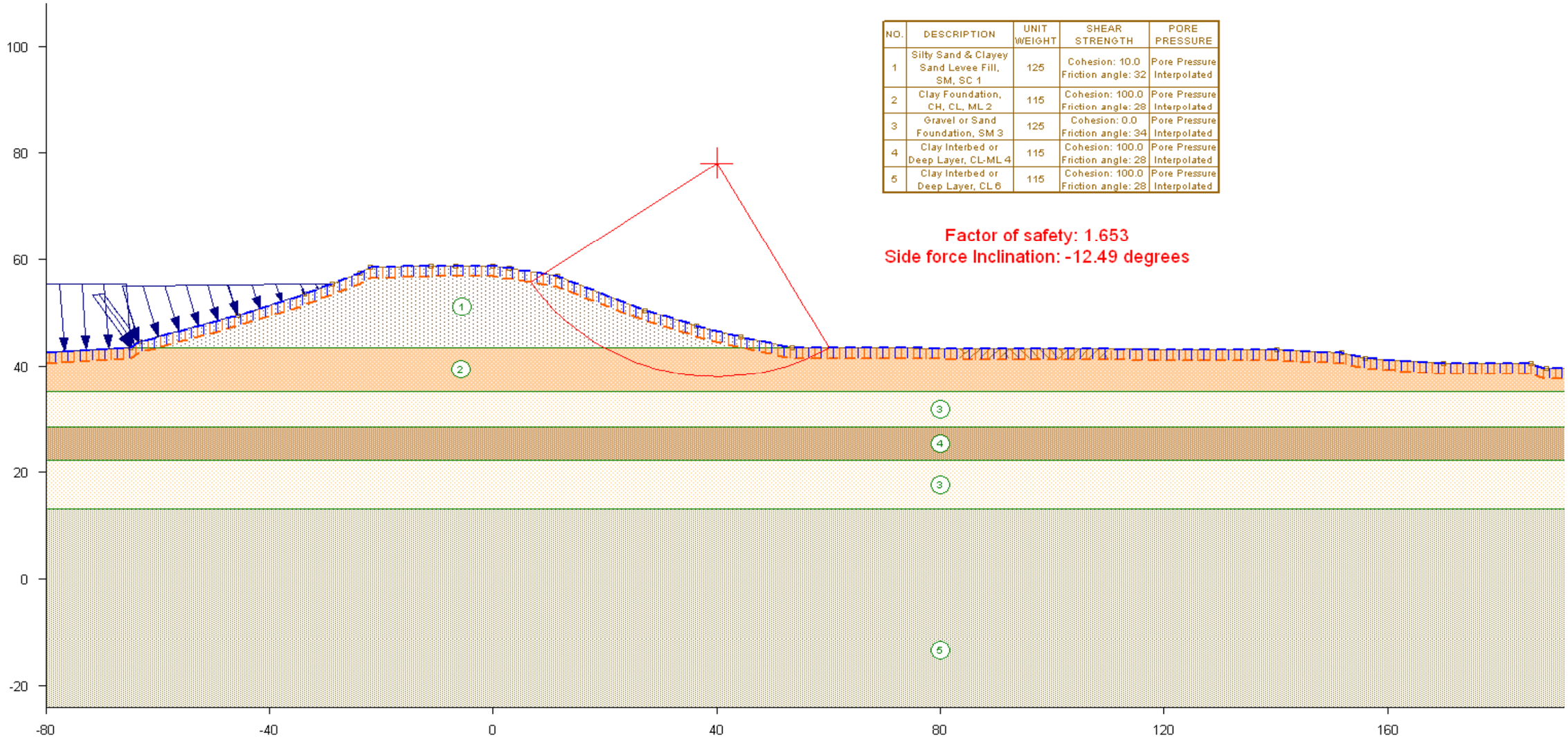
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
WADSWORTH CANAL, LEFT LEVEE, LM0.83
EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Silty Sand & Clayey Sand Levee Fill, SM, SC 1	125	Cohesion: 10.0 Friction angle: 32	Pore Pressure Interpolated
2	Clay Foundation, CH, CL, ML 2	115	Cohesion: 100.0 Friction angle: 28	Pore Pressure Interpolated
3	Gravel or Sand Foundation, SM 3	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated
4	Clay Interbed or Deep Layer, CL-ML 4	115	Cohesion: 100.0 Friction angle: 28	Pore Pressure Interpolated
5	Clay Interbed or Deep Layer, CL 6	115	Cohesion: 100.0 Friction angle: 28	Pore Pressure Interpolated

Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Silty Sand & Clayey Sand Levee Fill, SM, SC	1.40	0.35	4	125	10	32
2	Clay Foundation, CH, CL, ML	0.028	0.028	1	115	100	28
3	Gravel or Sand Foundation, SM	2.800	0.710	4	125	0	34
4	Clay Interbed or Deep Layer, CL-ML	0.03	0.01	4	115	100	28
5	Gravel or Sand Foundation, SM	2.80	0.71	4	125	0	34
6	Clay Interbed or Deep Layer, CL	0.03	0.01	4	115	100	28

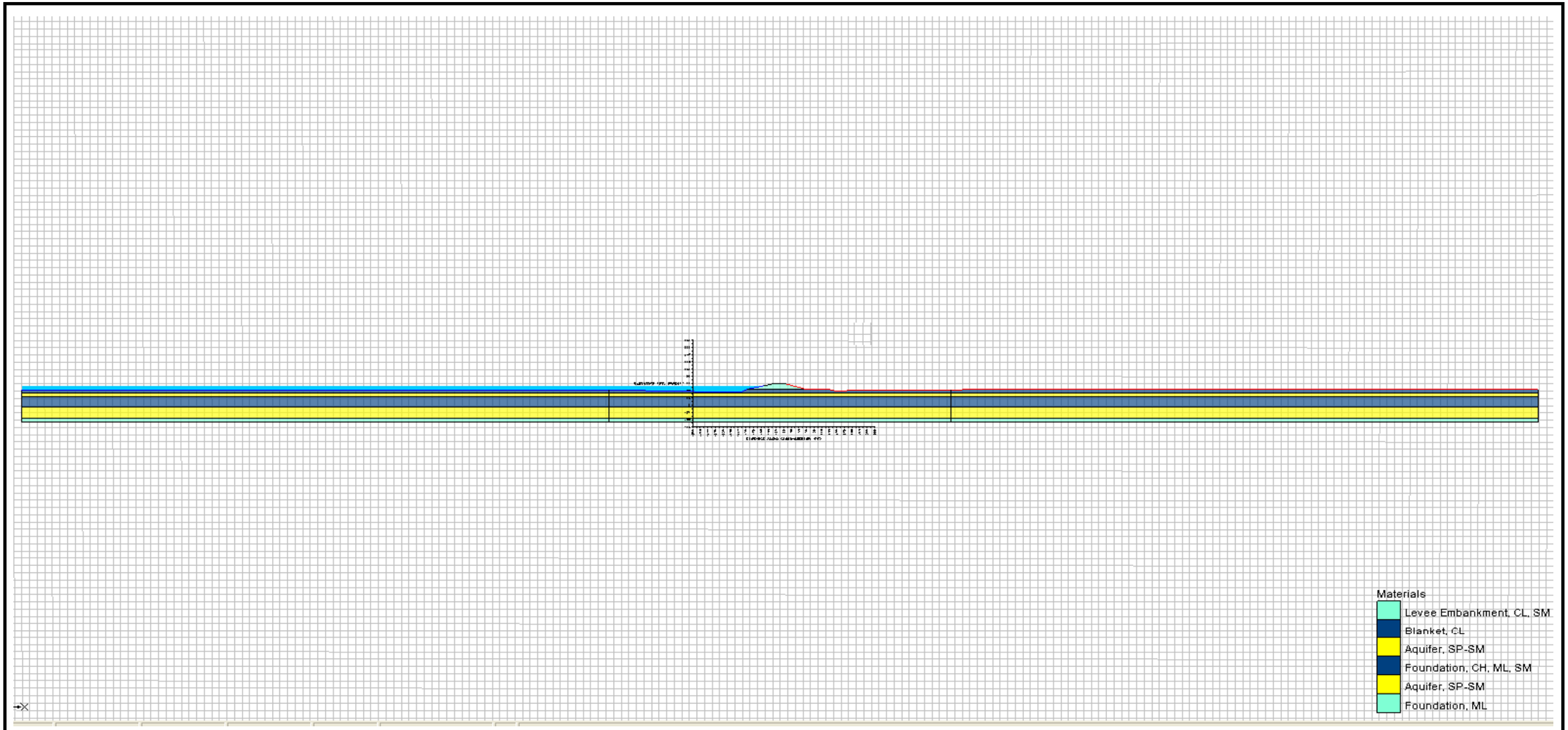
NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSEWWC_001B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 55.5 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER BASIN CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
WADSWORTH CANAL, LEFT LEVEE, LM0.83
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, CL, SM	0.57	0.14	4	115	50	28
2	Blanket, CL	0.028	0.007	4	115	100	28
3	Aquifer, SP-SM	14.000	1.400	10	125	0	32
4	Foundation, CH, ML, SM	0.57	0.14	4	120	100	28
5	Aquifer, SP-SM	14.00	1.40	10	125	0	32
6	Foundation, ML	0.57	0.14	4	120	10	28

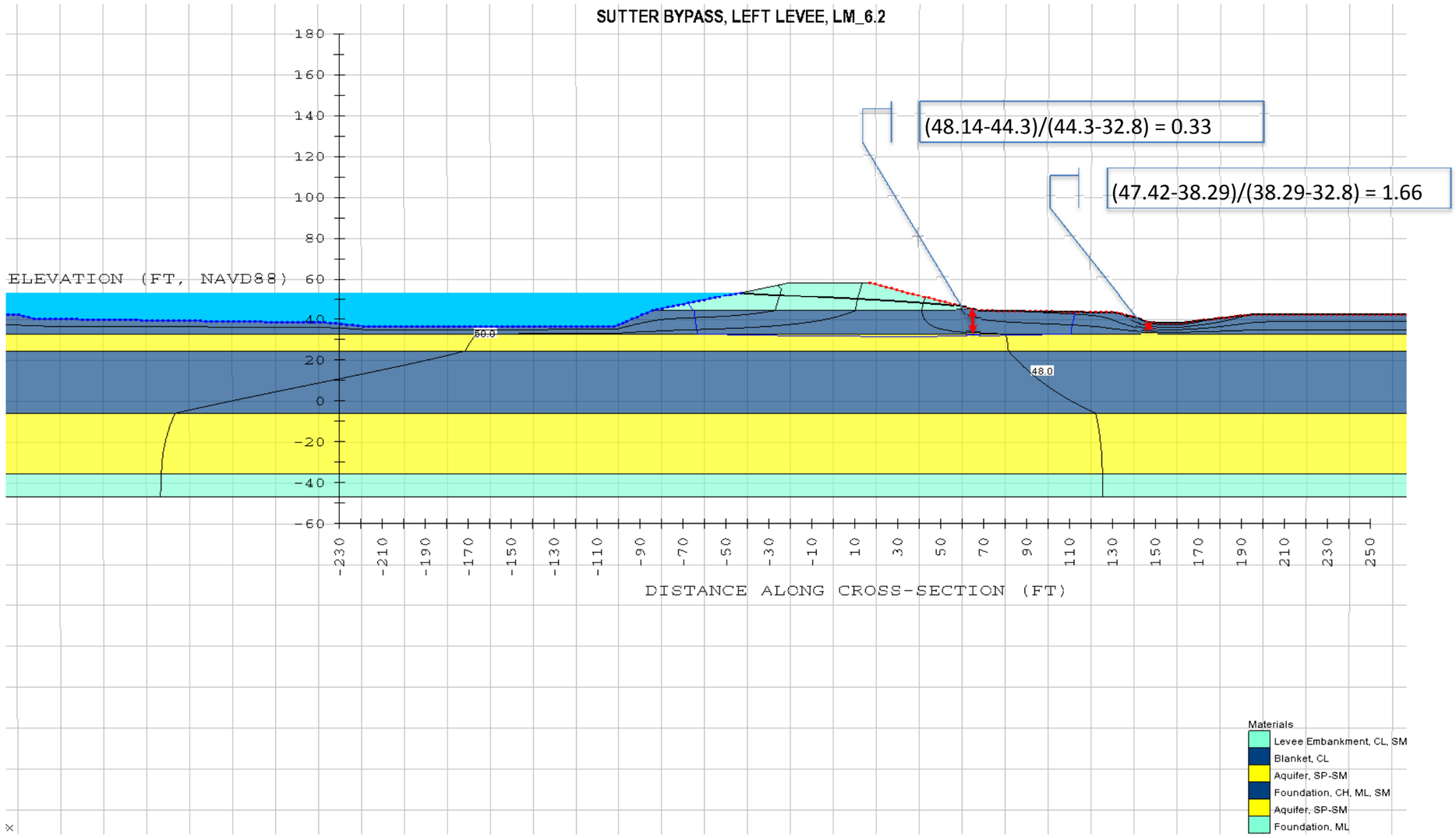
NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSESBP_017B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 53.29 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER BASIN CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
SUTTER BYPASS, LM_6.2, STATION 823+27
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, CL, SM	0.57	0.14	4	115	50	28
2	Blanket, CL	0.028	0.007	4	115	100	28
3	Aquifer, SP-SM	14.000	1.400	10	125	0	32
4	Foundation, CH, ML, SM	0.57	0.14	4	120	100	28
5	Aquifer, SP-SM	14.00	1.40	10	125	0	32
6	Foundation, ML	0.57	0.14	4	120	10	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSESBP_017B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 53.29 ft.

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SACRAMENTO DISTRICT
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GEOTECHNICAL ENGINEERING APPENDIX

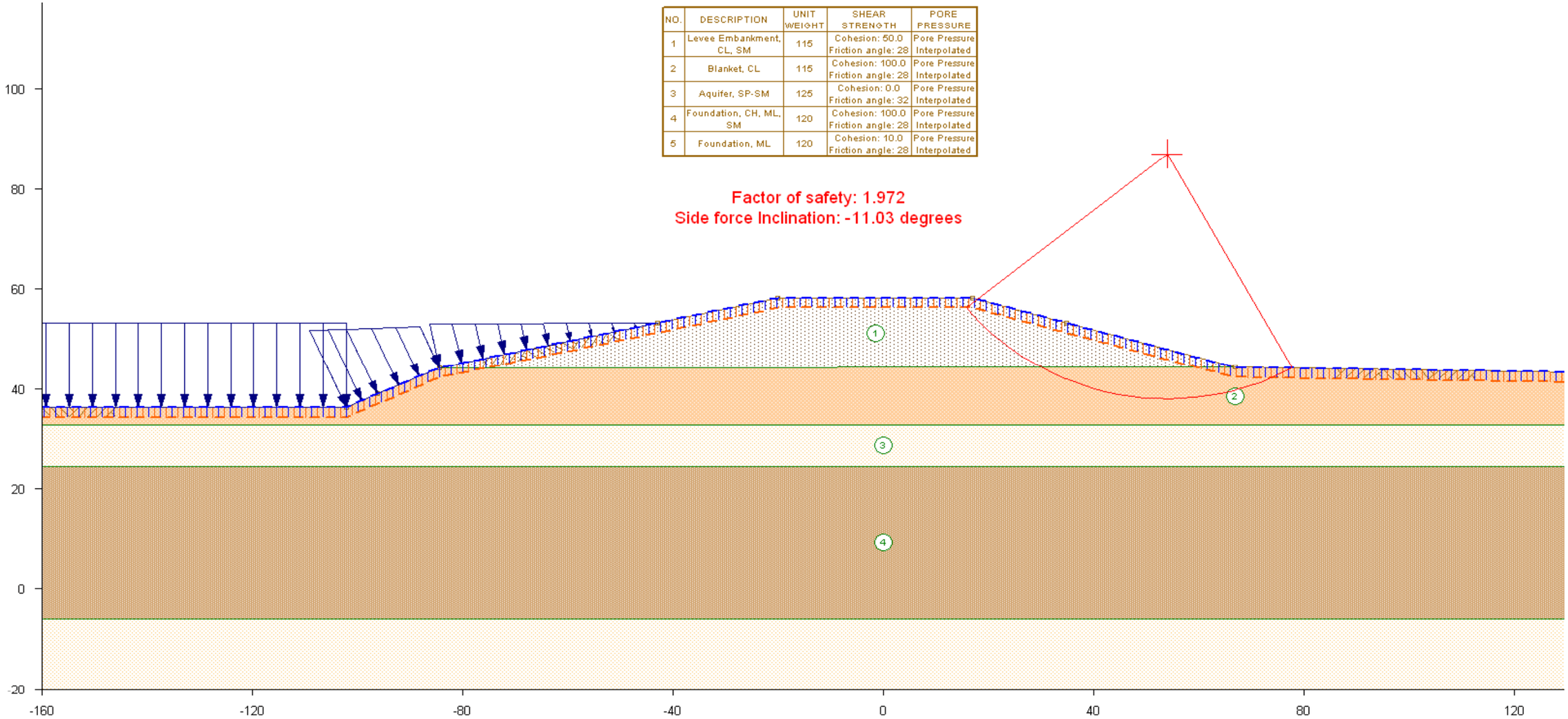
SEEPAGE AND STABILITY ANALYSIS

SUTTER BYPASS, LM_6.2, STATION 823+27

EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Embankment, CL, SM	115	Cohesion: 50.0 Friction angle: 28	Pore Pressure Interpolated
2	Blanket, CL	115	Cohesion: 100.0 Friction angle: 28	Pore Pressure Interpolated
3	Aquifer, SP-SM	125	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated
4	Foundation, CH, ML, SM	120	Cohesion: 100.0 Friction angle: 28	Pore Pressure Interpolated
5	Foundation, ML	120	Cohesion: 10.0 Friction angle: 28	Pore Pressure Interpolated



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, CL, SM	0.57	0.14	4	115	50	28
2	Blanket, CL	0.028	0.007	4	115	100	28
3	Aquifer, SP-SM	14.000	1.400	10	125	0	32
4	Foundation, CH, ML, SM	0.57	0.14	4	120	100	28
5	Aquifer, SP-SM	14.00	1.40	10	125	0	32
6	Foundation, ML	0.57	0.14	4	120	10	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSESBP_017B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 53.29 ft.

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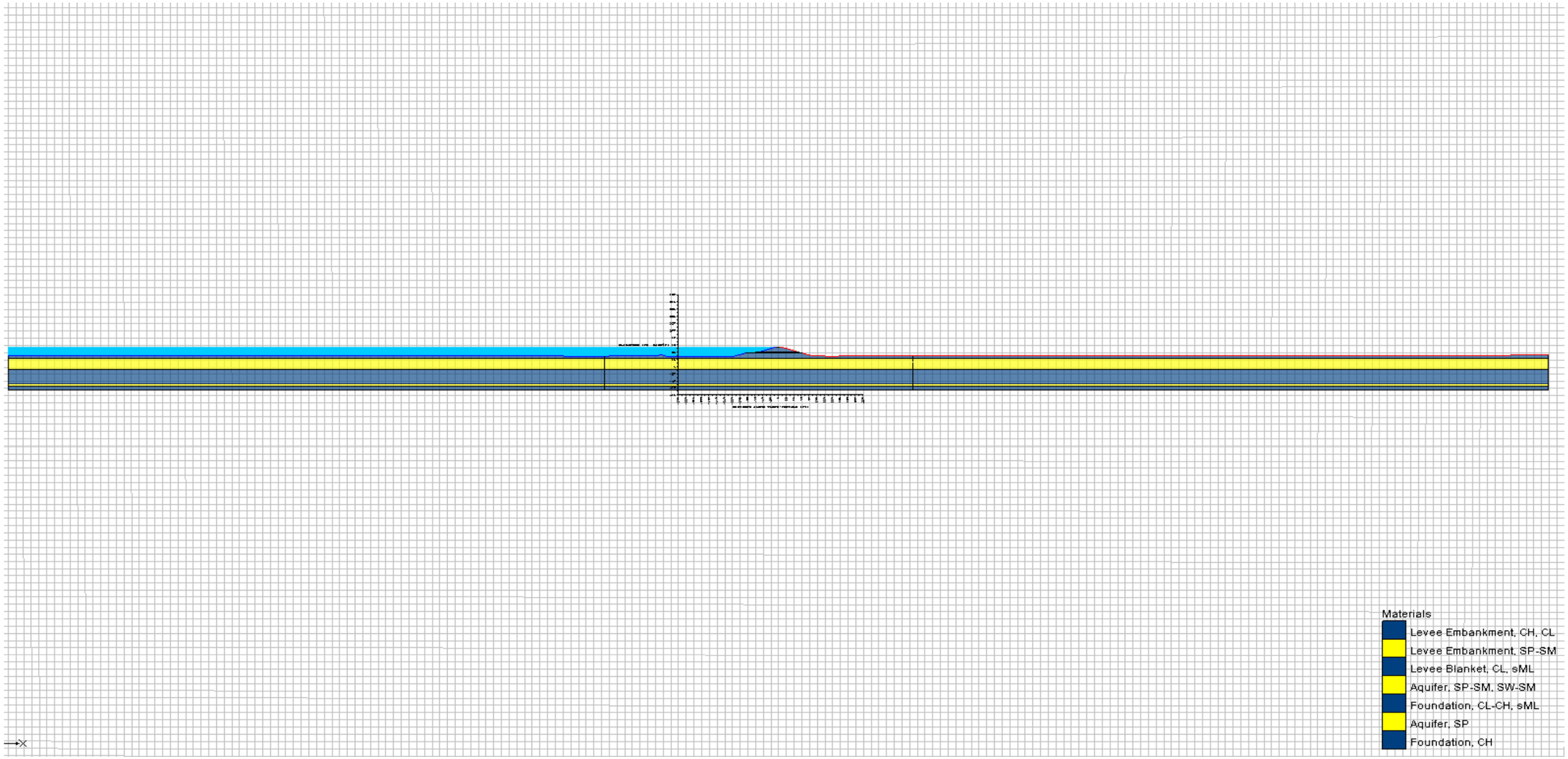
GEOTECHNICAL ENGINEERING APPENDIX

SEEPAGE AND STABILITY ANALYSIS

SUTTER BYPASS, LM_6.2, STATION 823+27

EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL, (CL)s	0.028	0.007	4	115	150	27
3	Blanket, CL, (CL)s	0.028	0.007	4	115	150	27
4	Aquifer, SP-SM	14.00	1.40	10	125	0	34
5	Foundation, (ML)s	0.57	0.14	4	120	10	28
6	Aquifer, SP-SM	14.00	1.40	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSESBP_005B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 54.1 ft.

DEPARTMENT OF THE ARMY
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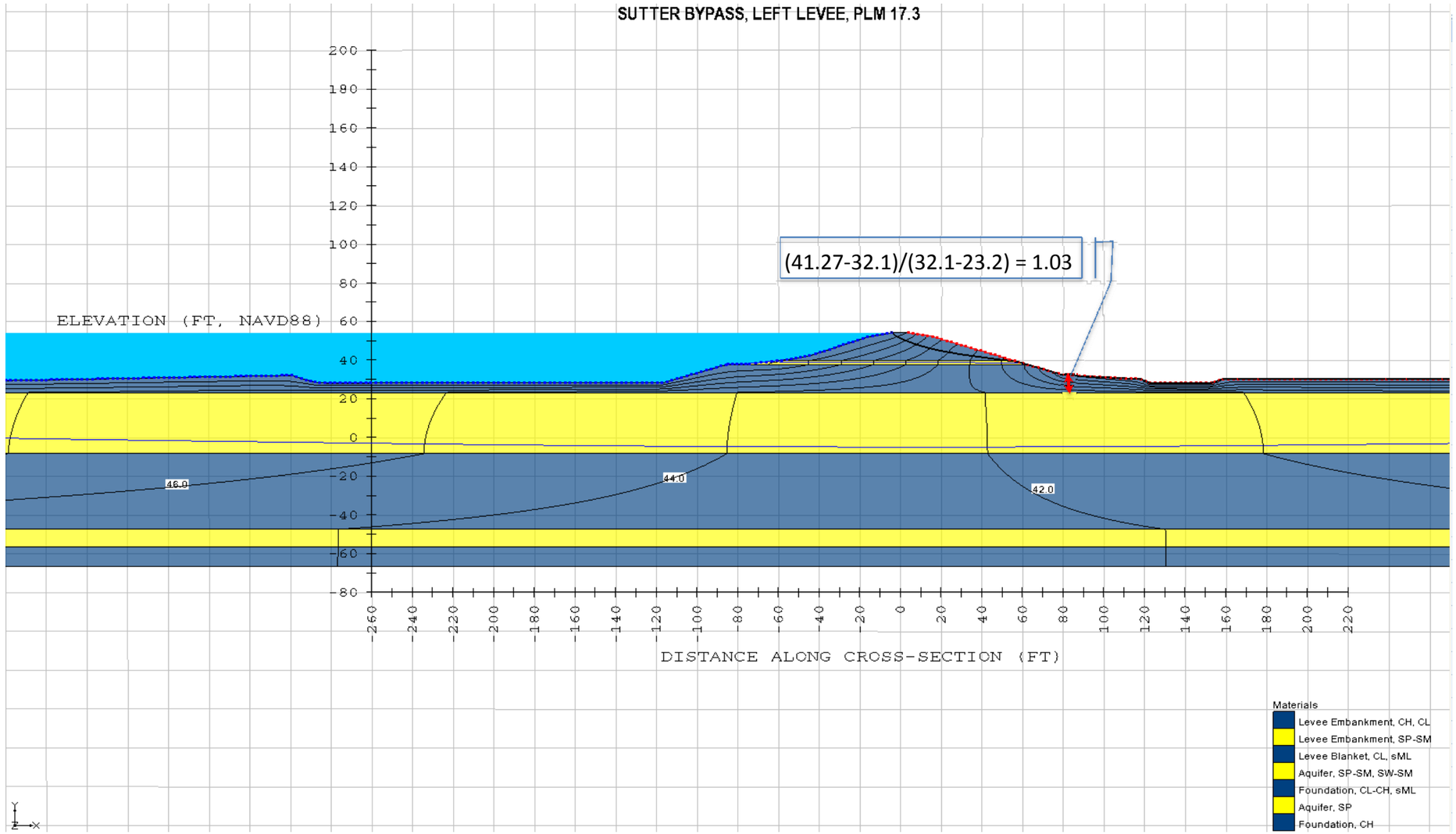
SACRAMENTO, CALIFORNIA

SUTTER BASIN CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
SUTTER BYPASS, LM_17.3 STATION 293+00
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL, (CL)s	0.028	0.007	4	115	150	27
3	Blanket, CL, (CL)s	0.028	0.007	4	115	150	27
4	Aquifer, SP-SM	14.00	1.40	10	125	0	34
5	Foundation, (ML)s	0.57	0.14	4	120	10	28
6	Aquifer, SP-SM	14.00	1.40	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSESBP_005B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 54.1 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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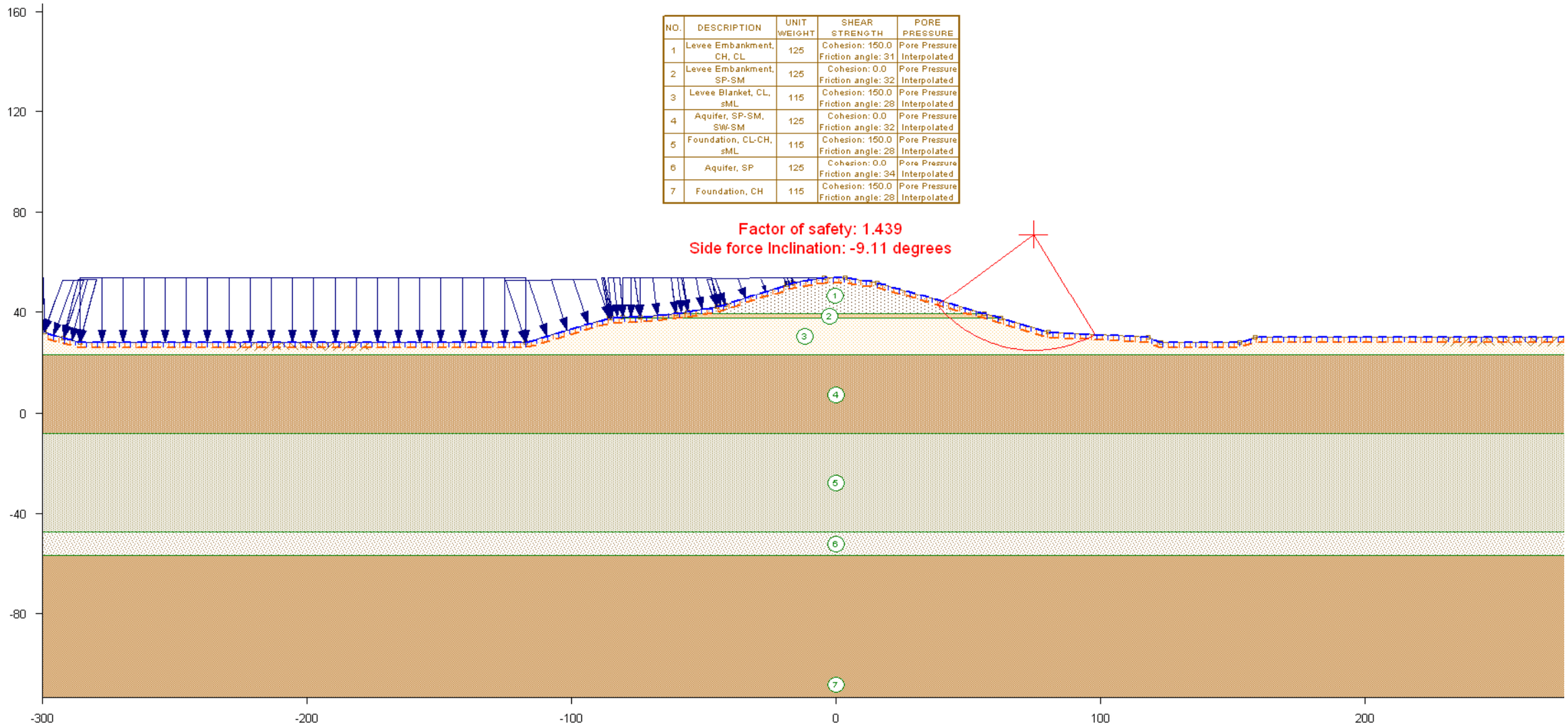
GEOTECHNICAL ENGINEERING APPENDIX

SEEPAGE AND STABILITY ANALYSIS

SUTTER BYPASS, LM_17.3 STATION 293+00

EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Embankment, CH, CL	125	Cohesion: 150.0 Friction angle: 31	Pore Pressure Interpolated
2	Levee Embankment, SP-SM	125	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated
3	Levee Blanket, CL, sML	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated
4	Aquifer, SP-SM, SW-SM	125	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated
5	Foundation, CL-CH, sML	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated
6	Aquifer, SP	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated
7	Foundation, CH	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated

Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL, (CL)s	0.028	0.007	4	115	150	27
3	Blanket, CL, (CL)s	0.028	0.007	4	115	150	27
4	Aquifer, SP-SM	14.00	1.40	10	125	0	34
5	Foundation, (ML)s	0.57	0.14	4	120	10	28
6	Aquifer, SP-SM	14.00	1.40	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSESBP_005B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 54.1 ft.

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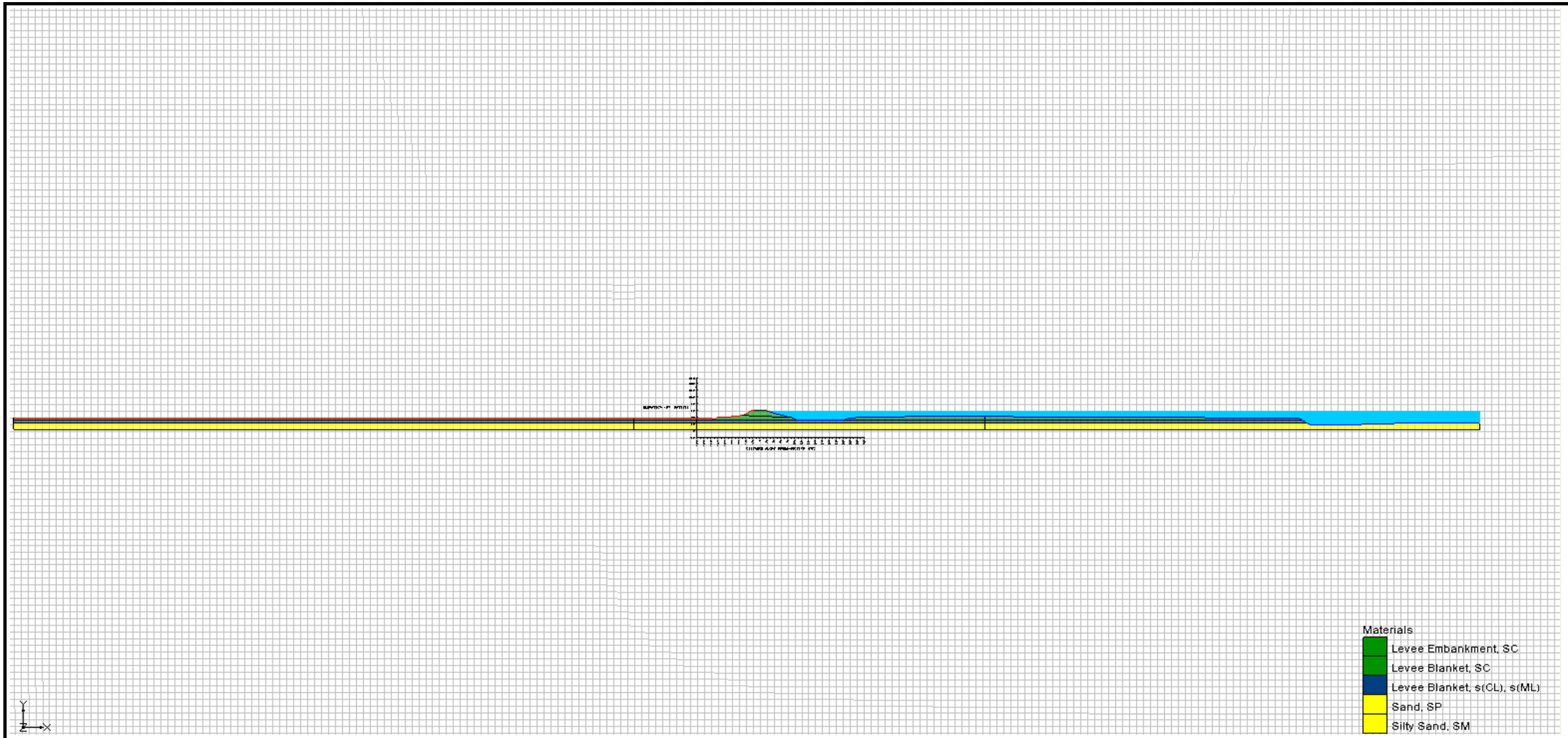
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
SUTTER BYPASS, LM_17.3 STATION 293+00
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, SC	0.28	0.07	4	115.00	10.00	27.00
2	Blanket, SC	0.28	0.07	4	115.00	10.00	27.00
3	Blanket, s(ML), s(CL)	0.57	0.14	4	120.00	10.00	28.00
4	Aquifer, SP	28.00	2.80	10	125.00	0.00	34.00
5	Aquifer, SM	28.00	2.80	10	125.00	0.00	32.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on borings WM0003_002B, 2F-91-7, 5F-73-CD10 (1957 boring)
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 59 ft.

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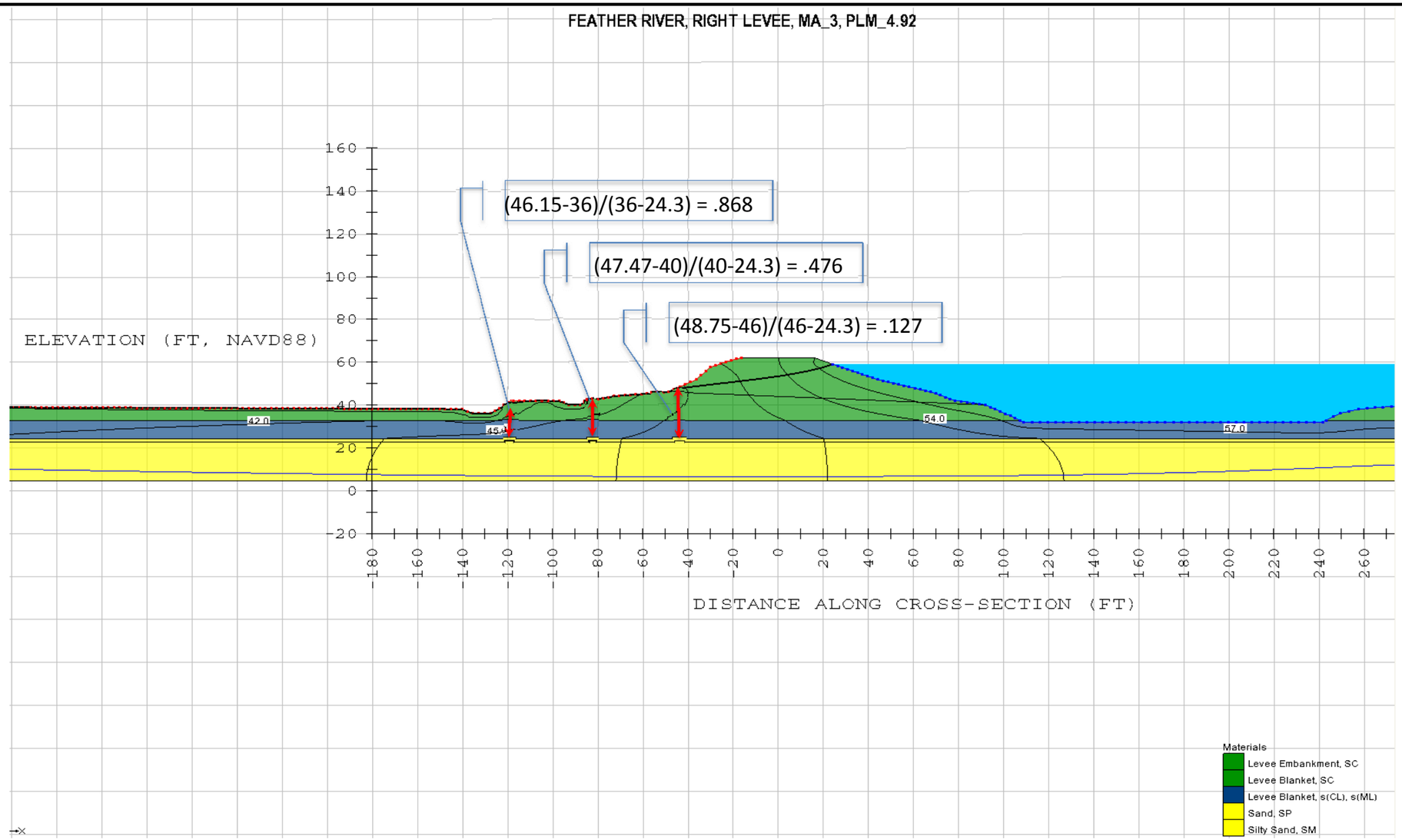
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_4.92, STATION 262+00
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	φ'
1	Levee Embankment, SC	0.28	0.07	4	115.00	10.00	27.00
2	Blanket, SC	0.28	0.07	4	115.00	10.00	27.00
3	Blanket, s(ML), s(CL)	0.57	0.14	4	120.00	10.00	28.00
4	Aquifer, SP	28.00	2.80	10	125.00	0.00	34.00
5	Aquifer, SM	28.00	2.80	10	125.00	0.00	32.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on borings WM0003_002B, 2F-91-7, 5F-73-CD10 (1957 boring)
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 59 ft.

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SACRAMENTO, CALIFORNIA

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GEOTECHNICAL ENGINEERING APPENDIX

SEEPAGE AND STABILITY ANALYSIS

FEATHER RIVER, LM_4.92, STATION 262+00

EXISTING CONDITION SEEPAGE DWSE

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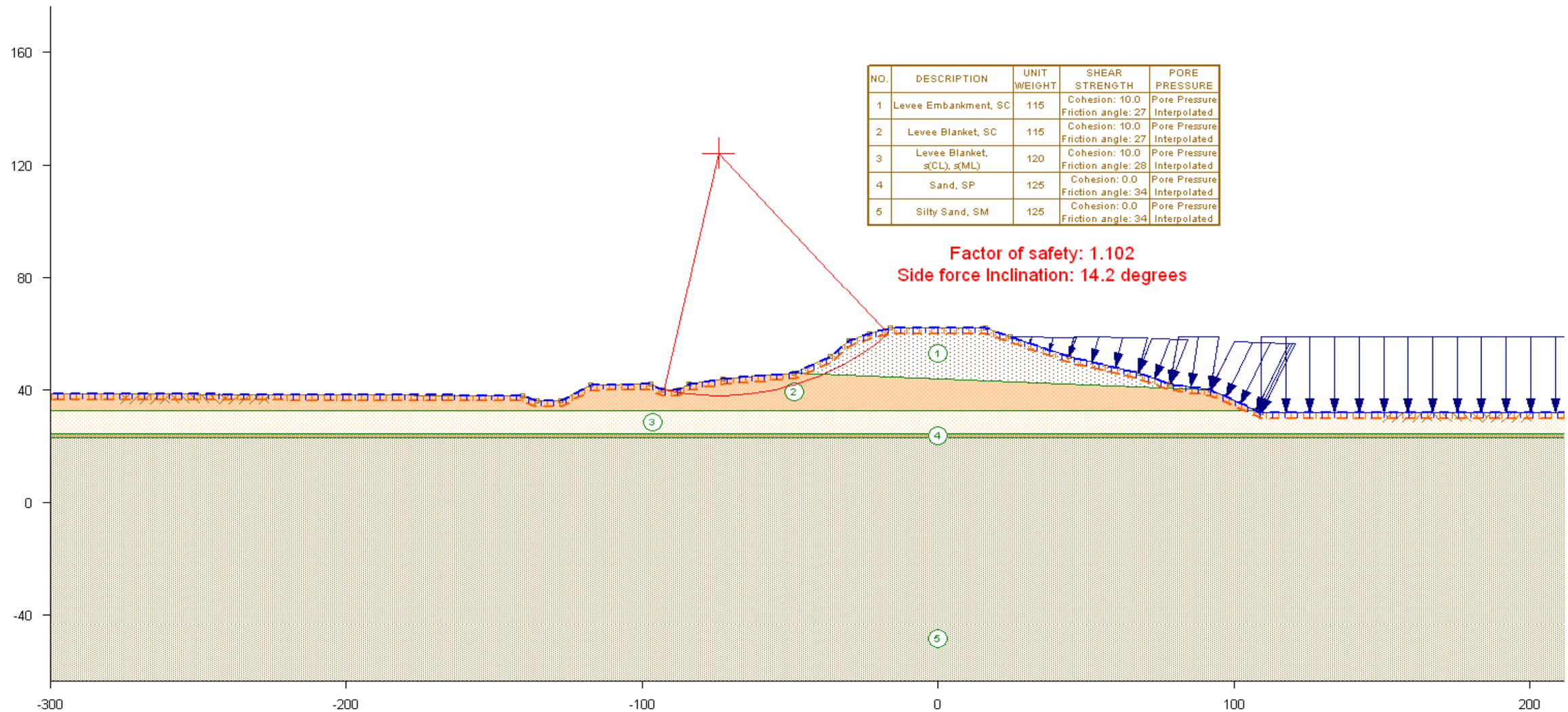

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Embankment, SC	115	Cohesion: 10.0 Friction angle: 27	Pore Pressure Interpolated
2	Levee Blanket, SC	115	Cohesion: 10.0 Friction angle: 27	Pore Pressure Interpolated
3	Levee Blanket, s(CL), s(ML)	120	Cohesion: 10.0 Friction angle: 28	Pore Pressure Interpolated
4	Sand, SP	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated
5	Silty Sand, SM	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated

Factor of safety: 1.102
Side force Inclination: 14.2 degrees

Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, SC	0.28	0.07	4	115.00	10.00	27.00
2	Blanket, SC	0.28	0.07	4	115.00	10.00	27.00
3	Blanket, s(ML), s(CL)	0.57	0.14	4	120.00	10.00	28.00
4	Aquifer, SP	28.00	2.80	10	125.00	0.00	34.00
5	Aquifer, SM	28.00	2.80	10	125.00	0.00	32.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on borings WM0003_002B, 2F-91-7, 5F-73-CD10 (1957 boring)
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 59 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
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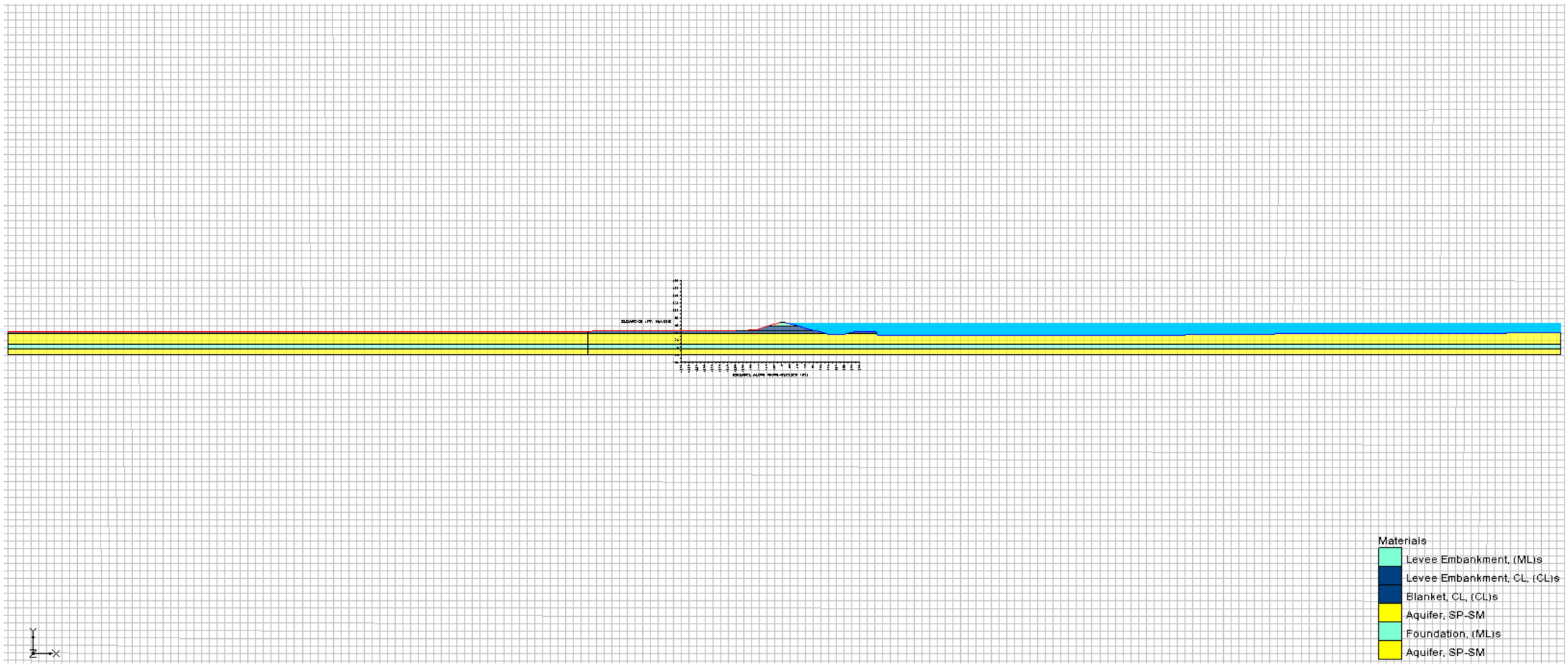
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_4.92, STATION 262+00
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL, (CL)s	0.028	0.007	4	115	200	28
3	Blanket, CL, (CL)s	0.028	0.007	4	115	200	28
4	Aquifer, SP-SM	14.00	1.40	10	125	0	34
5	Foundation, (ML)s	0.57	0.14	4	120	10	28
6	Aquifer, SP-SM	14.00	1.40	10	125	0	34

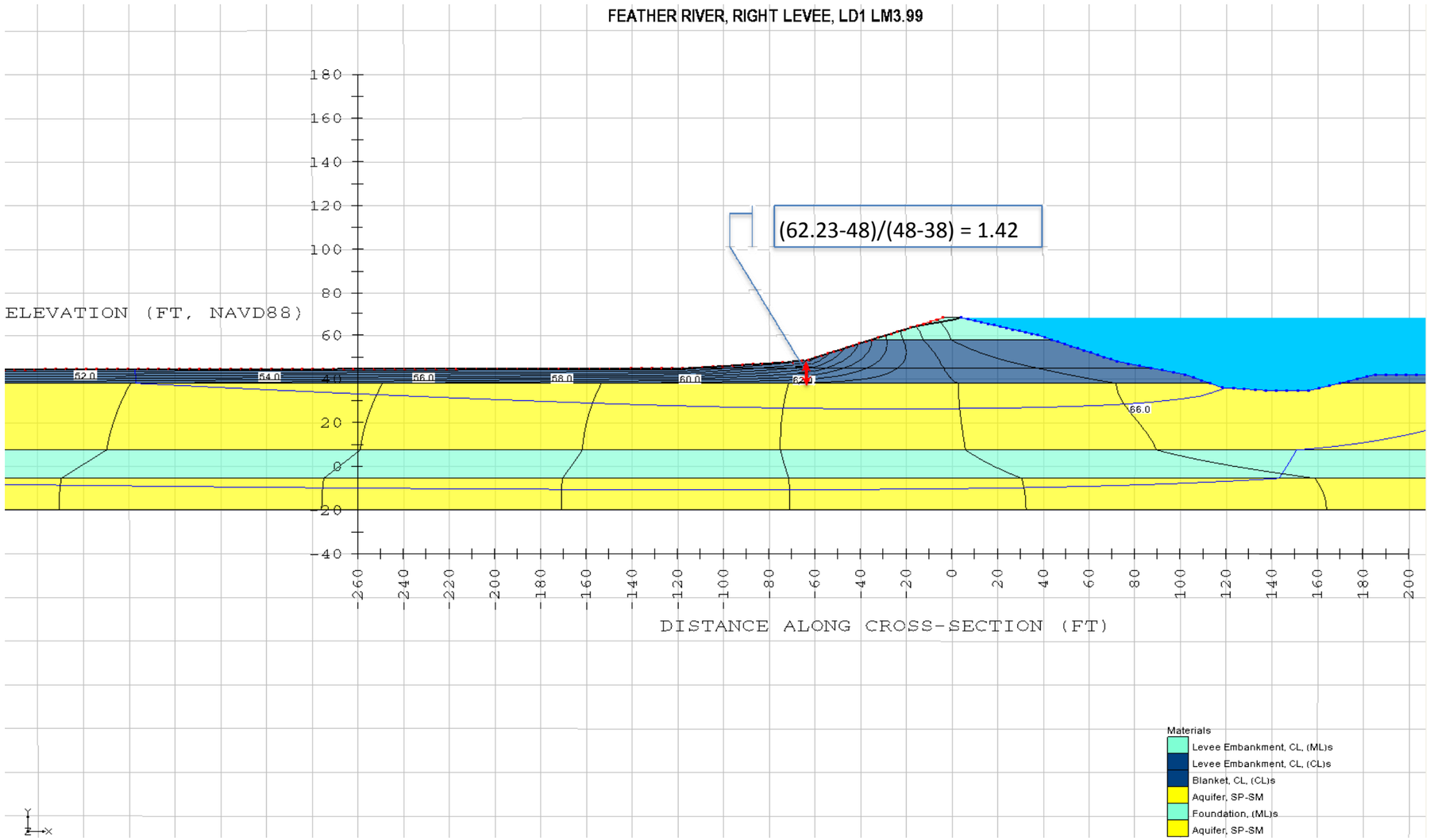
NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WL0001_088B, WL0001_007S
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 68 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER BASIN CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER LM_3.99, STA 540+00
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL, (CL)s	0.028	0.007	4	115	200	28
3	Blanket, CL, (CL)s	0.028	0.007	4	115	200	28
4	Aquifer, SP-SM	14.00	1.40	10	125	0	34
5	Foundation, (ML)s	0.57	0.14	4	120	10	28
6	Aquifer, SP-SM	14.00	1.40	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WL0001_088B, WL0001_007S
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 68 ft.

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SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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GEOTECHNICAL ENGINEERING APPENDIX

SEEPAGE AND STABILITY ANALYSIS

FEATHER RIVER LM_3.99, STA 540+00

EXISTING CONDITION SEEPAGE DWSE

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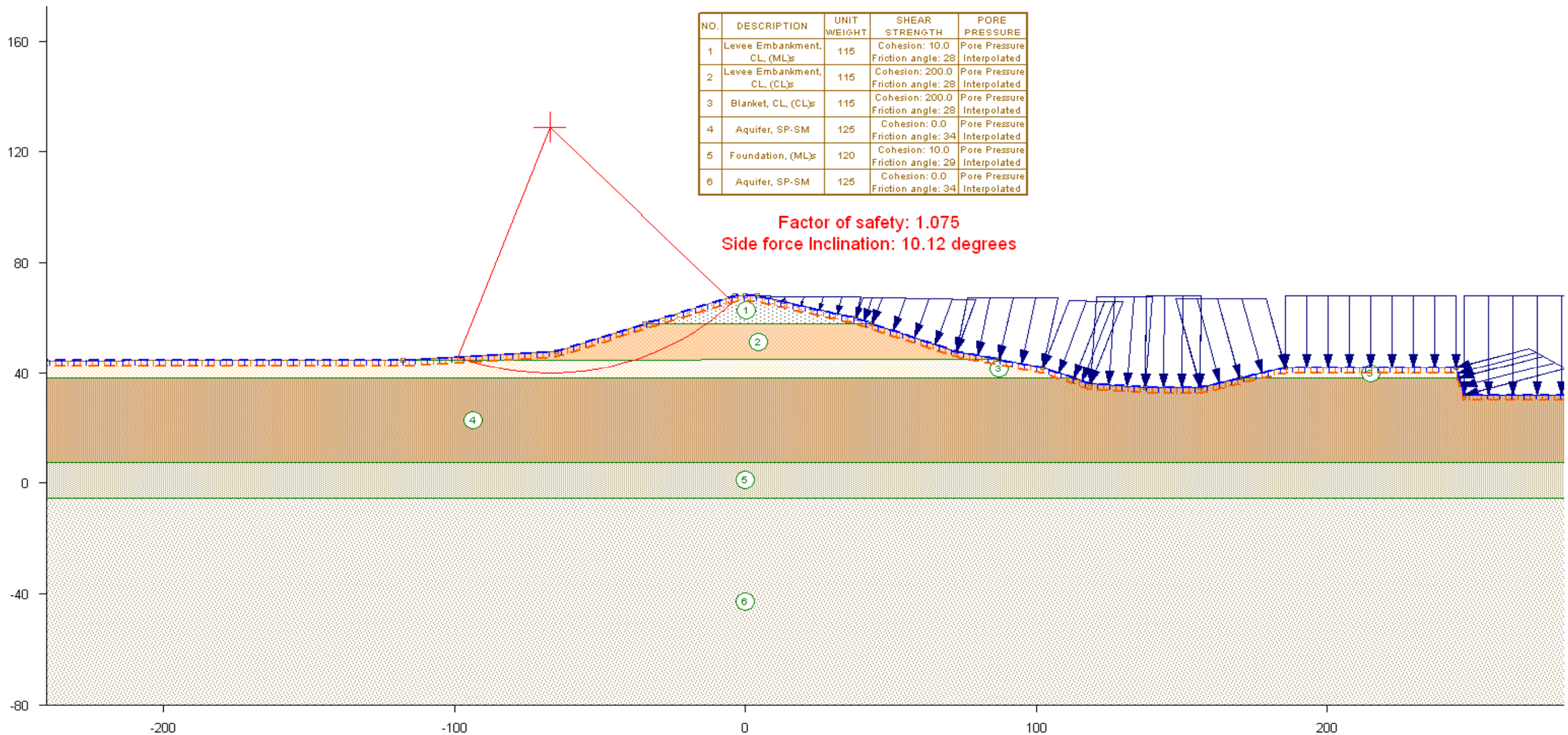

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Embankment, CL, (ML)s	115	Cohesion: 10.0 Friction angle: 28	Pore Pressure Interpolated
2	Levee Embankment, CL, (CL)s	115	Cohesion: 200.0 Friction angle: 28	Pore Pressure Interpolated
3	Blanket, CL, (CL)s	115	Cohesion: 200.0 Friction angle: 28	Pore Pressure Interpolated
4	Aquifer, SP-SM	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated
5	Foundation, (ML)s	120	Cohesion: 10.0 Friction angle: 29	Pore Pressure Interpolated
6	Aquifer, SP-SM	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated

Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL, (CL)s	0.028	0.007	4	115	200	28
3	Blanket, CL, (CL)s	0.028	0.007	4	115	200	28
4	Aquifer, SP-SM	14.00	1.40	10	125	0	34
5	Foundation, (ML)s	0.57	0.14	4	120	10	28
6	Aquifer, SP-SM	14.00	1.40	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WL0001_088B, WL0001_007S
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 68 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
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GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER LM_3.99, STA 540+00
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3

Seepage and Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	50	28
2	Blanket, (ML)s	0.570	0.140	4	115	50	28
3	Aquifer, SM	2.800	0.710	4	125	0	32
4	Foundation, (ML)s	0.57	0.14	4	120	50	28
5	Aquifer, SM	2.80	0.71	4	125	0	32
6	Foundation, (ML)s	0.57	0.14	4	120	50	28
7	Aquifer, SP-SM	14	1.4	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring 2F-07-05 & 2F-07-06
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 79.6 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
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SACRAMENTO, CALIFORNIA

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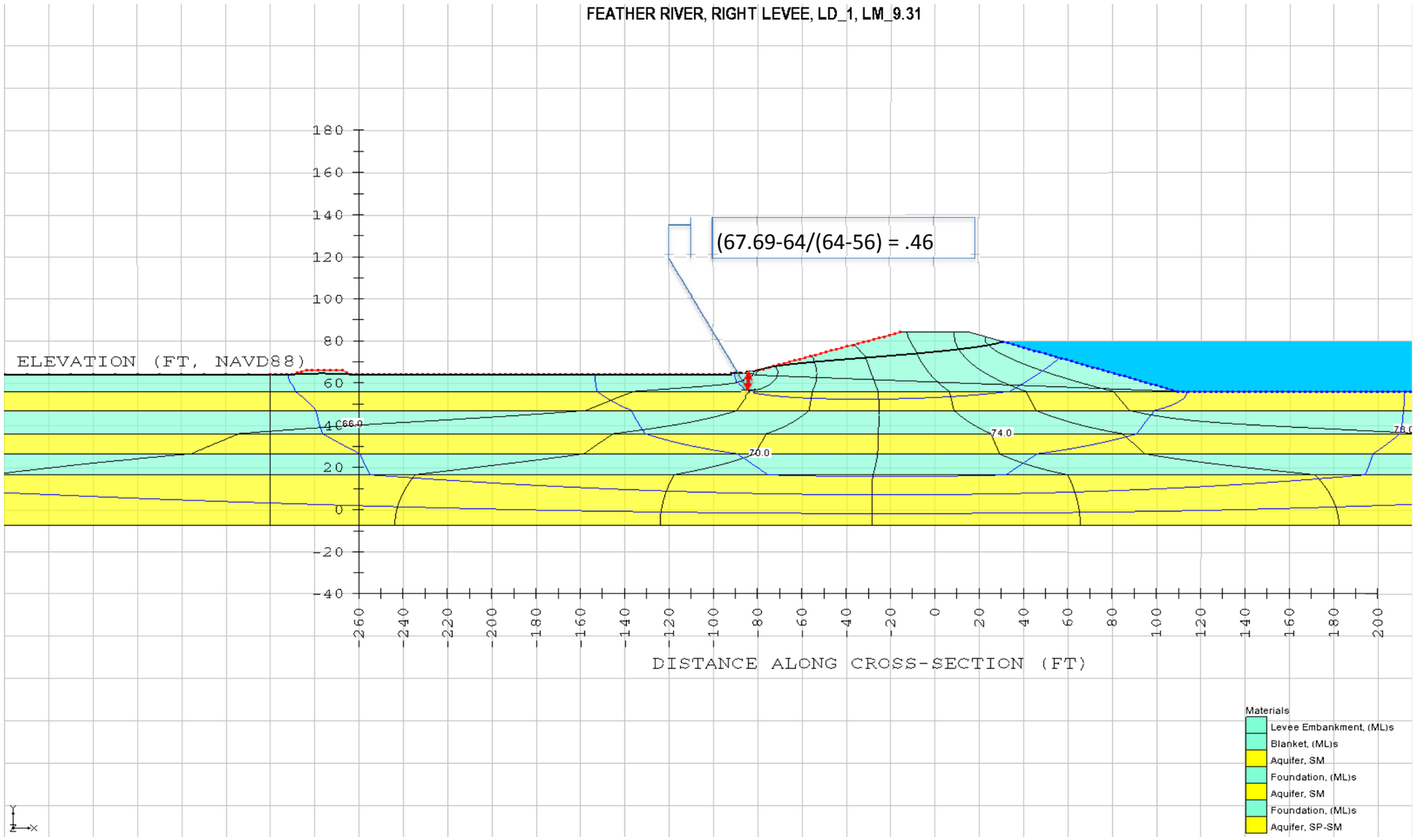
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_9.31, STA 1108+86
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	50	28
2	Blanket, (ML)s	0.570	0.140	4	115	50	28
3	Aquifer, SM	2.800	0.710	4	125	0	32
4	Foundation, (ML)s	0.57	0.14	4	120	50	28
5	Aquifer, SM	2.80	0.71	4	125	0	32
6	Foundation, (ML)s	0.57	0.14	4	120	50	28
7	Aquifer, SP-SM	14	1.4	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring 2F-07-05 & 2F-07-06
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 79.6 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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GEOTECHNICAL ENGINEERING APPENDIX

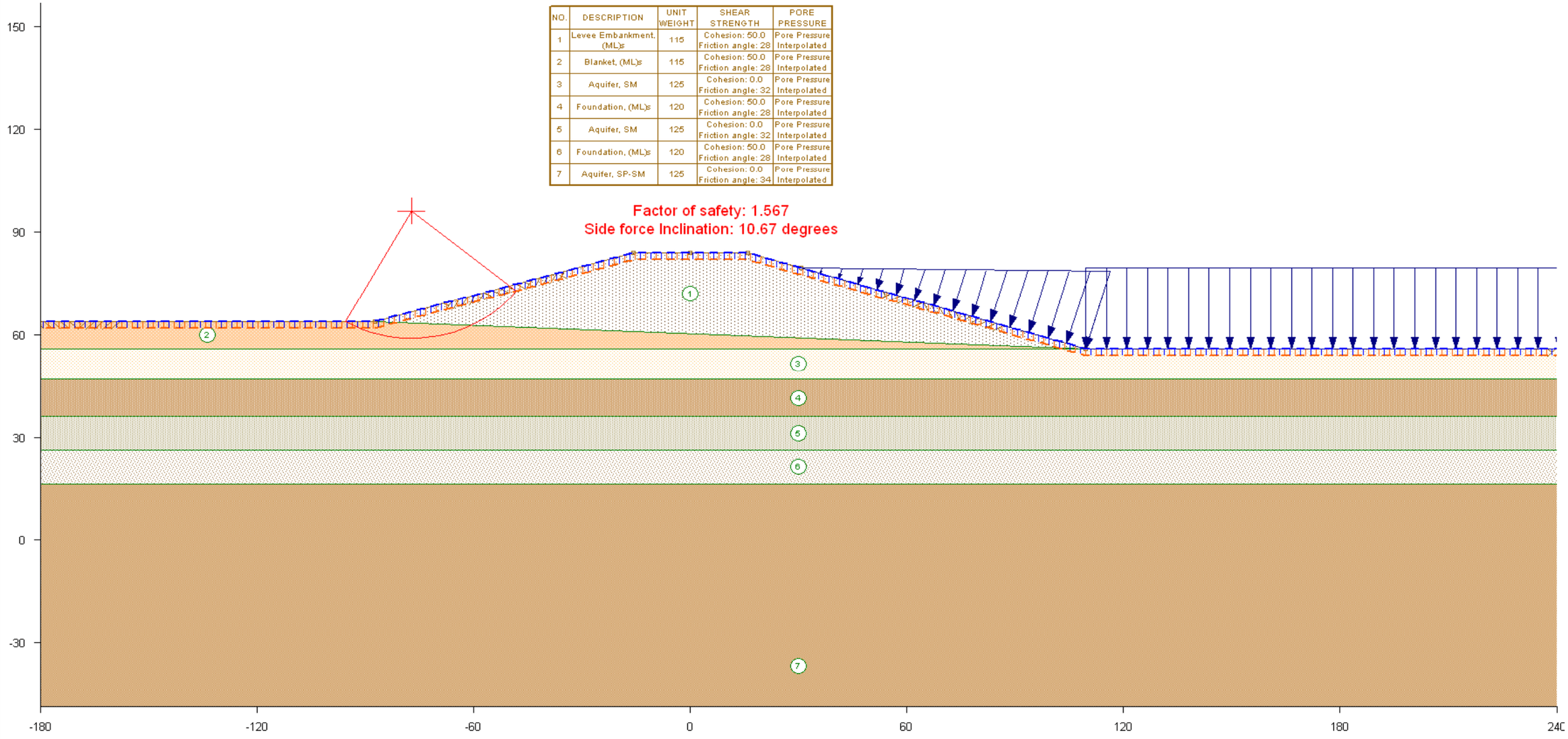
SEEPAGE AND STABILITY ANALYSIS

FEATHER RIVER, LM_9.31, STA 1108+86

EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Embankment, (ML)s	115	Cohesion: 50.0 Friction angle: 28	Pore Pressure Interpolated
2	Blanket, (ML)s	115	Cohesion: 50.0 Friction angle: 28	Pore Pressure Interpolated
3	Aquifer, SM	125	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated
4	Foundation, (ML)s	120	Cohesion: 50.0 Friction angle: 28	Pore Pressure Interpolated
5	Aquifer, SM	125	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated
6	Foundation, (ML)s	120	Cohesion: 50.0 Friction angle: 28	Pore Pressure Interpolated
7	Aquifer, SP-SM	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	50	28
2	Blanket, (ML)s	0.570	0.140	4	115	50	28
3	Aquifer, SM	2.800	0.710	4	125	0	32
4	Foundation, (ML)s	0.57	0.14	4	120	50	28
5	Aquifer, SM	2.80	0.71	4	125	0	32
6	Foundation, (ML)s	0.57	0.14	4	120	50	28
7	Aquifer, SP-SM	14	1.4	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring 2F-07-05 & 2F-07-06
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 79.6 ft.

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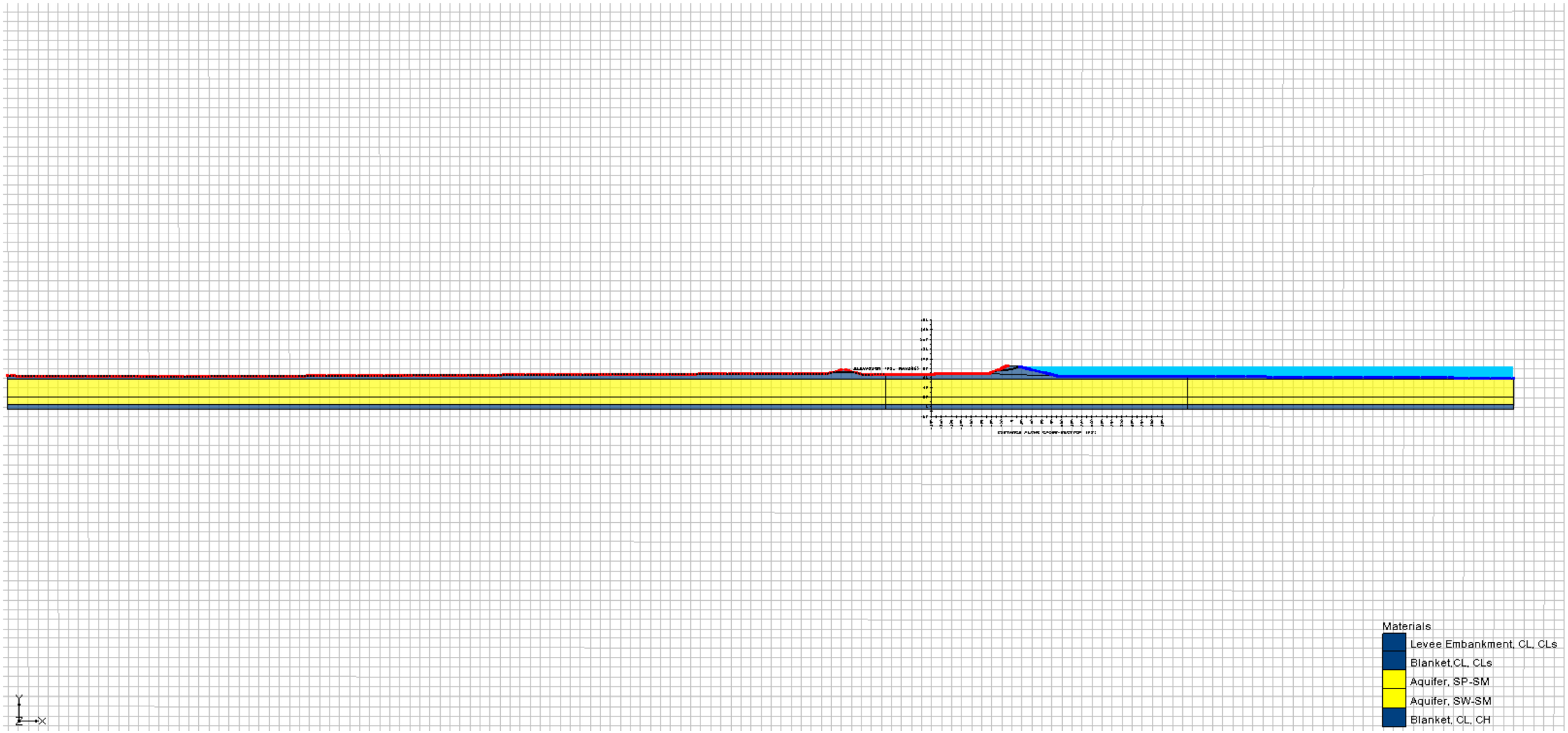
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_9.31, STA 1108+86
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment CL CLs	0.028	0.007	4	115.00	150	28.00
2	Blanket CL CLs	0.028	0.007	4	115.00	150	28.00
3	Aquifer SP-SM	14.00	1.40	10	125.00	0	34.00
4	Aquifer SW-SM	14.00	1.40	10	125.00	0	34.00
5	Blanket CL CH	0.028	0.007	4	115.00	150	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WL0009_001S, WL0009_007A
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 84 ft.

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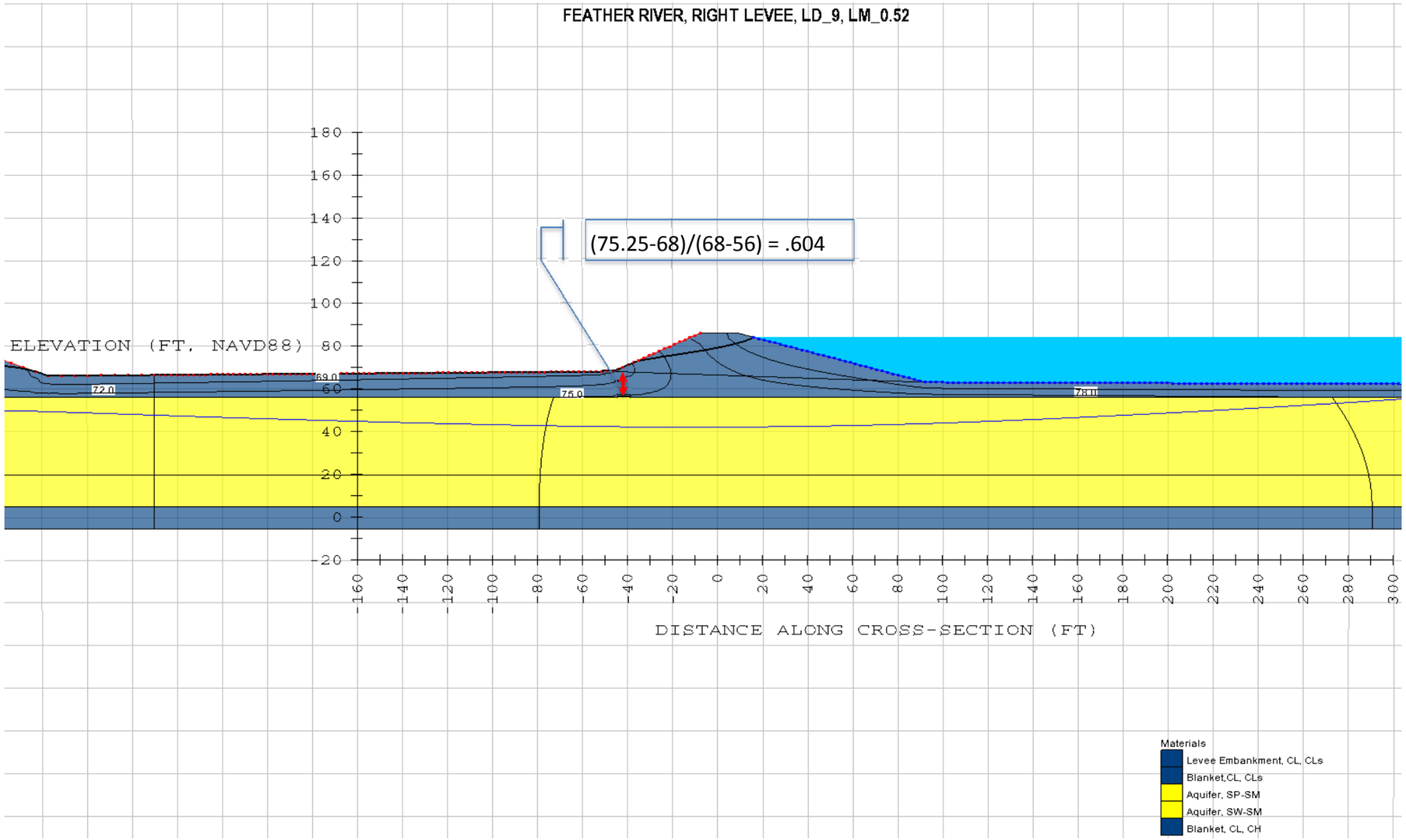
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_9, STATION 1138+68
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment CL CLs	0.028	0.007	4	115.00	150	28.00
2	Blanket CL CLs	0.028	0.007	4	115.00	150	28.00
3	Aquifer SP-SM	14.00	1.40	10	125.00	0	34.00
4	Aquifer SW-SM	14.00	1.40	10	125.00	0	34.00
5	Blanket CL CH	0.028	0.007	4	115.00	150	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WL0009_001S, WL0009_007A
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 84 ft.

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SACRAMENTO DISTRICT
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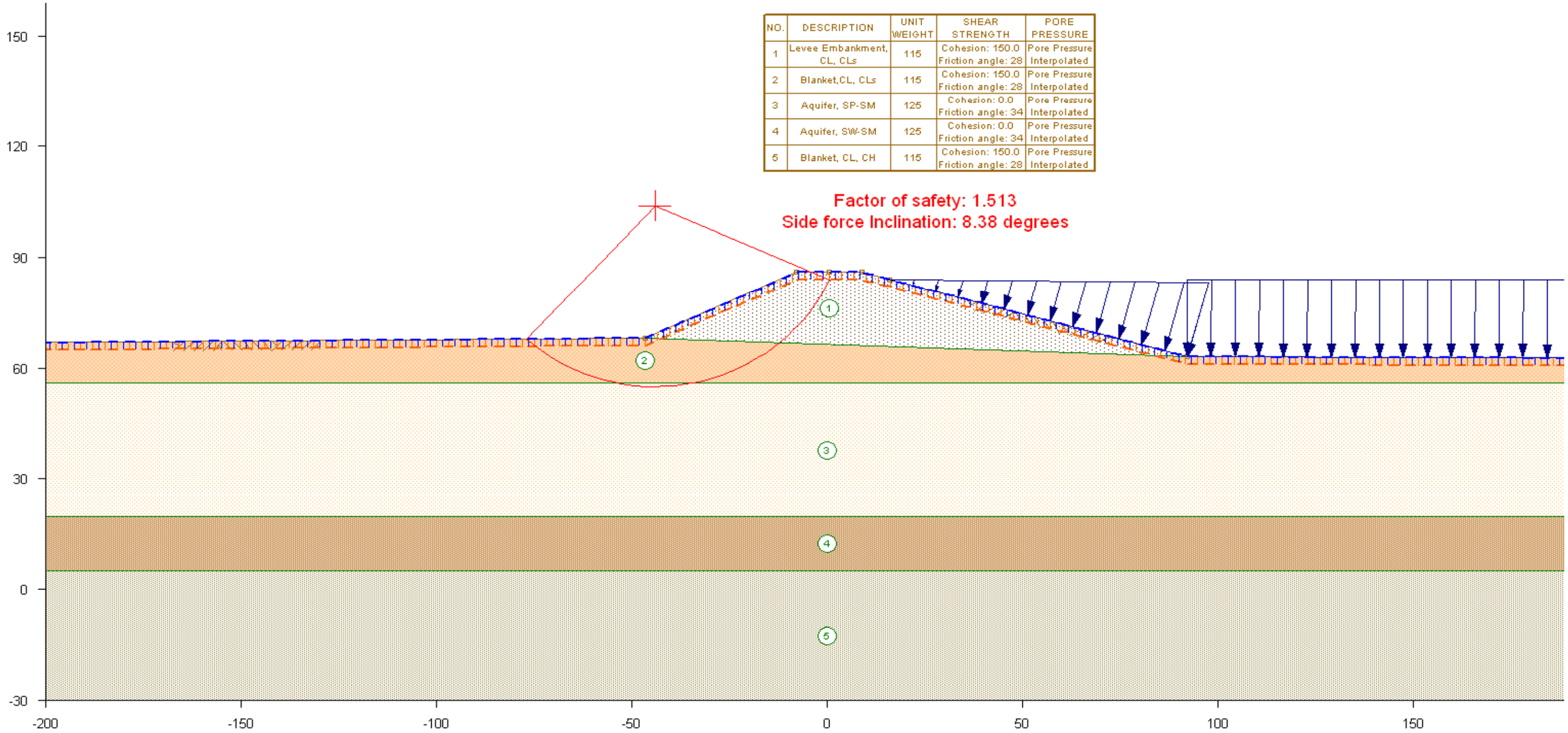
SEEPAGE AND STABILITY ANALYSIS

FEATHER RIVER, LM_9, STATION 1138+68

EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Embankment, CL, CLs	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated
2	Blanket,CL, CLs	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated
3	Aquifer, SP-SM	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated
4	Aquifer, SW-SM	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated
5	Blanket, CL, CH	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment CL CLs	0.028	0.007	4	115.00	150	28.00
2	Blanket CL CLs	0.028	0.007	4	115.00	150	28.00
3	Aquifer SP-SM	14.00	1.40	10	125.00	0	34.00
4	Aquifer SW-SM	14.00	1.40	10	125.00	0	34.00
5	Blanket CL CH	0.028	0.007	4	115.00	150	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WL0009_001S, WL0009_007A
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 84 ft.

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SACRAMENTO DISTRICT
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SACRAMENTO, CALIFORNIA

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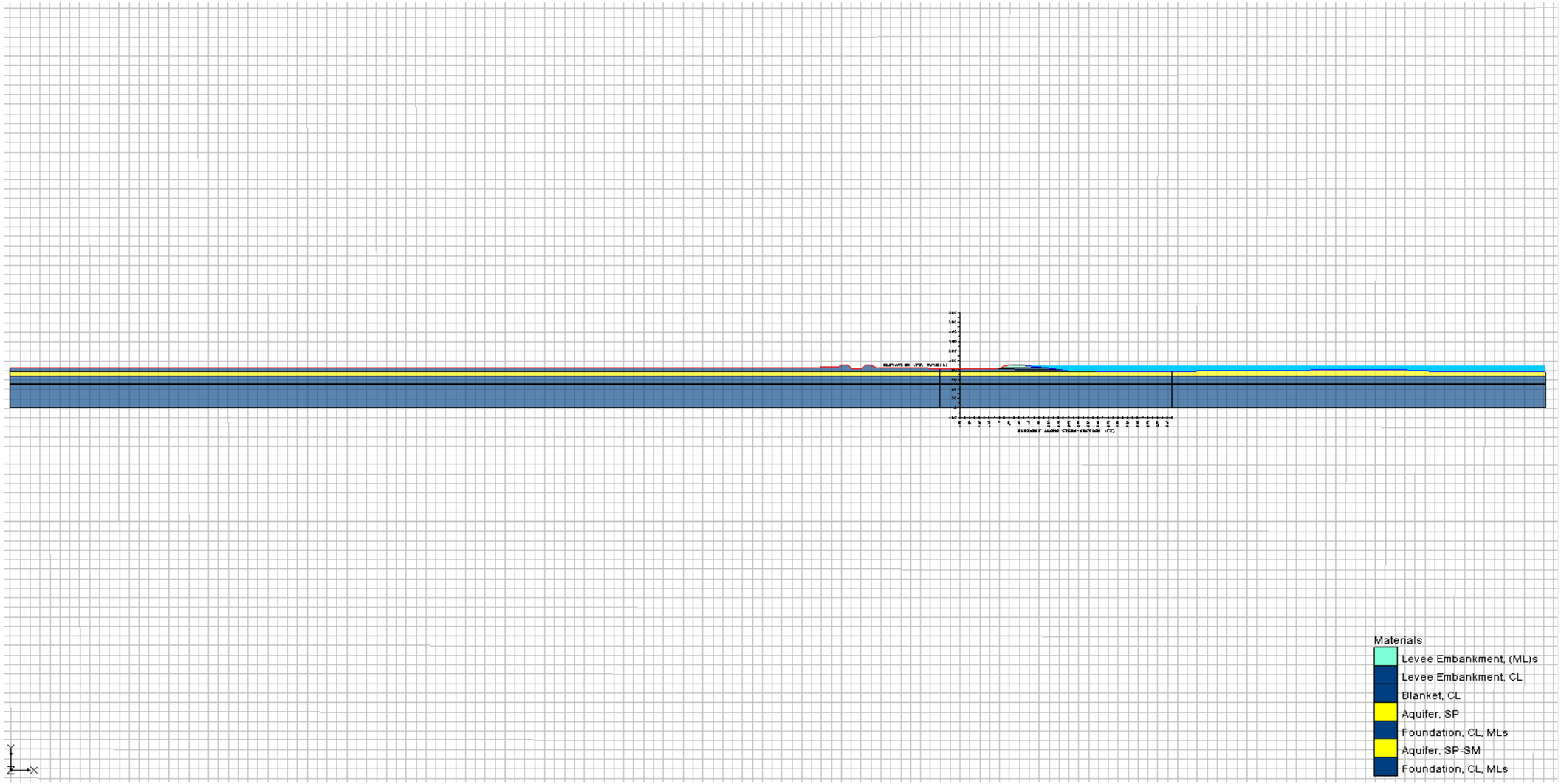
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_9, STATION 1138+68
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL	0.028	0.007	4	115	150	28
3	Blanket, CL	0.028	0.007	4	115	150	28
4	Aquifer, SP	28.00	2.80	10	125	0	34
5	Foundation, CL, MLs	0.57	0.14	4	120	150	29
6	Aquifer, SP-SM	14.00	1.40	10	125	0	32
7	Foundation, CL, MLs	0.57	0.14	4	120	150	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WM0016_011B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 88.79 ft.

DEPARTMENT OF THE ARMY
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SACRAMENTO, CALIFORNIA

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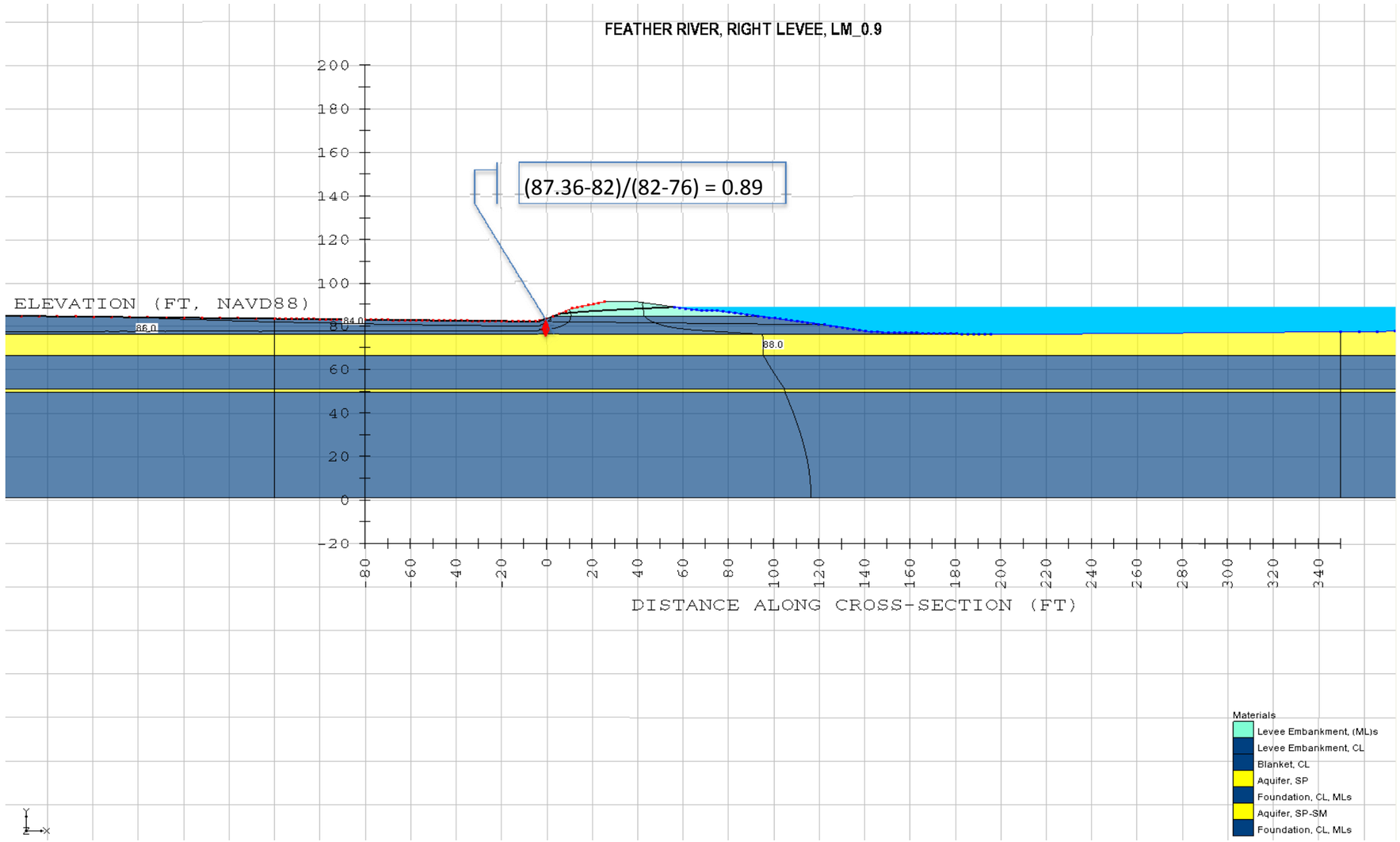
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_0.9, STA 1508+33
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL	0.028	0.007	4	115	150	28
3	Blanket, CL	0.028	0.007	4	115	150	28
4	Aquifer, SP	28.00	2.80	10	125	0	34
5	Foundation, CL, MLs	0.57	0.14	4	120	150	29
6	Aquifer, SP-SM	14.00	1.40	10	125	0	32
7	Foundation, CL, MLs	0.57	0.14	4	120	150	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WM0016_011B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 88.79 ft.

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SEEPAGE AND STABILITY ANALYSIS

FEATHER RIVER, LM_0.9, STA 1508+33

EXISTING CONDITION SEEPAGE DWSE

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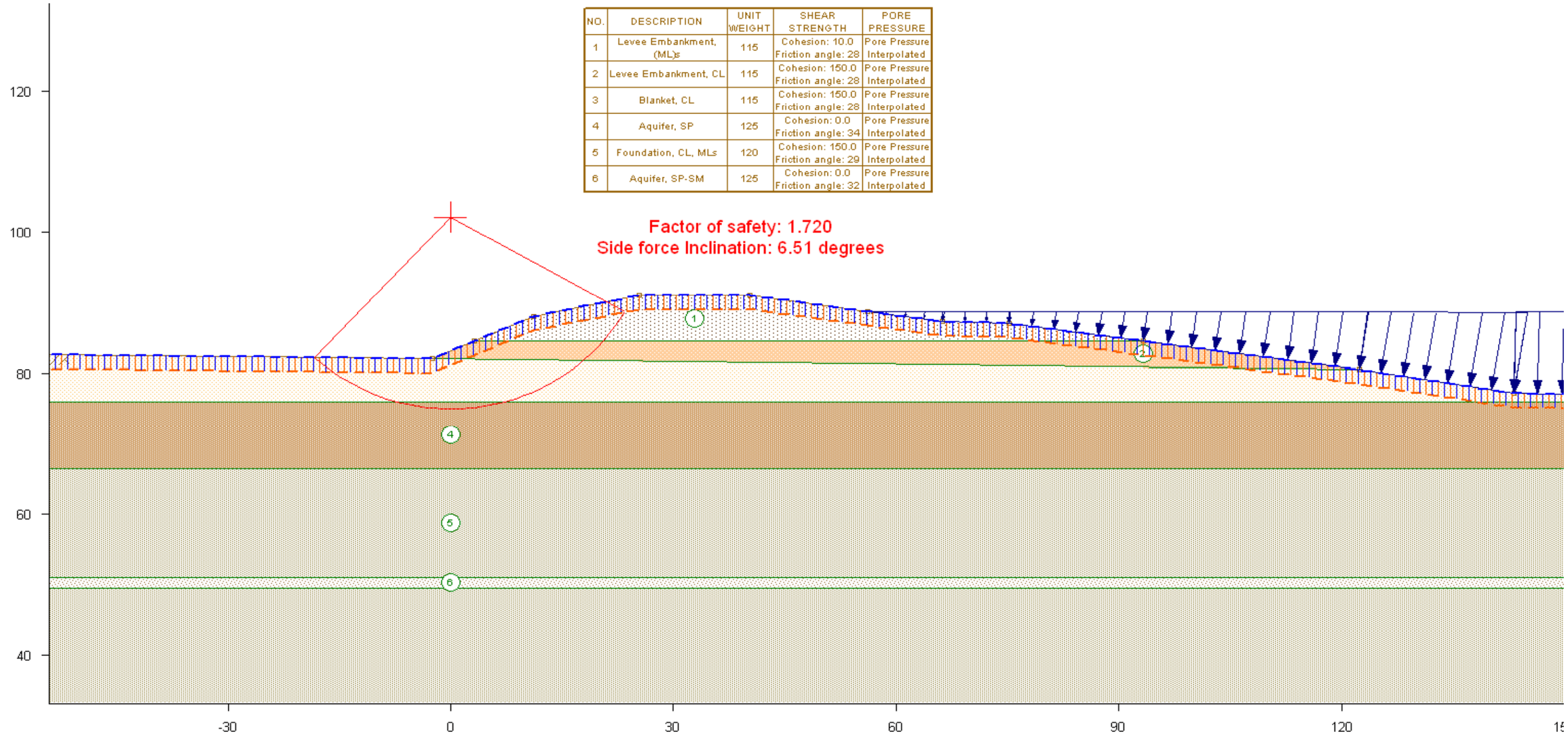
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Embankment, (ML)s	115	Cohesion: 10.0 Friction angle: 28	Pore Pressure Interpolated
2	Levee Embankment, CL	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated
3	Blanket, CL	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated
4	Aquifer, SP	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated
5	Foundation, CL, MLs	120	Cohesion: 150.0 Friction angle: 29	Pore Pressure Interpolated
6	Aquifer, SP-SM	125	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL	0.028	0.007	4	115	150	28
3	Blanket, CL	0.028	0.007	4	115	150	28
4	Aquifer, SP	28.00	2.80	10	125	0	34
5	Foundation, CL, MLs	0.57	0.14	4	120	150	29
6	Aquifer, SP-SM	14.00	1.40	10	125	0	32
7	Foundation, CL, MLs	0.57	0.14	4	120	150	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WM0016_011B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 88.79 ft.

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SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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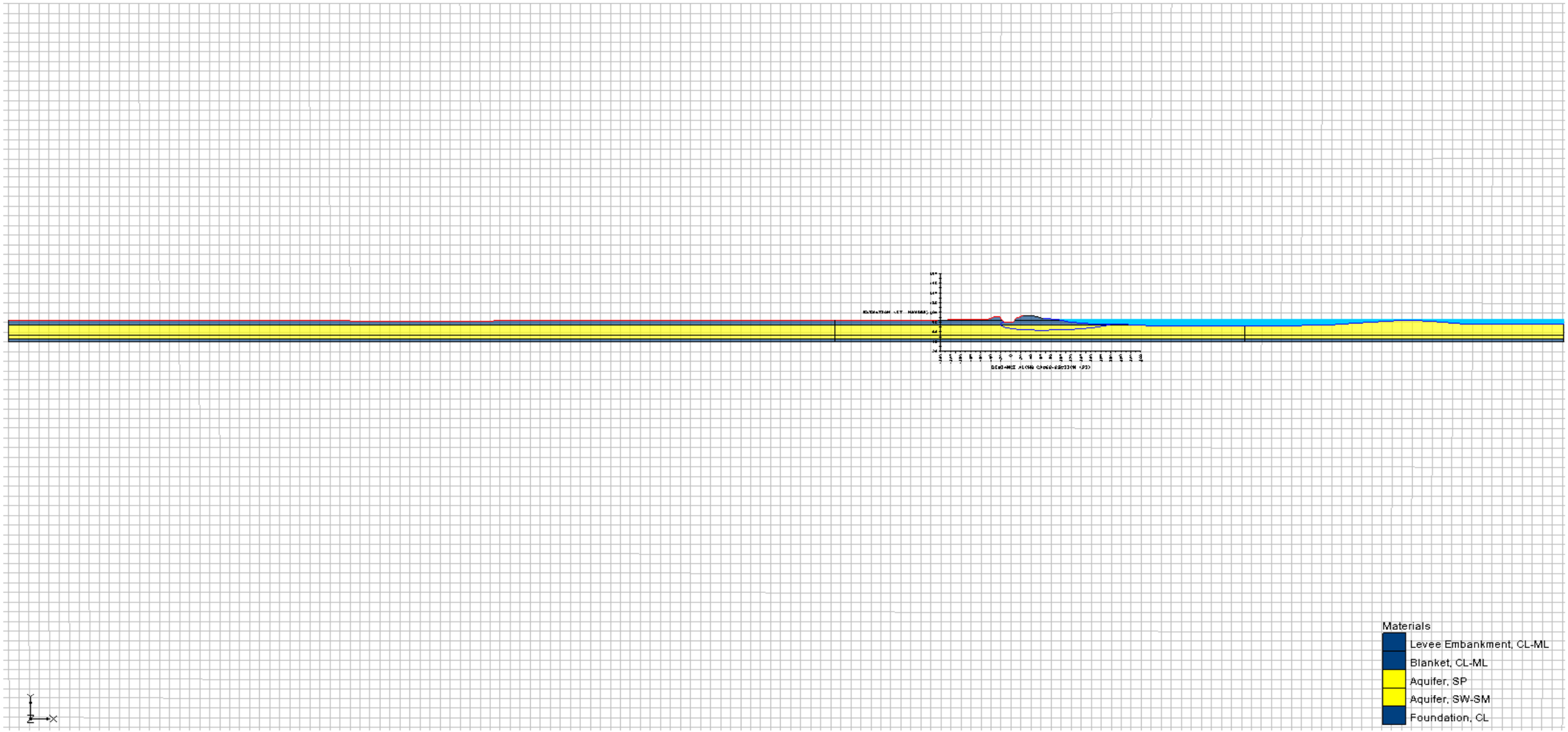
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_0.9, STA 1508+33
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, CL-ML	0.57	0.14	4	115.00	50.00	28.00
2	Blanket, CL-ML	0.570	0.140	4	115.00	50.00	28.00
3	Aquifer, SW-SM	14.00	1.40	10	125.00	0.00	32.00
4	Aquifer, SP	28.000	2.8	10	125.00	0.00	34.00
5	Aquifer, SW-SM	14.00	1.40	10	125.00	0.00	32.00
6	Foundation, CL	0.03	0.007	4	120.00	100.00	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WM0016_019S, WM0016-020B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 87.4 ft.

DEPARTMENT OF THE ARMY
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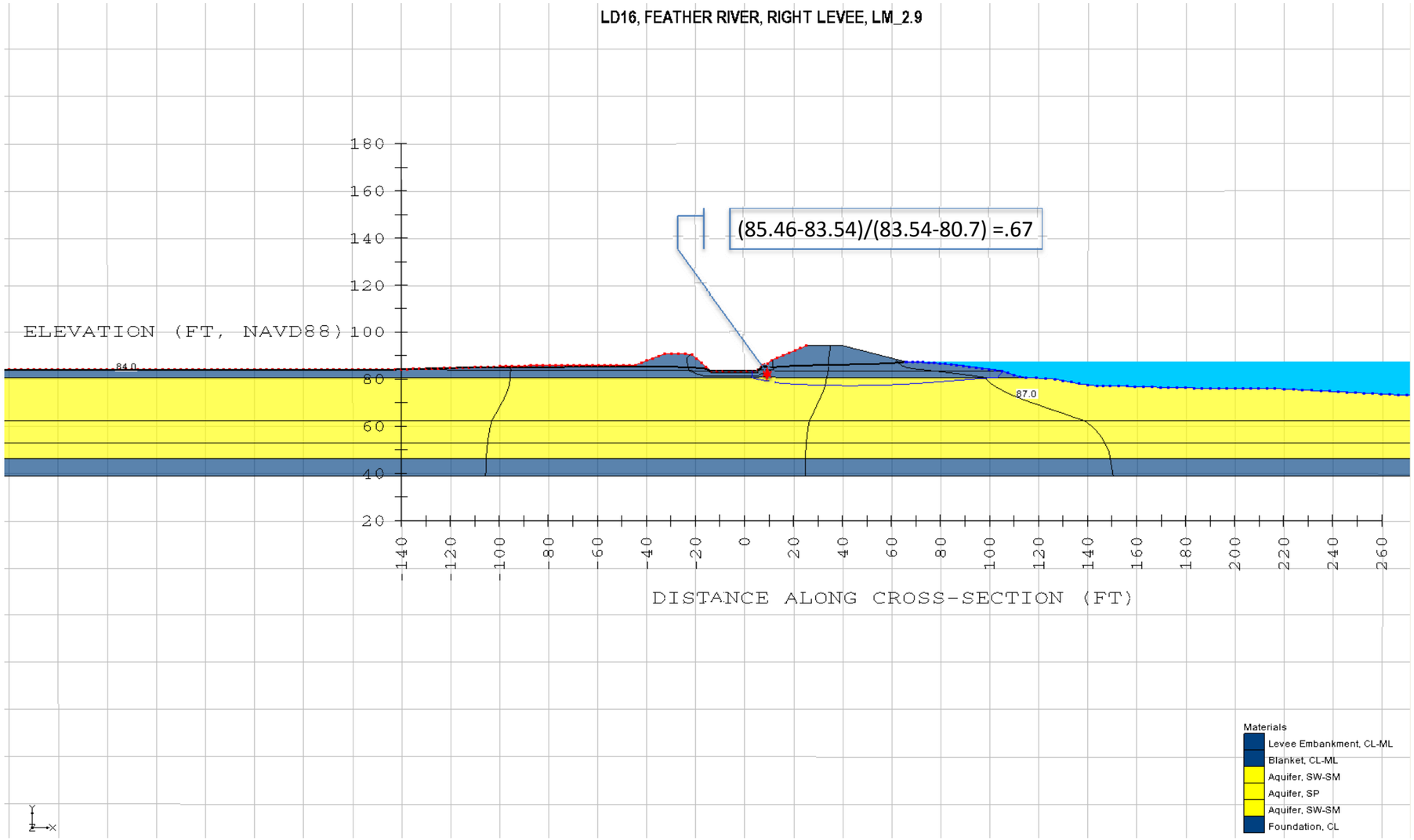
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER STATION 1615+62
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, CL-ML	0.57	0.14	4	115.00	50.00	28.00
2	Blanket, CL-ML	0.570	0.140	4	115.00	50.00	28.00
3	Aquifer, SW-SM	14.00	1.40	10	125.00	0.00	32.00
4	Aquifer, SP	28.000	2.8	10	125.00	0.00	34.00
5	Aquifer, SW-SM	14.00	1.40	10	125.00	0.00	32.00
6	Foundation, CL	0.03	0.007	4	120.00	100.00	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WM0016_019S, WM0016-020B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 87.4 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER BASIN CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX

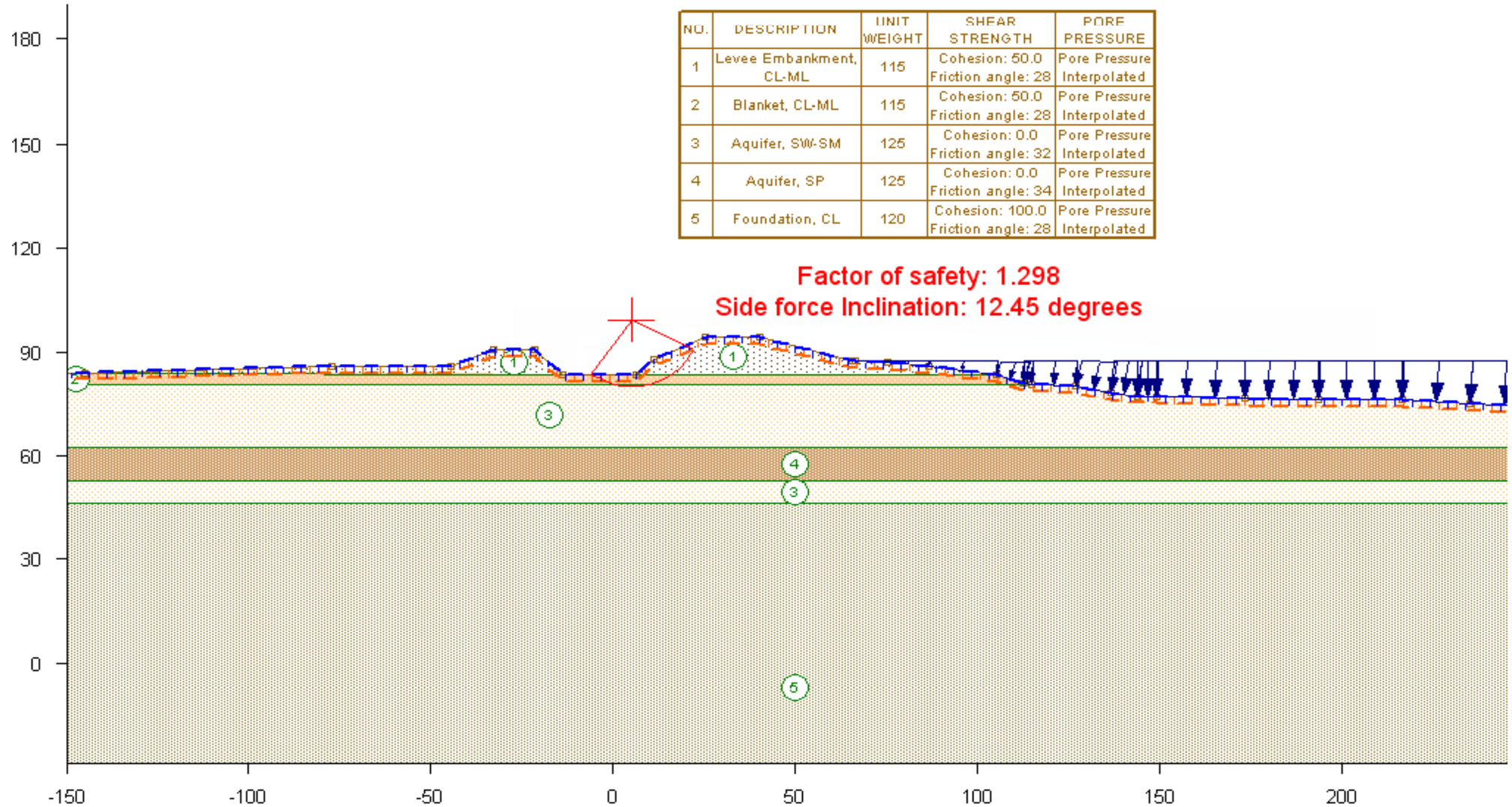
SEEPAGE AND STABILITY ANALYSIS

FEATHER RIVER STATION 1615+62

EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Embankment, CL-ML	115	Cohesion: 50.0 Friction angle: 28	Pore Pressure Interpolated
2	Blanket, CL-ML	115	Cohesion: 50.0 Friction angle: 28	Pore Pressure Interpolated
3	Aquifer, SW-SM	125	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated
4	Aquifer, SP	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated
5	Foundation, CL	120	Cohesion: 100.0 Friction angle: 28	Pore Pressure Interpolated



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, CL-ML	0.57	0.14	4	115.00	50.00	28.00
2	Blanket, CL-ML	0.570	0.140	4	115.00	50.00	28.00
3	Aquifer, SW-SM	14.00	1.40	10	125.00	0.00	32.00
4	Aquifer, SP	28.000	2.8	10	125.00	0.00	34.00
5	Aquifer, SW-SM	14.00	1.40	10	125.00	0.00	32.00
6	Foundation, CL	0.03	0.007	4	120.00	100.00	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WM0016_019S, WM0016-020B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 87.4 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER BASIN CALIFORNIA

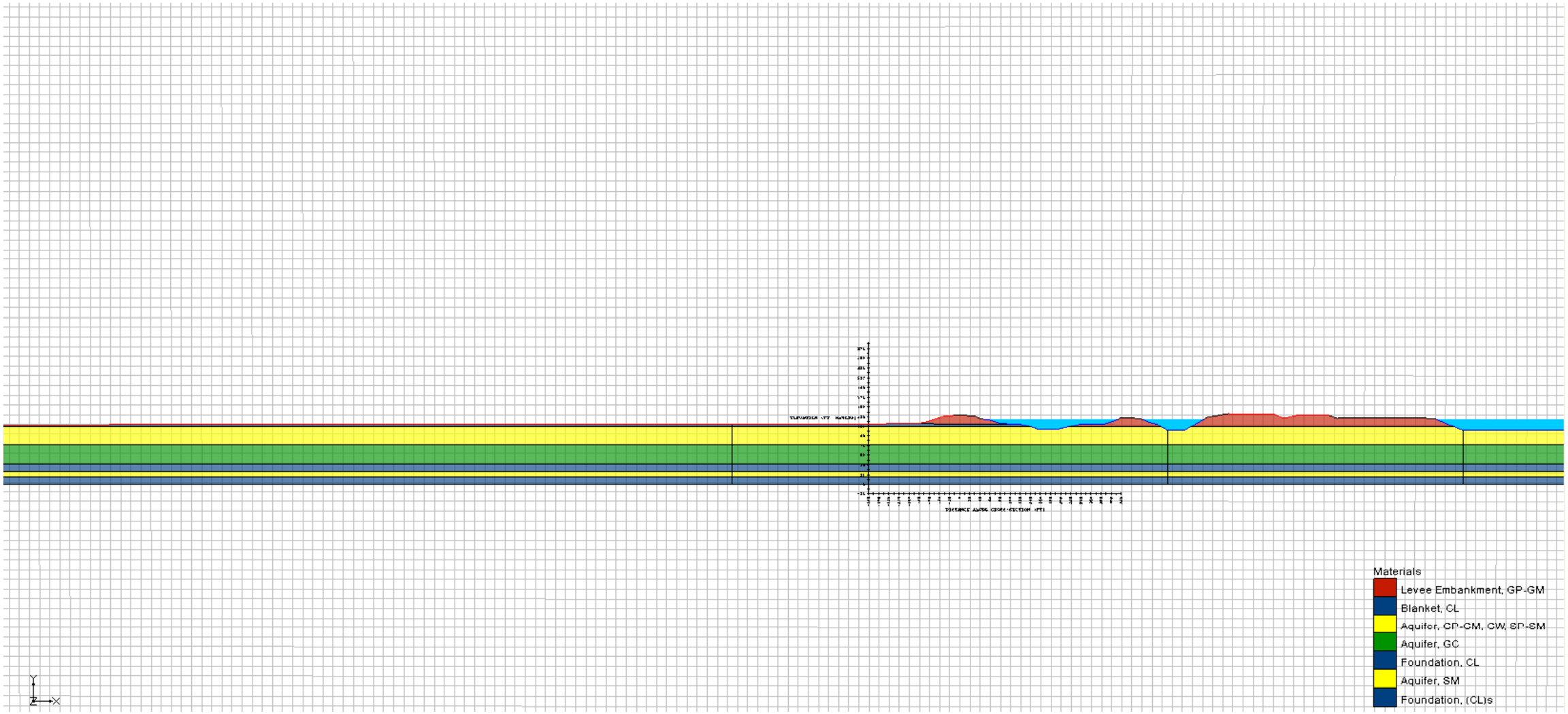
GEOTECHNICAL ENGINEERING APPENDIX

SEEPAGE AND STABILITY ANALYSIS

FEATHER RIVER STATION 1615+62

EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, GP-GM	14.0	1.4	10	125.00	0.00	34.00
2	Blanket, CL	0.028	0.007	4	115.00	150.00	28.00
3	Aquifer, GP-GM, GW, SP-SM	14.0	1.4	10	125.00	0.00	34.00
4	Aquifer, GC	2.80	0.71	4	135.00	0.00	35.00
5	Foundation, CL	0.03	0.01	4	115.00	150.00	28.00
6	Aquifer, SM	1.40	0.35	4	125.00	0.00	32.00
7	Foundation, (CL)s	0.028	0.007	4	115.00	150.00	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on borings WL0007_072S, WL0007_014S
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 130 ft.

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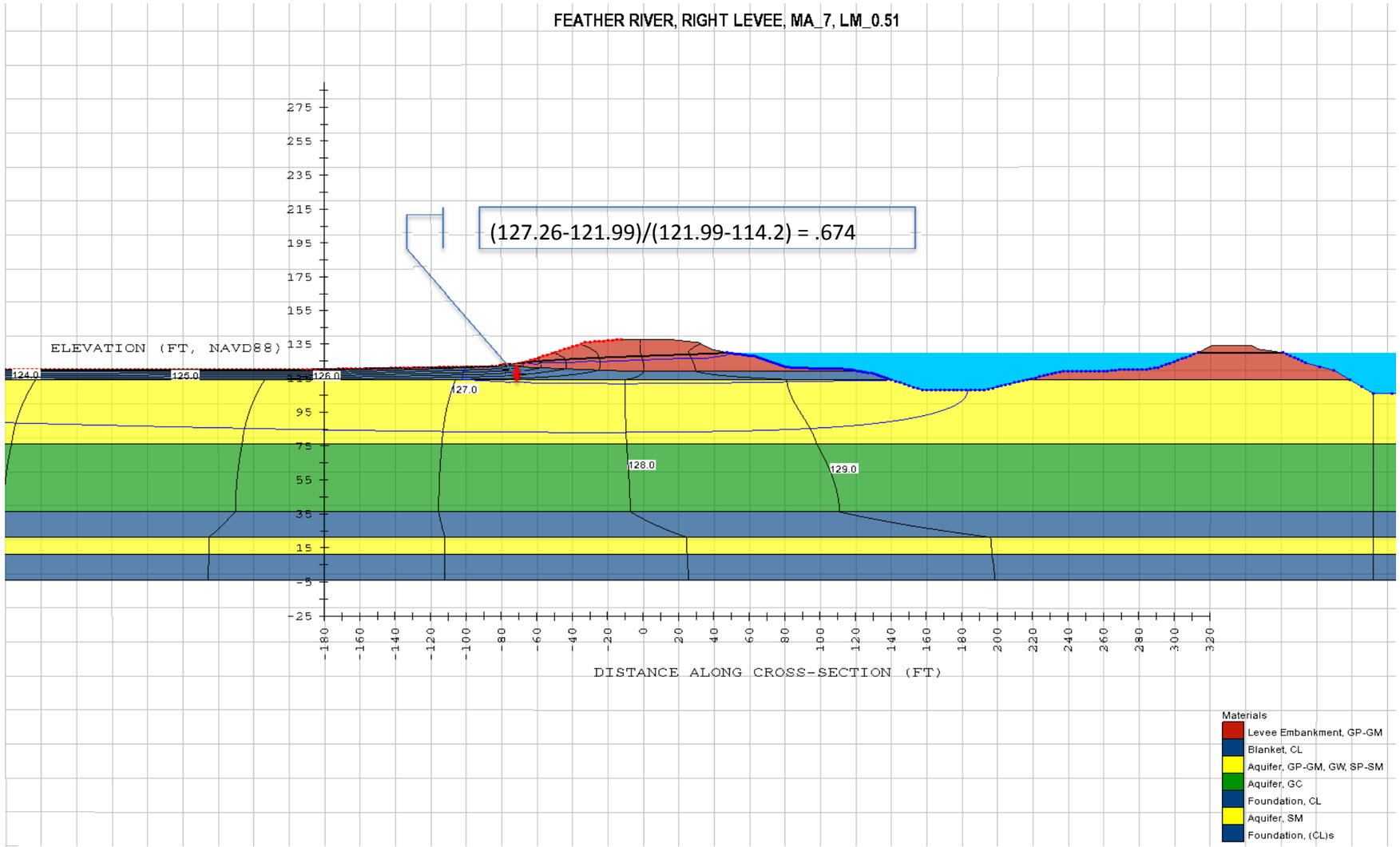
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_0.51, STATION 2332+91
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, GP-GM	14.0	1.4	10	125.00	0.00	34.00
2	Blanket, CL	0.028	0.007	4	115.00	150.00	28.00
3	Aquifer, GP-GM, GW, SP-SM	14.0	1.4	10	125.00	0.00	34.00
4	Aquifer, GC	2.80	0.71	4	135.00	0.00	35.00
5	Foundation, CL	0.03	0.01	4	115.00	150.00	28.00
6	Aquifer, SM	1.40	0.35	4	125.00	0.00	32.00
7	Foundation, (CL)s	0.028	0.007	4	115.00	150.00	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on borings WL0007_072S, WL0007_014S
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 130 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
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SACRAMENTO, CALIFORNIA

SUTTER BASIN CALIFORNIA

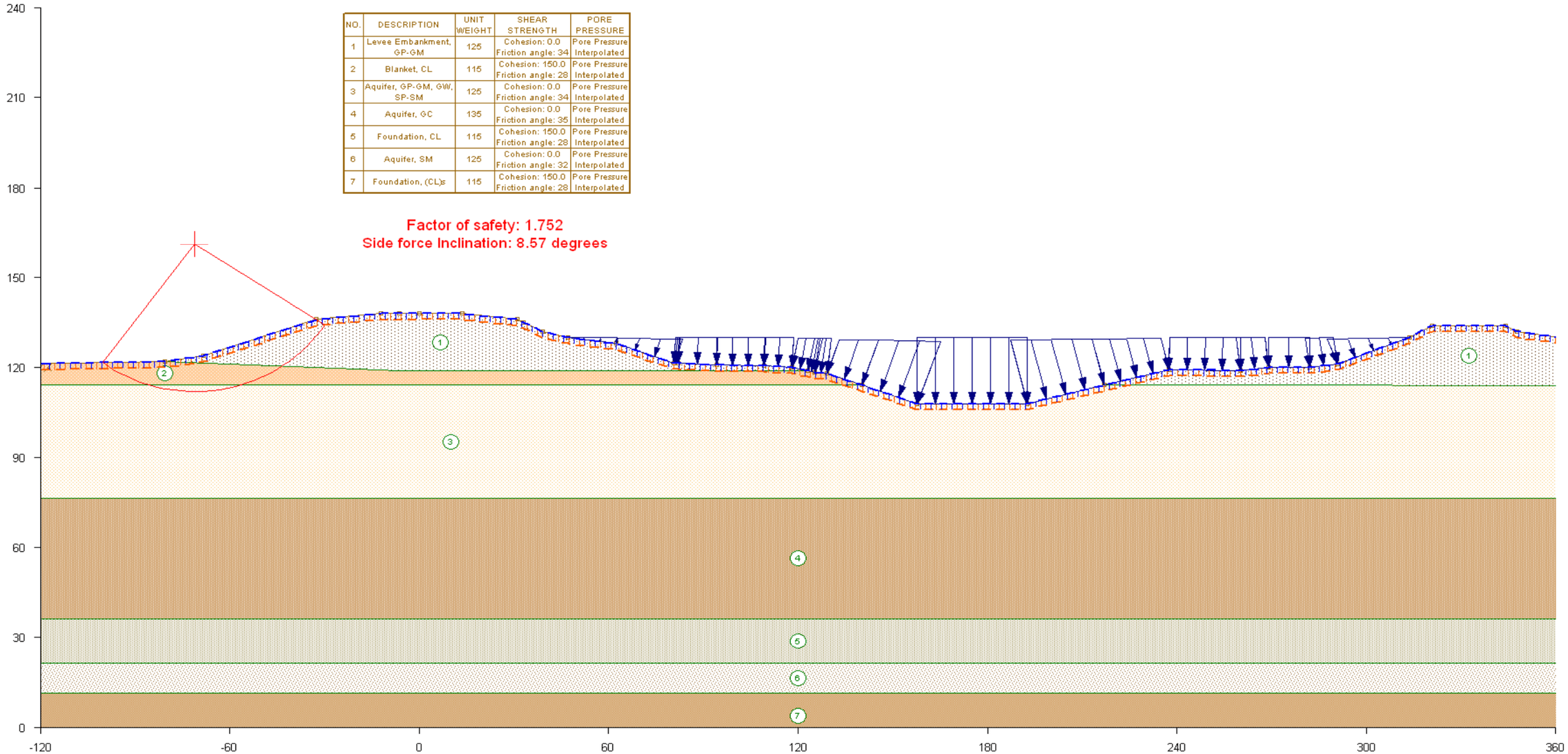
GEOTECHNICAL ENGINEERING APPENDIX

SEEPAGE AND STABILITY ANALYSIS

FEATHER RIVER, LM_0.51, STATION 2332+91

EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Embankment, GP-GM	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated
2	Blanket, CL	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated
3	Aquifer, GP-GM, GW, SP-SM	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated
4	Aquifer, GC	135	Cohesion: 0.0 Friction angle: 35	Pore Pressure Interpolated
5	Foundation, CL	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated
6	Aquifer, SM	125	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated
7	Foundation, (CL)s	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated

Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, GP-GM	14.0	1.4	10	125.00	0.00	34.00
2	Blanket, CL	0.028	0.007	4	115.00	150.00	28.00
3	Aquifer, GP-GM, GW, SP-SM	14.0	1.4	10	125.00	0.00	34.00
4	Aquifer, GC	2.80	0.71	4	135.00	0.00	35.00
5	Foundation, CL	0.03	0.01	4	115.00	150.00	28.00
6	Aquifer, SM	1.40	0.35	4	125.00	0.00	32.00
7	Foundation, (CL)s	0.028	0.007	4	115.00	150.00	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on borings WL0007_072S, WL0007_014S
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 130 ft.

DEPARTMENT OF THE ARMY
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SACRAMENTO, CALIFORNIA

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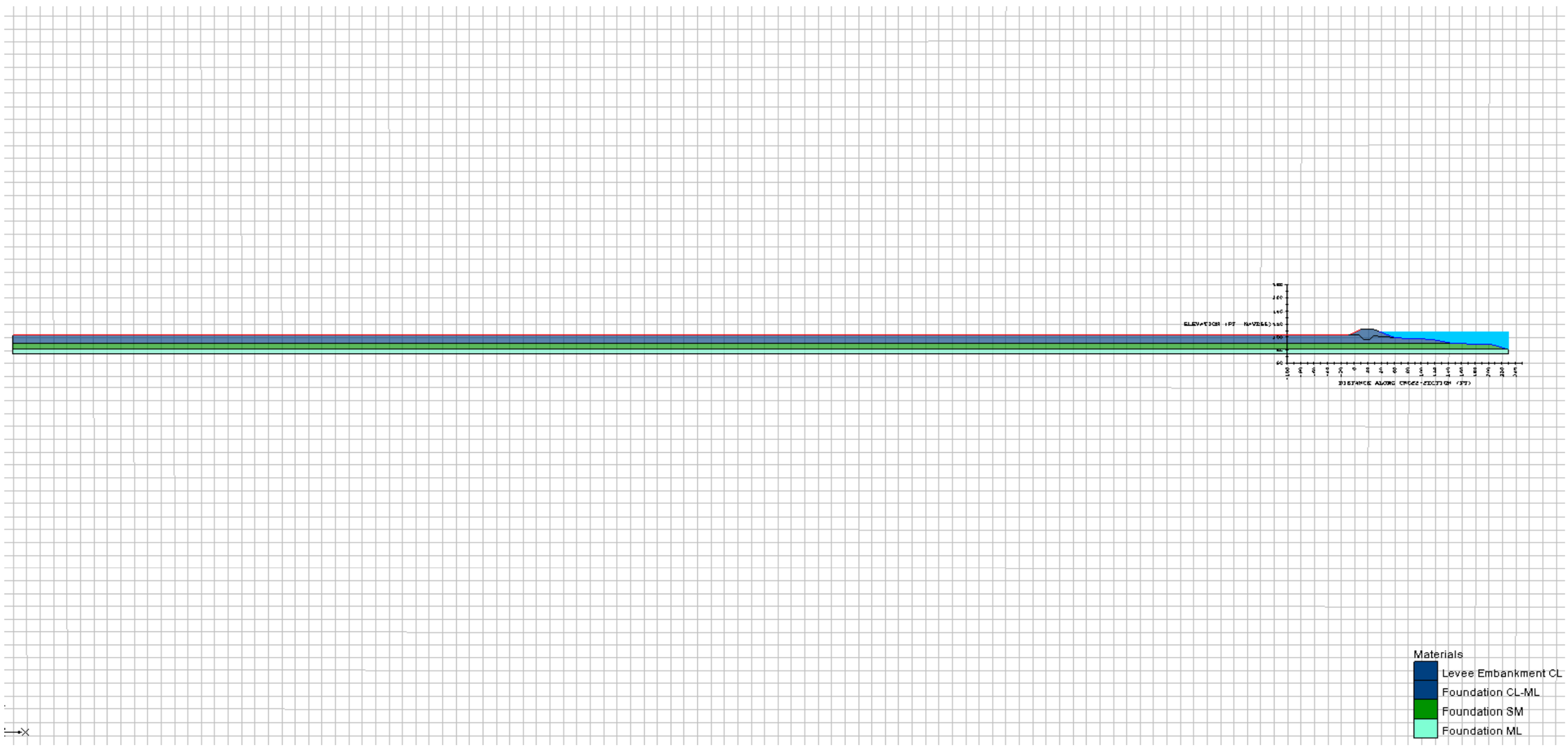
GEOTECHNICAL ENGINEERING APPENDIX

SEEPAGE AND STABILITY ANALYSIS

FEATHER RIVER, LM_0.51, STATION 2332+91

EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment CL	0.028	0.0071	4	115	150	28
2	Foundation CL-ML	0.028	0.0071	4	115	150	28
3	Foundation SM	2.8	0.71	4	120	0	32
4	Foundation ML	0.14	0.035	4	120	0	31

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring 2F-08-34
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 109 ft.

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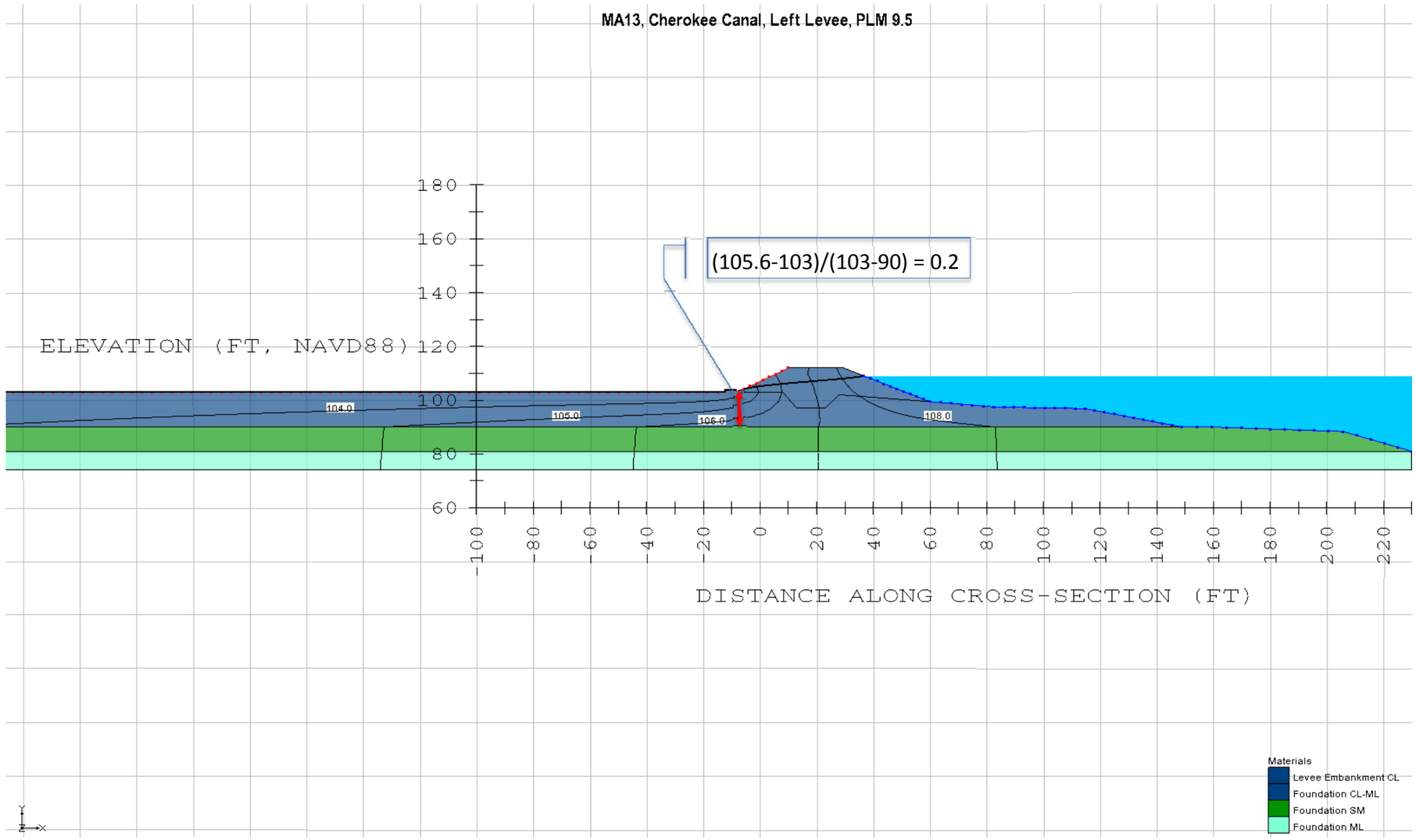
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
CHEROKEE CANAL-LEFT LEVEE, PLM 9.5
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment CL	0.028	0.0071	4	115	150	28
2	Foundation CL-ML	0.028	0.0071	4	115	150	28
3	Foundation SM	2.8	0.71	4	120	0	32
4	Foundation ML	0.14	0.035	4	120	0	31

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring 2F-08-34
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 109 ft.

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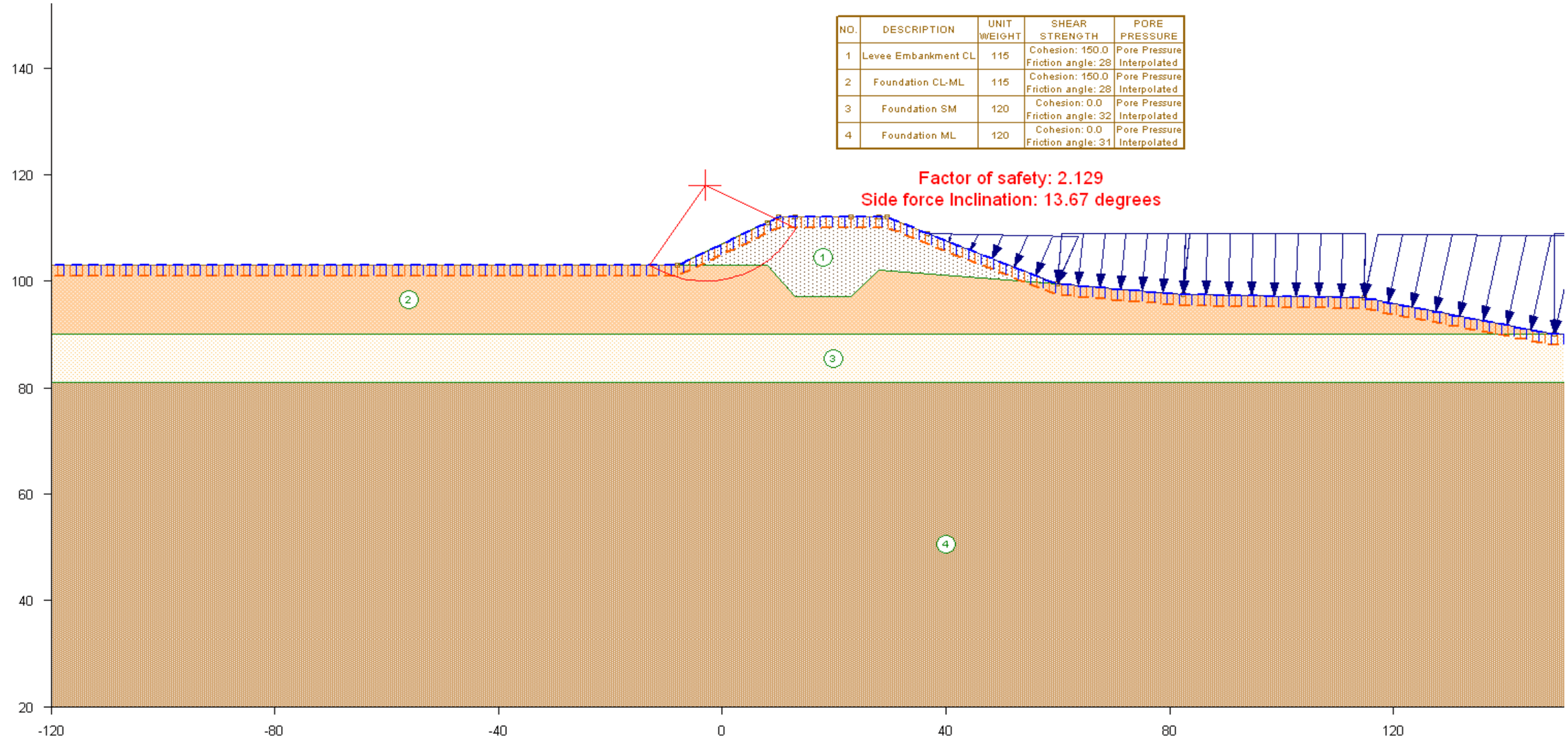
SEEPAGE AND STABILITY ANALYSIS
CHEROKEE CANAL-LEFT LEVEE, PLM 9.5
EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Embankment CL	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated
2	Foundation CL-ML	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated
3	Foundation SM	120	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated
4	Foundation ML	120	Cohesion: 0.0 Friction angle: 31	Pore Pressure Interpolated

Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment CL	0.028	0.0071	4	115	150	28
2	Foundation CL-ML	0.028	0.0071	4	115	150	28
3	Foundation SM	2.8	0.71	4	120	0	32
4	Foundation ML	0.14	0.035	4	120	0	31

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring 2F-08-34
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 109 ft.

DEPARTMENT OF THE ARMY
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SACRAMENTO, CALIFORNIA

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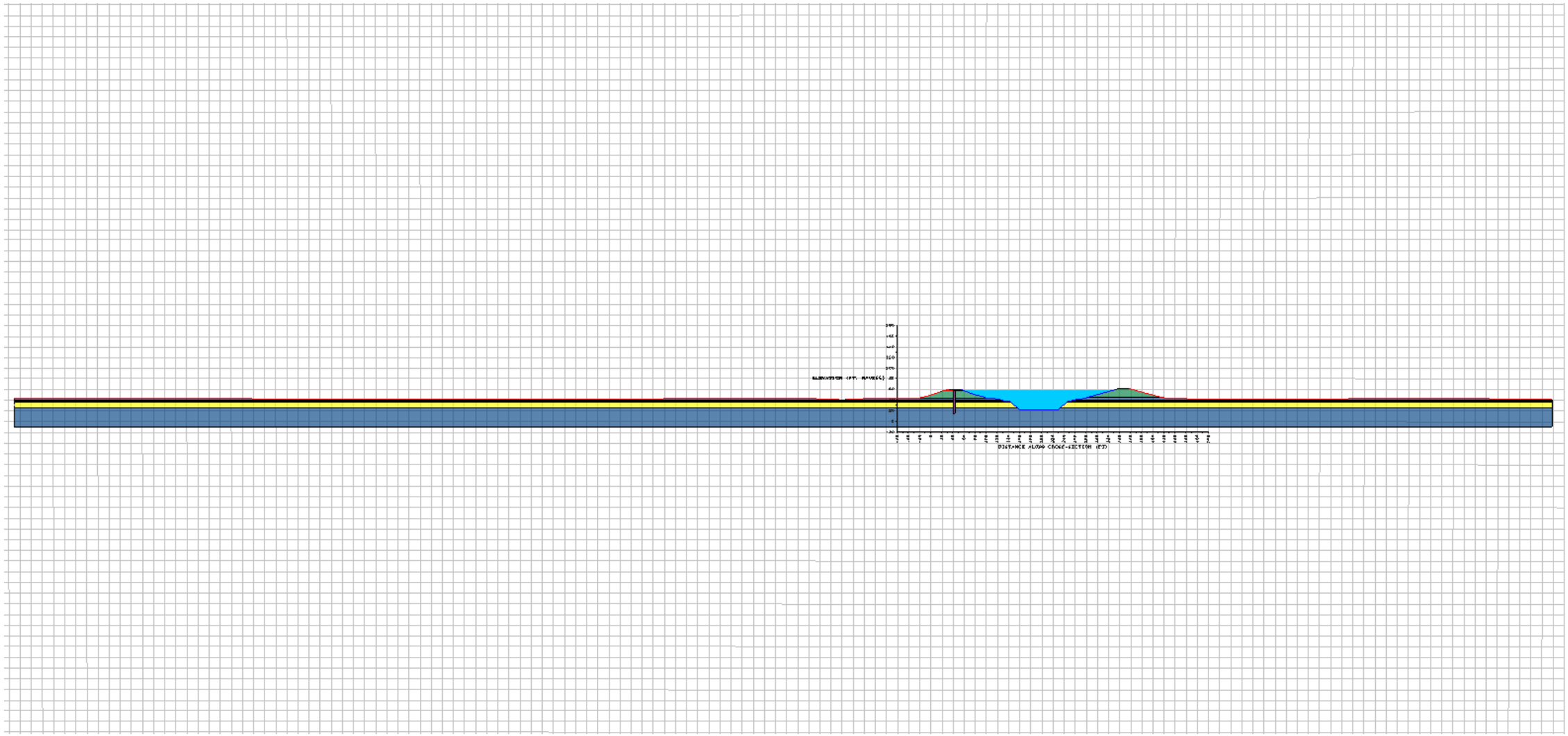
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
CHEROKEE CANAL-LEFT LEVEE, PLM 9.5
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	See Attached Sheet A						
2							
3							
4							
5							
6							
7							
8							
9							
10							

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSEWWC_029B, WSEWWC_001B, WSEWWC_002A
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation =58.5 ft.

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SACRAMENTO DISTRICT
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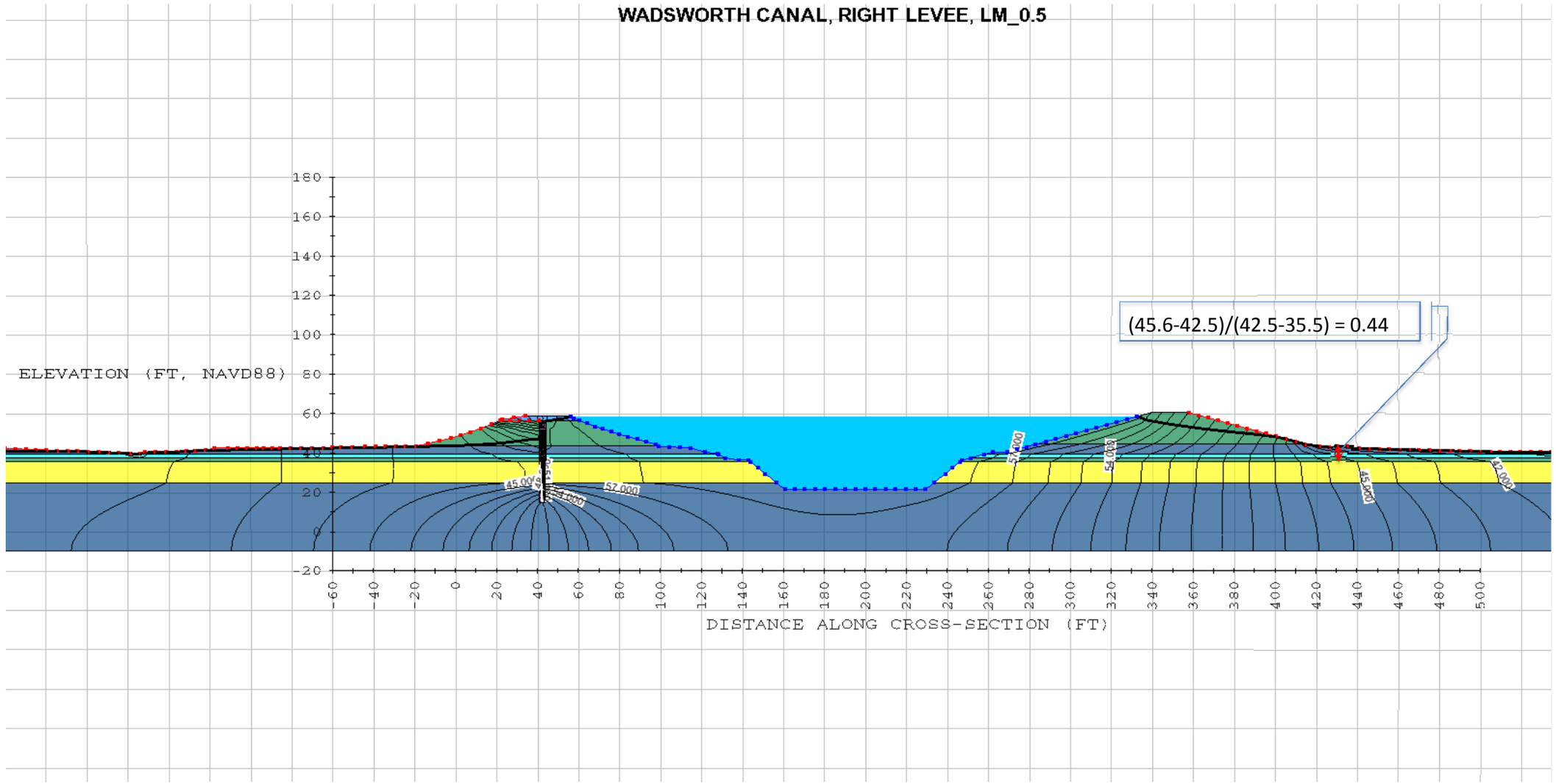
SACRAMENTO, CALIFORNIA

SUTTER BASIN CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
WADSWORTH CANAL, RIGHT LEVEE, LM_0.5
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	See Attached Sheet A						
2							
3							
4							
5							
6							
7							
8							
9							
10							

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSEWWC_029B, WSEWWC_001B, WSEWWC_002A
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation =58.5 ft.

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SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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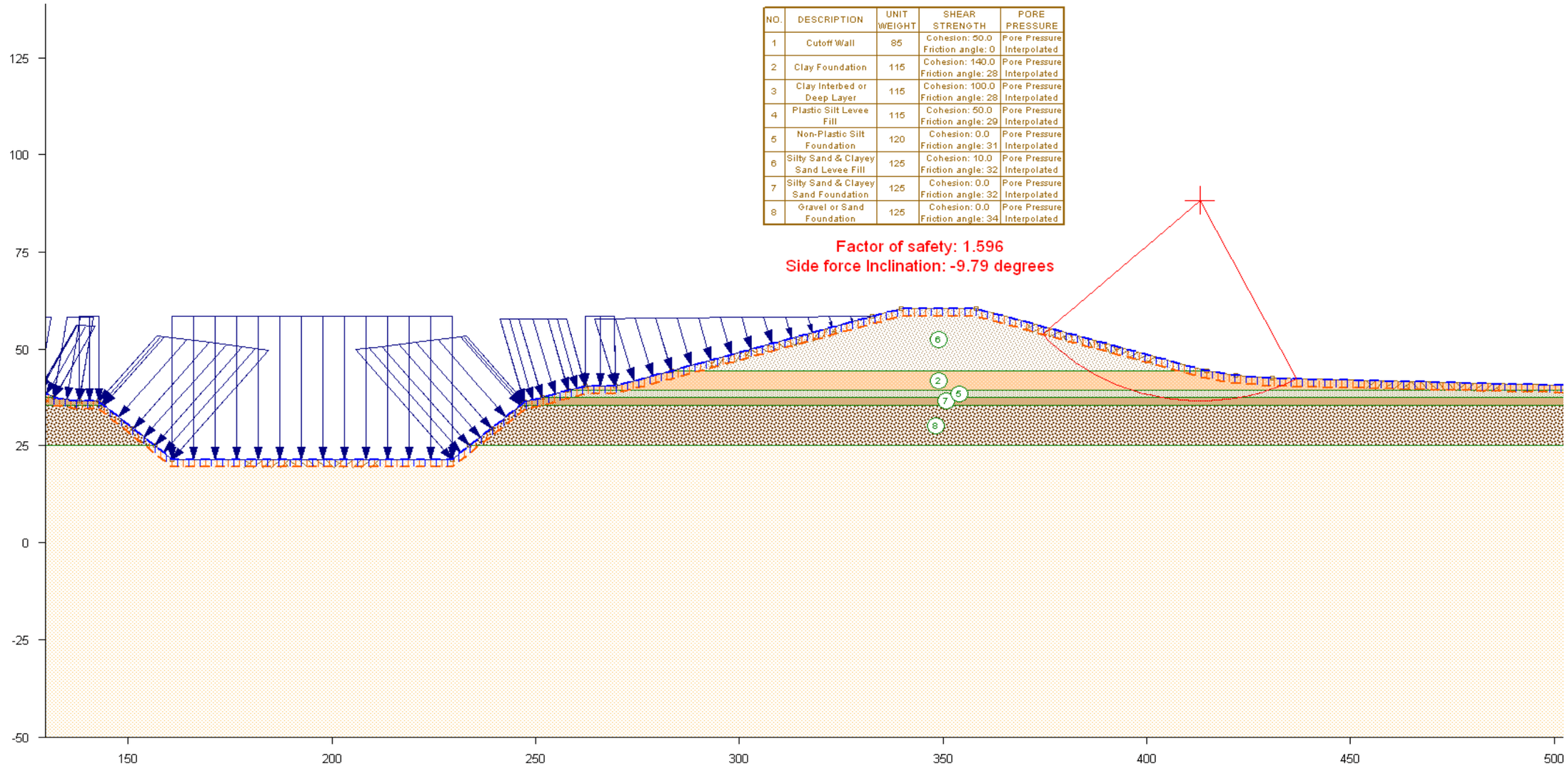
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
WADSWORTH CANAL, RIGHT LEVEE, LM_0.5
EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Cutoff Wall	85	Cohesion: 50.0 Friction angle: 0	Pore Pressure Interpolated
2	Clay Foundation	115	Cohesion: 140.0 Friction angle: 28	Pore Pressure Interpolated
3	Clay Interbed or Deep Layer	115	Cohesion: 100.0 Friction angle: 28	Pore Pressure Interpolated
4	Plastic Silt Levee Fill	115	Cohesion: 50.0 Friction angle: 29	Pore Pressure Interpolated
5	Non-Plastic Silt Foundation	120	Cohesion: 0.0 Friction angle: 31	Pore Pressure Interpolated
6	Silty Sand & Clayey Sand Levee Fill	125	Cohesion: 10.0 Friction angle: 32	Pore Pressure Interpolated
7	Silty Sand & Clayey Sand Foundation	125	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated
8	Gravel or Sand Foundation	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	φ'
1	See Attached Sheet A						
2							
3							
4							
5							
6							
7							
8							
9							
10							

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSEWWC_029B, WSEWWC_001B, WSEWWC_002A
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation =58.5 ft.

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SACRAMENTO DISTRICT
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GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
WADSWORTH CANAL, RIGHT LEVEE, LM_0.5
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3

lope Stability Parameters							
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Cutoff Wall	0.00284	0.00071	4.0	85	50	0
2	Clay Levee Fill	0.0284	0.0071	4.0	115	150	27
3	Clay Foundation	0.0284	0.0071	4.0	115	150	27
4	Clay Interbed or Deep Layer	0.0284	0.0071	4.0	115	150	27
5	Plastic Silt Levee Fill	0.14	0.035	4.0	115	10	28
6	Plastic Silt Foundation	0.14	0.035	4.0	115	10	28
7	Plastic Silt Interbed or Deep Layer	0.14	0.035	4.0	115	10	28
8	Non-Plastic Silt Levee Fill	0.57	0.1425	4.0	115	0	28
9	Non-Plastic Silt Foundation	0.57	0.1425	4.0	115	0	28
10	Non-Plastic Silt Interbed or Deep Layer	0.57	0.1425	4.0	115	0	28
11	Silty Sand & Clayey Sand Levee Fill	0.14	0.035	4.0	125	0	32
12	Silty Sand & Clayey Sand Foundation	0.28	0.07	4.0	125	0	32
13	Silty Sand & Clayey Sand Interbed or Deep Layer	0.28	0.07	4.0	125	0	32
14	Silty or Clayey Gravel	1.13	0.113	10.0	120	0	32
15	Gravel or Sand Foundation	2.8	0.70	4.0	135	0	34
16	Gravel or Sand Interbeds or Deep Layer	17	1.7	10.0	135	0	34
17	Sand Levee Fill (drainage layer)	1	1	1.0	125	0	32

Seepage and Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSEWWC_029B, WSEWWC_001B, WSEWWC_002A
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation =58.5 ft.

DEPARTMENT OF THE ARMY
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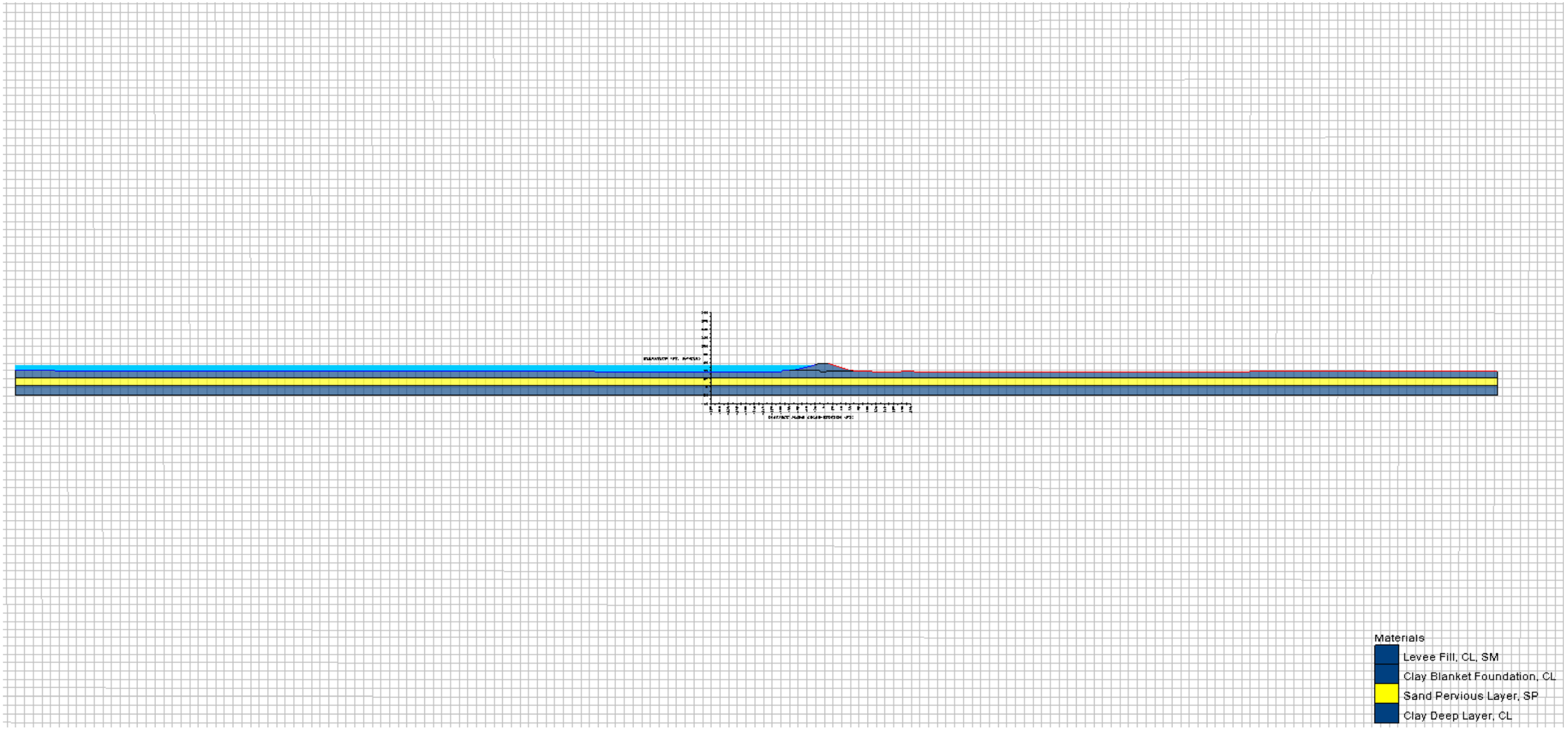
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER BASIN CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
WADSWORTH CANAL, RIGHT LEVEE, LM_0.5
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET A OF A



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Fill Sand-Clay Clam Fill	2.80	0.71	4	115	50	28
2	Clay Blanket Foundation	0.028	0.007	4	120	100	28
3	Sand Pervious Layer	28.000	2.800	10	125	0	34
4	Clay Deep Layer	0.03	0.01	4	120	150	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSESBP_019B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 55.3 ft.

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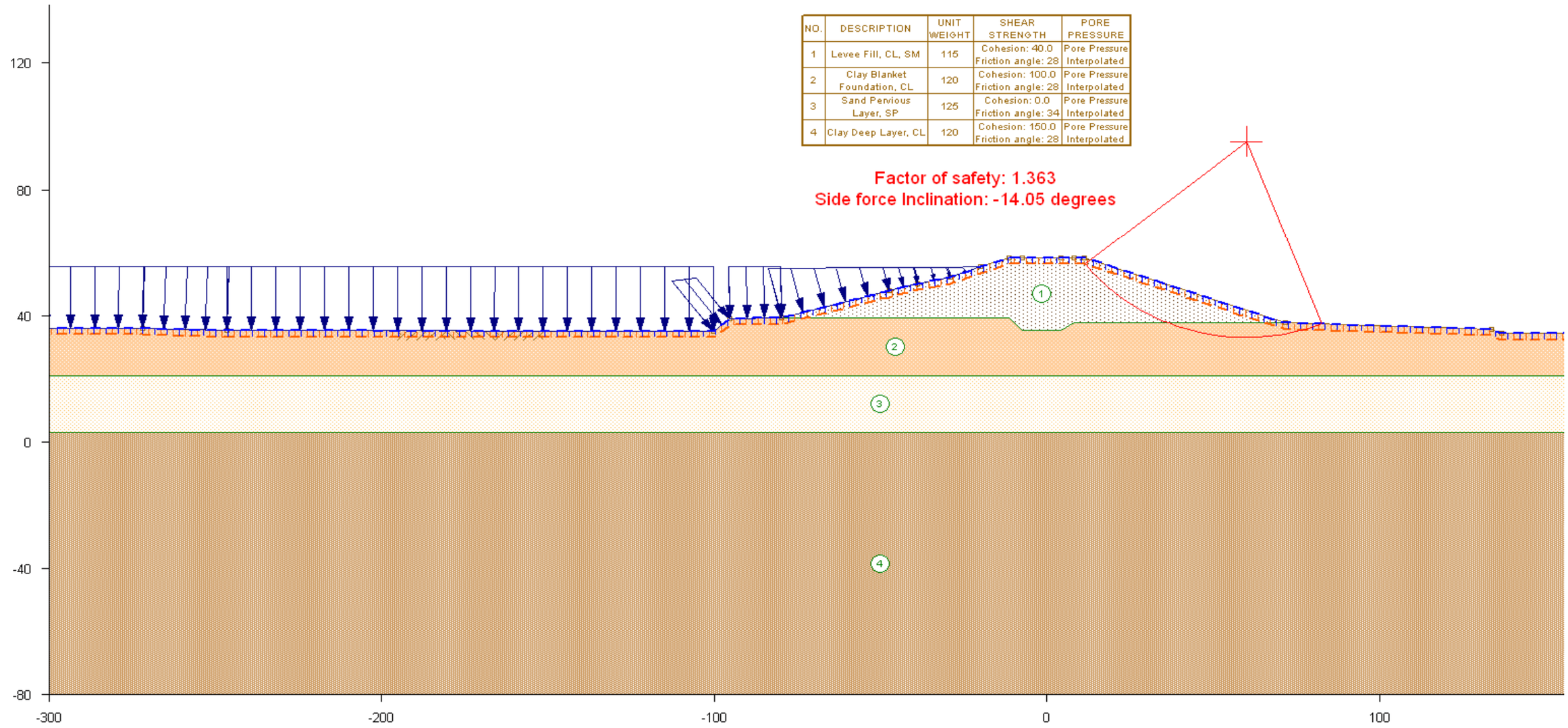
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER BASIN CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
SUTTER BYPASS LM 4.0
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Fill, CL, SM	115	Cohesion: 40.0 Friction angle: 28	Pore Pressure Interpolated
2	Clay Blanket Foundation, CL	120	Cohesion: 100.0 Friction angle: 28	Pore Pressure Interpolated
3	Sand Pervious Layer, SP	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated
4	Clay Deep Layer, CL	120	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated

Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
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7. Water Surface Elevation = 55.3 ft.

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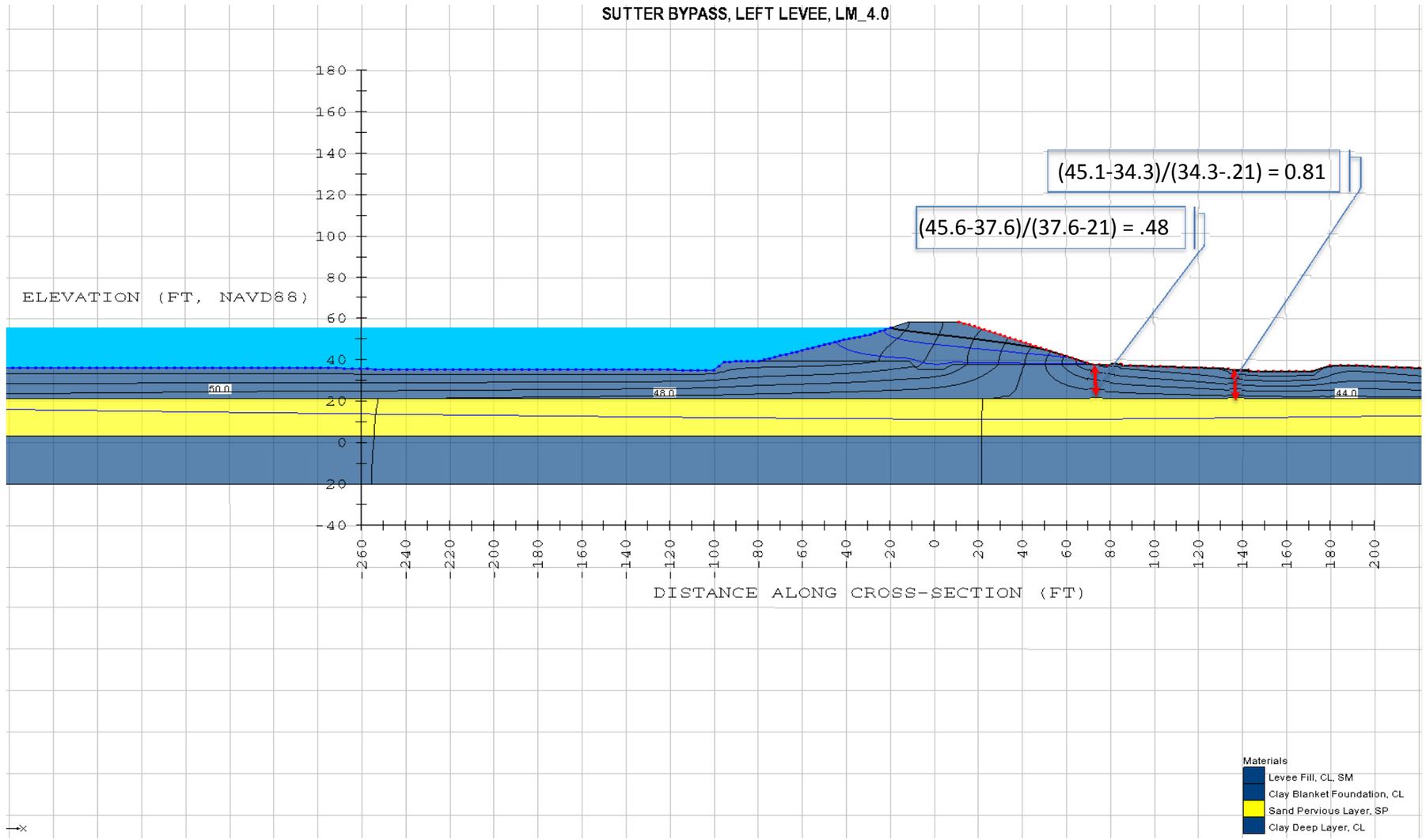
GEOTECHNICAL ENGINEERING APPENDIX

SEEPAGE AND STABILITY ANALYSIS

SUTTER BYPASS LM 4.0

EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
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GEOTECHNICAL ENGINEERING APPENDIX

SEEPAGE AND STABILITY ANALYSIS

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EXISTING CONDITION SEEPAGE DWSE

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ENCLOSURE H

TECHNICAL MEMORANDUM FOR ALTERNATIVES SELECTION

GEOTECHNICAL ENGINEERING

TECHNICAL MEMORANDUM

FOR

ALTERNATIVES SELECTION

SUTTER BASIN, CALIFORNIA

Prepared By:

U.S. Army Corps of Engineers

Sacramento District

Geotechnical Branch

Levee Safety Section

January 2013

1.0 INTRODUCTION

This technical memorandum presents the geotechnical recommendations for screening of the draft array of alternatives for the Sutter Feasibility Study. These recommendations are intended to facilitate the selection of the final array of alternatives. As a result, the recommendations of this report are general and not site-specific, though each reach or segment recommendation is adjusted for large scale understanding of local conditions. Additionally, construction considerations were provided to the Civil Design section including typical design sections, haul and staging, construction sequencing, and borrow. This technical memorandum was prepared not using the Class 3 (feasibility level) analysis to develop seepage and stability mitigation measures (i.e. finite element seepage analysis or limit-equilibrium slope stability calculations). Instead, engineering judgment and experience on local projects was utilized for this Class 4 (reconnaissance level) analysis.

2.0 EVALUATION

This section presents the evaluation of the site conditions based on previous reports and studies, which provides the basis upon which the conclusions and recommendation are developed for the fix-in-place seepage measures.

2.1 Existing Condition Report

The Corps existing condition report indicates that pervasive underseepage concerns exist through the Sutter Feasibility Study area. Each reach has existing conditions where design criteria are not met for embankment geotechnical requirements (i.e. underseepage and stability). Breach failure before overtopping has happened three times during the life of this levee system (1909, 1911, and 1955) near Shanghai Bend, just south of Yuba City; the 1955 breach resulted in 38 fatalities. Without seepage control measures, the system will be subject to failure at less-than-overtopping loading conditions in the future. Levee modifications to the levee systems of the Yuba Basin on the opposite side of the Feather River, including Reclamation District 784 and the City of Marysville levees, have improved or are in the process of improving adjacent systems. Historically, at least one levee system on the Feather River has failed during each major flood during the last century.

2.2 External Document Review

Previous work for this project includes studies done by the local sponsors, the State of California Department of Water Resources and the Sutter Butte Flood Control Agency. This work was reviewed and utilized as part of the basis of our evaluation of the existing conditions , and used to develop the conclusions and recommendations presented for the Sutter basin Feasibility Study. These reports indicate that the levees of the Sutter Basin, including the east (left) levee of the Sutter Bypass from Wadsworth Canal to the Feather River, and the Feather River west (right)

levee from Thermolito Afterbay Dam to the Sutter Bypass (see Map Plate 1), do not meet steady-state stability criteria for underseepage. The extent to which each reach fails to meet design criteria varies, but without exception, each reach has locations that do not meet underseepage criteria, often in multiple locations.

2.3 Key Assumptions

The following assumptions were used in the evaluation of the existing conditions (including for a potential ring levee around Yuba City, bypass and setback levees.) and for the analyzed alternatives.

- Levees will be modified or constructed considering seepage control or stability measures to provide embankment performance in accordance with USACE criteria for the entire levee system.
- Seepage and stability mitigation will be provided by construction of a cut-off wall along the entire system for all alternatives. Alternative selections are not based on a choice of seepage or stability mitigation measure. Selection of different mitigation measures such as seepage berms, relief wells, or cut-off walls along each reach is considered a design refinement and will be addressed in PED. Cutoff walls are less impactful to the environment and do not require the acquisition of real estate. The cost of soil-bentonite (SB) cutoff walls is competitive with berm construction.
- The exception to cutoff walls as seepage control mitigation measures are:

  Existing Relief Well Systems: used to the maximum extent possible in the reaches south of Yuba City at Shanghai Bend and Abbot Lakes/Star Bend.

  Seepage and Stability Berms: used in the northern reach near Thermalito Afterbay. The sponsor had previous indicated an interest and using gravel from the Oroville Goldfields dredger tailings to facility environmental mitigation. The presence of this gravel very close to the levee makes berm construction highly cost-effective in this area.

- Fix-in-place levee modifications have adequate subsurface geotechnical data for the development of feasibility level alternatives. For ring, setback, and bypass levees, there is no geotechnical subsurface data meeting the needs of a feasibility study. In order to develop feasibility recommendations that provide a reasonable basis for comparing alternatives, the structural measures for existing levees and new levees should ideally have a similar level of detail. This would best be achieved by having subsurface information and loading conditions developed to the same level of detail for new and existing levees. Since this is not possible without subsurface data on the ring, bypass and setback levee measures, a parametric approach was used. This approach was based only on a generalized understanding of the subsurface condition in Sutter and Butte counties, combined with past experience on fix-in-place and setback construction projects in the area (Yuba Basin).

- The parametric approach uses the maximum and minimum expected value concept. For example, design of a cutoff wall used estimates of the minimum and maximum expected depth and percentage of reach length requiring seepage control. After the maximum and minimum values were chosen, they were used to guide the selection of expected value. The median value was not used directly. These values were provided to civil designer so that quantities could be developed.
- New levees founded on older alluvium and located away from depressions, ditches or canals will likely require less seepage control (e.g. cutoff walls, seepage berms, etc) by percent of length.
- New levees will require more seepage control by percentage of length if the levee is taller (e.g. 8 feet or more) and less if it is shorter (e.g. 8 feet or less).
- For existing and new levees, deep cutoffs requiring specialized technology (e.g. deep soil mixing, jet grouting, etc) were considered design refinements and are not recommended at the feasibility level. It is expected that the reaches requiring the use of these methods will be short (e.g. bridge abutments or major utility crossing which may be left in place, etc). The increased cost of deep soil mixing (DSM) at $25 per square foot versus SB cutoff walls using slurry methods and excavators at $12 per square foot is significant; however, the percentage of the reaches is likely less than one percent of the entire project length. If long reaches requiring deep seepage control were encountered, the design level determination would most likely be the utilization of seepage using seepage berms or relief wells in lieu of cutoff walls.
- For areas where levee modification is required, including the addition of seepage control or stability mitigation, the resulting levee after construction will provide 1V:2H landside and 1V:3H waterside slopes and a 20-ft crest width.
- O&M easements for existing levees will be provided in the design of reaches requiring modification to not less than that prescribed by the current O&M manual. Additional O&M should be required to 15 or 20 ft of the landside to when feasible.
- Vegetation removal for ETL 1110-1-571 compliance will require at a minimum, removal of all non-compliant vegetation on the upper two-thirds of the waterside of the levee, the crest, landside slope and the existing landside easement.(if less than 15 feet, than a flooding easement will be required at least 15 feet from the landside toe free of woody vegetation)
- Seismic evaluation will be performed later in the Feasibility Study process, but seismic considerations are not considered to have a significant impact in alternative selection. Seismic analyses will be performed only to evaluate the extent of the damages but the levee alternatives will be not be affected by the seismic evaluation.
- A levee design template will be used by the civil and cost engineers to develop quantities based on inputs from this geotechnical engineering report. This template was developed by URS, and takes input for several key factors of a levee modification design (e.g. existing levee height and crest width, new depth of cutoff wall or width of seepage berm) and provides a parametric cost estimate for the levee segment for which this template is applied. The typical sections used are provided in the plates for Typical Drawing in this report.

3.0 CONCLUSIONS

The following geotechnical engineering conclusions are based on the evaluation of the subsurface conditions identified along the levees part of the Sutter basin and on the past performance of these levee and of the levees east site of Feather River. These conclusions are based heavily on engineering judgment which is guided strongly by experience in the local region and knowledge of the local soils.

3.1 General Conclusions for Fix-in-Place Alternatives

Based on the results of seepage and stability modeling, the existing levee system fails seepage design criteria within every reach, typically within multiple subreaches, and at a range of water surface profiles. The existing levee system fails to meet seepage and stability to varying degrees through the system, and underseepage mitigation in every reach is required to varying degrees.

3.2 Conclusions by Structural Segment

The conclusions are presented in clockwise order beginning with the Wadsworth Canal at the East/West Interceptor and progressing along the Sutter Bypass and Feather River to Thermalito Afterbay. Structural measure designations were developed by the Sutter PDT, and are broken down by geotechnical reach for the fix-in-place alternatives.

3.2.1 Wadsworth Canal (S7J)

The levee in this reach is approximately 20 ft in height (as measured from the landside toe to crest) at the downstream end, and the upper one-half of the segment, the levee is less than 7 feet tall, dropping to 3 feet at the upstream connection to the interceptor canals. A one-half mile long, 30 to 60 ft deep centerline soil-cement-bentonite (SCB) cutoff wall was constructed in this segment by the Corps near the downstream connection with the Sutter Bypass. Exploration performed by the State of California as part of their levee evaluation show that upstream of the cutoff wall, borings indicate sand layers covered by a thin impervious blanket or next to the surface which may require seepage control. Considering the adequate existing cutoff wall, the underseepage concerns upstream of the cutoff wall, and the lack of height of the levee upstream, a seepage control consisting of a seepage cut-off wall is recommended along approximately 25% of the segment. Based on the geotechnical conditions and of the existing cut-off wall, the depth varies between 20 and 50 feet, with an average depth of 40 ft.

3.2.2 Sutter Bypass (S7I)

The geotechnical and geomorphologic data provided by the State of California for the levee evaluation studies were used to evaluate the existing conditions and to recommend the mitigation

alternatives. Exploratory borings and cone penetrometer testing (CPT) spaced at 1000 ft intervals, a long history of general past performance issues, and a series of seepage control measures of unknown quality and performance (toe drains, small seepage berms) indicate that additional seepage mitigation is required. The geology of this area consists of shallow basin deposits overlying hard pan layers. The general direction of geologic trend of soil deposits is roughly perpendicular to the levee, meaning a high frequency of small sand deposits is likely. The borrow pit cut through the hardpan layer near the waterside levee toe for construction of the existing levee creates a direct seepage connection to underlying sand layers. These factors indicate this levee has seepage concerns. Seepage cut-off wall is recommended for 100% of the reach, the depths of positive cutoff walls being relatively shallow (30 ft depth) but vary as much as 20 to 50 ft.

3.2.3 Sutter Bypass (S7H)

Borings and CPTs spaced at 1000 ft intervals, a long history of general past performance issues, and a series of seepage control measures of unknown quality and performance (toe drains, small seepage berms) indicate that additional seepage mitigation is required. The geology of this area consists of shallow basin deposits overlying hardpan clay layers. The general direction of geologic trend of soil deposits is roughly perpendicular to the levee, meaning a high frequency of small sand deposits is also likely and not easily detected by 1000-ft spaced borings. This reach contains Gilsizer Slough which is the active overbank flow channel from the Feather River to the west. The borrow pit cut through the hardpan layer near the waterside levee toe to construct the existing levee creates a direct seepage connection to underlying sand layers. These factors indicate this levee has seepage concerns and combined with the borings at Gilsizer Slough the cutoff wall may be deeper than other reaches of the Sutter Bypass. Seepage cut-off wall is recommended for 100% of the reach, the depths of positive cutoff walls relatively shallow (30 ft depth) but vary as much as 20 to 75 ft.

3.2.4 Sutter Bypass (S7G)

Borings and CPT spaced at 1000 ft intervals, a long history of general past performance issues, and a series of seepage control measures of unknown quality and performance (toe drains, small seepage berms) indicate that seepage mitigation is required. The geology of this area consists of shallow basin deposits overlying hardpan layers. The general direction of geologic trend of soil deposits is roughly perpendicular to the levee, meaning a high frequency of small sand deposits is likely. The borrow pit cut through the hardpan near the waterside levee toe for construction of the existing levee creates a direct seepage connection to underlying sand layers. These factors indicate this levee has seepage concerns. The levee height in this reach is the tallest of the entire Sutter Bypass. Therefore, seepage cut-off wall is recommended for 100% of the reach, the depths of positive cutoff walls being relatively shallow (30 ft depth) but vary as much as 20 to 50 ft.

3.2.5 Feather River (S7F)

The levee in this reach is tall (20 plus ft), and irrigation ditches are excavated near the landside levee toe. Borings and CPTs indicate shallow sand layers and thin to moderate blanket thicknesses that may lead to seepage sand boils. Seepage cut-off walls are recommended for 75% of the reach, the depths of positive cutoff walls to being moderately deep, 50 ft, but vary as much as 20 to 75 ft.

3.2.6 Feather River (S7E)

The levee in this reach is tall (20 plus ft), and has irrigation ditches excavated near the landside toe. Borings indicate deep sand layers and thin to moderate blanket thicknesses that may lead to high gradients and sand boils, however portions of the reach have deep clay foundations. A portion of this reach has existing relief wells. Seepage cutoff walls are recommended for 25% of the reach, and relief well collection system on additional 25% of the reach length. We expect depths of positive cutoff walls to be moderately deep, 65 ft, but vary as much as 20 to 75 ft.

3.2.7 Feather River (S7D/S5D)

The levee in this reach is tall (20 plus ft), and has irrigation ditches excavated near the landside toe. Borings indicate shallow and deep sand layers and thin to moderate blanket thicknesses that may lead to high gradients at the levee toe; however, portions of the reach have deep clay foundations. A portion of this reach has existing relief wells. Seepage cutoff walls is recommended for 50% of the reach and an additional 15% will require relief well collection system modification. We expect depths of positive cutoff walls to be moderately deep, 65 ft, but vary as much as 20 to 75 ft.

3.2.8 Feather River (S7C)

The levee in this reach is tall (20 plus ft), and has irrigation ditches excavated near the landside toe. Borings indicate shallow and deep sand layers and thin to moderate blanket thicknesses that may lead to high gradients at the levee toe. Based on these considerations, seepage cut-off wall is recommended for 75% of the reach. The depths of positive cutoff walls should be moderately deep, 65 ft, but vary as much as 20 to 75 ft.

3.2.9 Feather River (S7B)

The levee in this reach variable in levee height from as little as 3 feet to as much as 15 ft, and has ditches excavated along the landside toe, including the major irrigation Sutter Butte Canal. Borings indicate shallow sand layers that may lead to high gradients at the levee toe for parts of this reach. Seepage control may be required as part the method in which the Sutter Butte Canal will be addressed. Based on these considerations, seepage cutoff walls are necessary for 100% of the reach, and we expect depths of positive cutoff walls to be moderately deep, 65 ft, but vary as much as 20 to 75 ft.

3.2.10 Feather River (S7A)

The levee in this reach varies in height from 3 to 4 feet to 18 ft. Borings indicate shallow sand layers and thin to moderate blanket thicknesses that may be seepage paths. The levee may require modification to address insufficient geometry in the Goldfields portion. Based on these considerations, seepage mitigation is recommended for 50% of the segment, seepage and stability mitigation for 25% of the segment and stability mitigation is required for 25% of the reach. Seepage berms and stability berms may be the best mitigation here, due to the sponsor's interest in using local borrow sources.

3.3 General Conclusions for New Levees (Setback Levees, Ring Levees and Cross Levees)

Based on experience with new levees, including setback levees previously constructed within the basin (e.g. Star and Shanghai Bends in Levee District 1, and the Feather River Setback Levee in Reclamation District 784), new levees will require a cutoff wall for some percentage of length, though typically to a lesser extent than existing levees. This is likely due to the distance from active river channels, and the lower likelihood of founding the levee on poor foundation conditions. Therefore we conclude that new levees far from the active river system will need seepage mitigation measures at a lower rate per unit length.

3.4 Conclusions by Reach

The conclusions for new levee segments are presented in clockwise order beginning with the Wadsworth Canal at the East/West Interceptor and progressing along the Sutter Bypass and Feather River to Thermalito Afterbay.

3.4.1 Sutter Bypass Setback Levee (S9I)

Seepage mitigation is assumed to be similar to the associated segment of the existing Sutter Bypass levee. Increased seepage path length by moving the levee back from the waterside borrow pit may result in a lower percentage of cutoff walls, but it will not eliminate the need for seepage control.

3.4.2 Sutter Bypass Setback Levee (S9H)

Seepage mitigation is assumed to be similar to the associated segment of the existing Sutter Bypass levee. Increased seepage path length by moving the levee back from the waterside borrow pit may result in a lower percentage of cutoff walls, but it will not eliminate the need for seepage control.

3.4.3 Sutter Bypass Setback Levee (S9G)

Seepage mitigation is assumed to be similar to the associated segment of the existing Sutter Bypass levee. Increased seepage path length by moving the levee back from the waterside borrow pit may result in a lower percentage of cutoff walls, but it will not eliminate the need for seepage control.

3.4.4 Lower Feather River Setback Levee (S11)

Depending on the final alignment, seepage control may be reduced below levels on the Sutter Bypass and south Feather River segment, due to the presence of an intact waterside blanket.

3.4.5 Star Bend Setback Levee (S12)

Based on borings for the Star Bend Setback Levee, seepage mitigation is required through the entire reach to depths of approximately 40 to 60 ft.

3.4.6 Yuba City, Ring Levee – South (S4) and J-Levee - South (S6)

Ring levees are assumed to be relatively short, and if they are constructed in areas with an intact blanket on the waterside of the levee (likely in this area based on experience), a lesser percentage of cutoff walls is expected. Seepage control is likely for one-third of this alignment.

3.4.7 Yuba City, Ring Levee – West (S4), J-Levee – West Lower (S6) and J-Levee – West Upper (S6)

Ring levees are assumed to be relatively short, and if they are constructed in areas with an intact blanket on the waterside of the levee (likely in this area based on experience), a lesser percentage of cutoff walls is expected. Seepage control is likely for one-third of this alignment.

3.4.8 Yuba City, Ring Levee – North (S4)

Ring levees are assumed to be relatively short, and if they are constructed in areas with an intact blanket on the waterside of the levee (likely in this area based on experience), a lesser percentage of cutoff walls is expected. Seepage control is likely for one-third of this alignment.

3.4.9 Northern Feather River Setback Levee (S10)

There is more uncertainty with the foundations conditions in this reach. Deep coarse-grained materials are known to exist in the Biggs area, so seepage mitigation is likely to be extensive. Also, this area was an overflow area for the Feather River during the 1800’s and early 1900’s.

This indicates that shallow sand layers and a high-frequency of sand lenses or stringers are likely to be present. Seepage mitigation is likely for 100% of the reach.

4.0 RECOMMENDATIONS

Recommendations for typical design sections (templates), new levees, construction staging and hauling, borrow, and structural segment-specific recommendations are provided within this section.

4.1 Typical Design Sections

Typical design sections are provided in the Plates section of this memorandum. These include all typical designs, which correspond to the templates used by URS in their parametric analysis performed for this project.

4.2 New Levee Design

All levees designs shall provide 1V:3H landside and waterside slope with a 20 ft crest width and 15 ft waterside and 20 ft landside O&M easements. Table 3 provides typical levee corridor widths, and Typical Detail Plates 6 and 7 provide the geometrical relationships of new levees with and without SB slurry walls.

4.3 Construction Staging and On-Site Hauling

Levee modification projects typically require long linear haul routes for on-site construction and staging areas situated at periodic intervals. For long slurry wall projects, we recommend that 2 acre sites every 2500 linear feet of levee. Typically slurry wall construction requires bentonite slurry ponds, and typically these are located about every one-half mile. The bentonite slurry is pumped to the active excavation site through pipes. Major staging areas are also required. Major staging areas are where equipment maintenance, employee parking and job trailers are located. Assume 5 acres for a typical 5 mile long slurry wall project. Multiple concurrent cutoff wall projects may require a large central staging area.

4.4 Borrow

We recommend that 15 miles as a typical haul distance for borrow. Values as low as 10 or as high as 30 may be reasonable, but 15 miles is conservative, and higher values are not warranted considering that suitable material can be typically found within the basin. It is likely that borrow will become cost prohibitive if not obtained within this distance, primarily due to air quality impacts. A conservative shrinkage percentage should be used. We recommend 15% at the feasibility level.

4.5 Seepage and Stability Mitigation by Structural Measure

These recommendations are presented as ranges (i.e. remediate reach X with a cutoff wall along 50 to 100% of the reach with a depth ranging from 20 ft to 60 ft). The measures are presented in a clockwise organization beginning on the Wadsworth Canal and progressing through the Sutter Bypass and Feather River to Thermalito Afterbay.

4.6 Fix-in-Place Measures

This section presents recommendation for seepage and stability mitigation, presented by fix-in—place structural segment.

4.6.1 Wadsworth Canal

Construct a centerline SB cutoff wall for 25% of the reach, to an expected depth of 40, with a range of typical depths of 20 to 50 ft.

4.6.2 Sutter Bypass (S7I)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 30 ft, with a range of typical depths of 20 to 50 ft.

4.6.3 Sutter Bypass (S7H)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 30 ft, with a range of typical depths of 20 to 75 ft.

4.6.4 Sutter Bypass (S7G)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 30 ft, with a range of typical depths of 20 to 50 ft.

4.6.5 Feather River (S7F)

Construct a centerline SB cutoff wall for 75% of the reach, to an expected depth of 50 ft, with a range of typical depths of 20 to 75 ft.

4.6.6 Feather River (S7E)

Construct a centerline SB cutoff wall for 25% of the reach, to an expected depth of 40 ft, with a range of typical depths of 20 to 75 ft.

4.6.7 Feather River (S7D/S5D)

Construct a centerline SB cutoff wall for 50% of the reach, to an expected depth of 50 ft, with a range of typical depths of 20 to 75 ft. Modify existing relief well systems by reconfiguration of the collection system, including lower well head rise height from 4 above grade to 1 ft below grade for 15% of the reach for a total of 65% seepage mititgation.

4.6.8 Feather River (S5C)

Construct a centerline SB cutoff wall for 75% of the reach, to an expected depth of 65 ft, with a range of typical depths of 20 to 75 ft.

4.6.9 Feather River (S5B)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 65 ft, with a range of typical depths of 20 to 75 ft.

4.6.10 Feather River (S5A)

Construct a seepage berm for 75% of the reach, to height of 5 ft and width of 12 ft. Construct a stability berm for 50% of the reach, with a height of 12 ft and top width of 12 ft. The resulting segment recommendation is for 50% of the segment to have a seepage berm only, 25% to have a stability berm only and 25% to have a combined seepage and stability berm.

4.7 Ring, Bypass and Setback Measures

This section presents recommendation for seepage control for new levees, presented by ring, bypass or setback levee structural segment.

4.7.1 Sutter Bypass Setback Levee (S9I)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 35 ft, with a range of typical depths of 20 to 50 ft.

4.7.2 Sutter Bypass Setback Levee (S9H)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 35 ft, with a range of typical depths of 20 to 50 ft.

4.7.3 Sutter Bypass Setback Levee (S9G)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 35 ft, with a range of typical depths of 20 to 50 ft.

4.7.4 Lower Feather River Setback Levee (S11)

Construct a centerline SB cutoff wall for 50% of the reach, to an expected depth of 35 ft, with a range of typical depths of 30 to 70 ft.

4.7.5 Star Bend Setback Levee (S12)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 65 ft, with a range of typical depths of 30 to 70 ft.

4.7.6 Yuba City, Ring Levee – South (S4) and J-Levee - South (S6)

Construct a centerline SB cutoff wall for 34% of the reach, to an expected depth of 35 ft, with a range of typical depths of 30 to 60 ft.

4.7.7 Yuba City, Ring Levee – West (S4), J-Levee – West Lower (S6) and J-Levee – West Upper (S6)

Construct a centerline SB cutoff wall for 34% of the reach, to an expected depth of 35 ft, with a range of typical depths of 30 to 60 ft.

4.7.8 Yuba City, Ring Levee – North (S4)

Construct a centerline SB cutoff wall for 34% of the reach, to an expected depth of 35 ft, with a range of typical depths of 30 to 60 ft.

4.7.9 Northern Feather River Setback Levee (S10)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 75 ft, with a range of typical depths of 20 to 75 ft.

5.0 REFERENCES

- State of California, Department of Water Resources Urban Levee Geotechnical Evaluations Program, Phase 1 Preliminary Geotechnical Evaluation Report, Sutter Study Area, March 2008, URS
- State of California, Department of Water Resources Urban Levee Geotechnical Evaluations Program, Phase 1 Geotechnical Data Report, Sutter Study Area, November 2008, URS
- State of California, Department of Water Resources Urban Levee Geotechnical Evaluations Program, Supplemental Geotechnical Data Report, Sutter Study Area, April 2010, URS
- Sutter Butte Flood Control Agency, Pre-Design Formulation Report, West Feather River Project, August 2011, prepared by HDR, Wood Rodgers, URS and MHM
- Sutter Butte Flood Control Agency, 60% design submittal package, West Feather River Project, January 2012, prepared by HDR, Wood Rodgers, URS and MHM

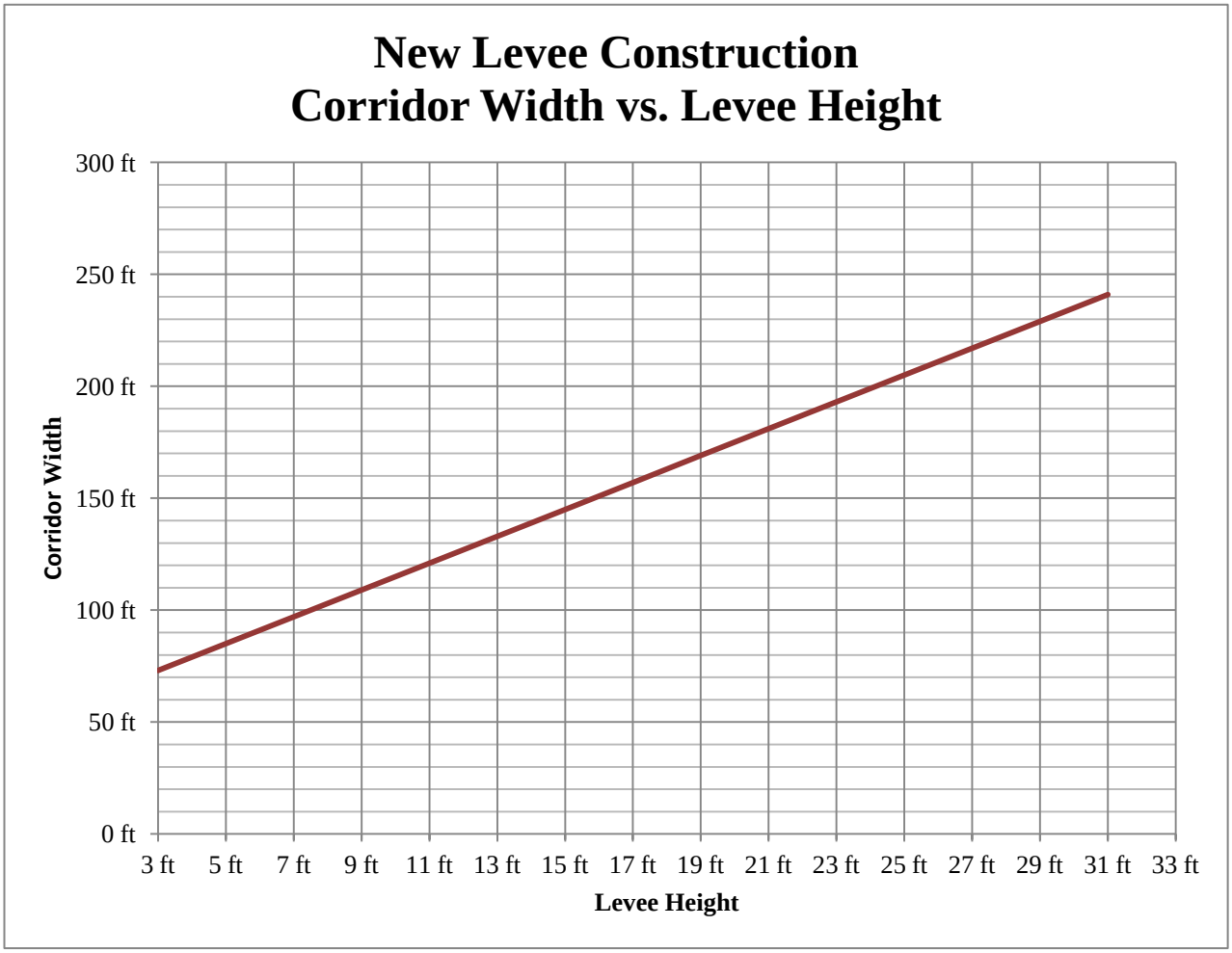
TABLES

Table 1, Summary of Recommendations by Structural Element of the Existing Levee System							
Structural Element	Name	PLM	PLM	Feature	% Length	Depth/Height	Width
S7J	Wadsworth Canal	0	4.66	SB CL Cutoff wall	25	40 ft (20 to 50)	N/A
S7I	Sutter Bypass	4.4	12.65	SB CL Cutoff wall	100	30 ft (20 to 50)	N/A
S7J	Sutter Bypass	12.65	14.35	SB CL Cutoff wall	100	30 ft (20 to 75)	N/A
S7H	Sutter Bypass	14.35	22.37	SB CL Cutoff wall	100	30 ft (20 to 50)	N/A
S7F	Feather River	MA03 0.00 LD1 0.00	MA 5.19 LD1 2.70	SB CL Cutoff wall	75	50 ft (20 to 75)	N/A
S7E	Feather River	LD1 2.70	LD1 6.20	SB CL Cutoff wall	25	65 ft (20 to 75)	N/A
S7D	Feather River	LD1 6.20	LD1 10.5	SB CL Cutoff wall[1]	50	65 ft (20 to 75)	N/A
S5D/S4-EAST	Feather River	LD1 10.5	LD1 16.65	SB CL Cutoff wall[1]	50	65 ft (20 to 75)	N/A
S5C	Feather River	LD9 0.00	LD9 5.50	SB CL Cutoff wall	75	65 ft (20 to 75)	N/A
S5B	Feather River	LD9 5.50| MA16 0 MA7 0.00	LD9 6.24 MA16 4.69 MA7 1.80	SB CL Cutoff wall	100	65 ft (20 to 75)	N/A
S5A	Feather River	MA7 1.80 MA7 HB 0.00	MA7 12.07 MA7 HG 0.08	Stability Berm Seepage Berm	50 75	12 ft 150 ft	12 ft 5 ft

[1] Modifications to the existing relief well system are required per section 4.6.7.

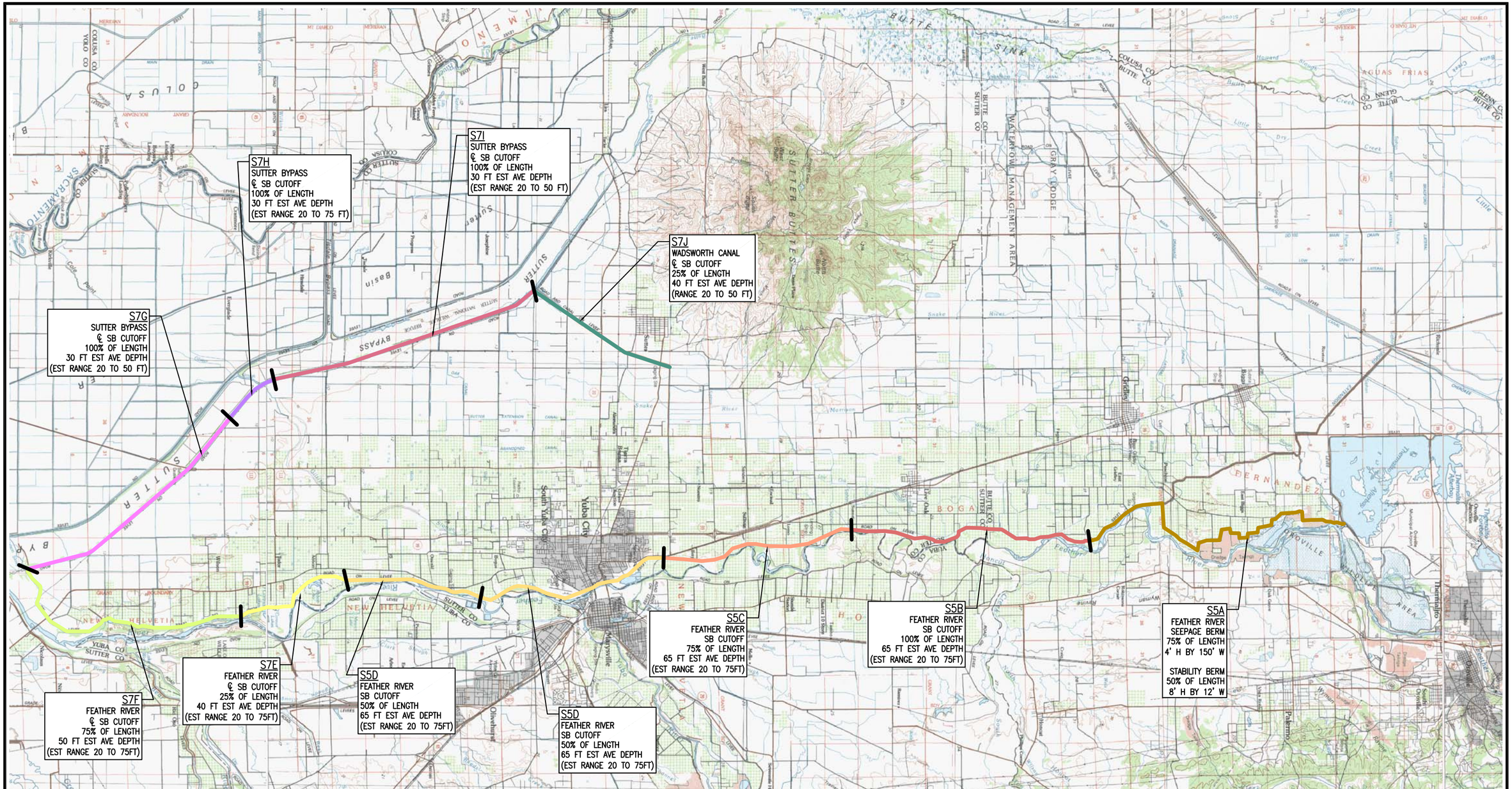
Table 2 Summary of Recommendations for Segments of Ring Levees, Setback Levees, and Bypass Levees							
Structural Element	Name	PLM	PLM	Feature	% Length	Depth/Height	Width
S9I	Sutter Bypass Setback	N/A	N/A	SB CL Cutoff wall	25	35 ft (20 to 50)	N/A
S9H	Sutter Bypass Setback	N/A	N/A	SB CL Cutoff wall	25	35 ft (20 to 50)	N/A
S9G	Sutter Bypass Setback	N/A	N/A	SB CL Cutoff wall	25	35 ft (20 to 50)	N/A
S11	Sutter Bypass and Feather River Confluence Setback Levee	N/A	N/A	SB CL Cutoff wall	50	35 ft (20 to 50)	N/A
S12	Star Bend Setback	N/A	N/A	SB CL Cutoff wall	100	65 ft (30 to 70)	N/A
S4-SOUTH **S6-SOUTH**	Yuba City J-Levee	N/A	N/A	SB CL Cutoff wall	34	35 ft (20 to 60)	N/A
S4-WEST **S6-WEST**	Yuba City J-Levee	N/A	N/A	SB CL Cutoff wall	34	35 ft (20 to 60)	N/A
S6-WEST-UPPER	Yuba City J-Levee	N/A	N/A	SB CL Cutoff wall	34	35 ft (20 to 60)	N/A
S4-NORTH	Yuba City J-Levee	N/A	N/A	SB CL Cutoff wall	34	35 ft (20 to 60)	N/A
S10	Northern Feather River Setback Levee	N/A	N/A	SB CL Cutoff wall	100	75 ft (20 to 50)	N/A

TABLE 3, Levee Geometrical and O&M Requirements for New Levees										
Levee Height	Landside O&M	Landside Slope	Landside Length	Landside Height	Crest Width	Waterside Slope	Waterside Length	Waterside Height	Waterside O&M	Corridor
3 ft	20 ft	1V:3H	9 ft	3 ft	20 ft	1V:3H	9 ft	3 ft	15 ft	73 ft
5 ft	20 ft	1V:3H	15 ft	5 ft	20 ft	1V:3H	15 ft	5 ft	15 ft	85 ft
7 ft	20 ft	1V:3H	21 ft	7 ft	20 ft	1V:3H	21 ft	7 ft	15 ft	97 ft
9 ft	20 ft	1V:3H	27 ft	9 ft	20 ft	1V:3H	27 ft	9 ft	15 ft	109 ft
11 ft	20 ft	1V:3H	33 ft	11 ft	20 ft	1V:3H	33 ft	11 ft	15 ft	121 ft
13 ft	20 ft	1V:3H	39 ft	13 ft	20 ft	1V:3H	39 ft	13 ft	15 ft	133 ft
15 ft	20 ft	1V:3H	45 ft	15 ft	20 ft	1V:3H	45 ft	15 ft	15 ft	145 ft
17 ft	20 ft	1V:3H	51 ft	17 ft	20 ft	1V:3H	51 ft	17 ft	15 ft	157 ft
19 ft	20 ft	1V:3H	57 ft	19 ft	20 ft	1V:3H	57 ft	19 ft	15 ft	169 ft
21 ft	20 ft	1V:3H	63 ft	21 ft	20 ft	1V:3H	63 ft	21 ft	15 ft	181 ft
23 ft	20 ft	1V:3H	69 ft	23 ft	20 ft	1V:3H	69 ft	23 ft	15 ft	193 ft
25 ft	20 ft	1V:3H	75 ft	25 ft	20 ft	1V:3H	75 ft	25 ft	15 ft	205 ft
27 ft	20 ft	1V:3H	81 ft	27 ft	20 ft	1V:3H	81 ft	27 ft	15 ft	217 ft
29 ft	20 ft	1V:3H	87 ft	29 ft	20 ft	1V:3H	87 ft	29 ft	15 ft	229 ft
31 ft	20 ft	1V:3H	93 ft	31 ft	20 ft	1V:3H	93 ft	31 ft	15 ft	241 ft



PLATES

MAP PLATES



SUTTER BASIN

STUDY MAP SHOWING GEOTECHNICAL RECOMMENDATIONS BY REACH FOR FIX-IN-PLACE MEASURES

MEASURE NAMING CONVENTION
S = STRUCTURAL MEASURE
5, 7, ETC = DESIGNATION INDICATING ASSOCIATED ALTERNATIVE
H, G, I = GEOTECHNICAL FIX-IN-PLACE REACH DESIGNATION

SCALE IN FEET
0 7500 15000 30000

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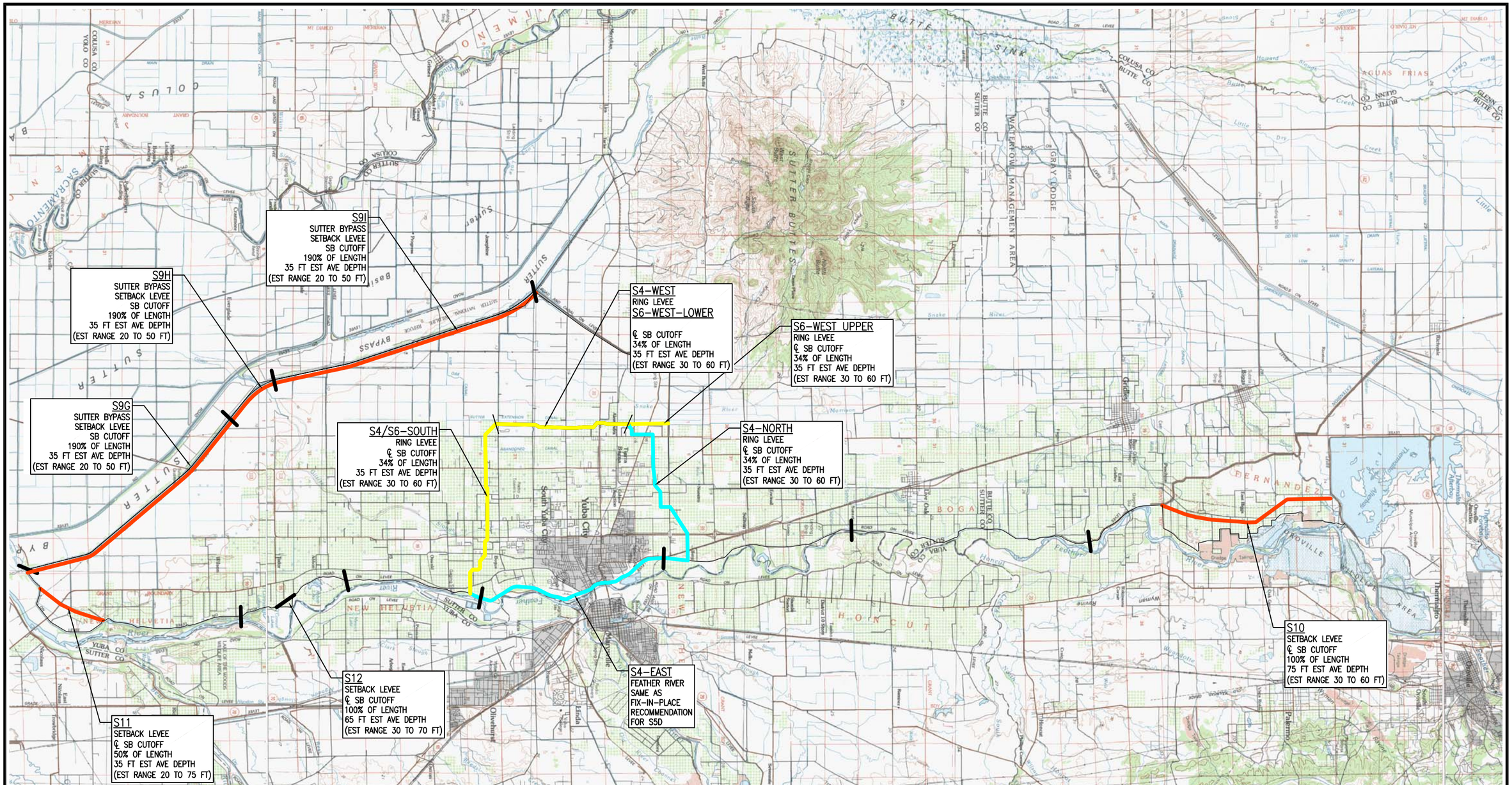
SACRAMENTO, CALIFORNIA

SUTTER AND BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
TECHNICAL MEMORANDUM FOR ALTERNATIVE EVALUATION

GEOTECHNICAL RECOMMENDATIONS FOR FIX-IN-PLACE MEASURES

DATE:	SCALE:	
5/30/12	1" = 15000'	MAP 1



SUTTER BASIN

STUDY MAP SHOWING GEOTECHNICAL RECOMMENDATIONS BY REACH FOR RING, SETBACK, AND BYPASS MEASURES

MEASURE NAMING CONVENTION
S = STRUCTURAL MEASURE
5, 7, ETC = DESIGNATION INDICATING ASSOCIATED ALTERNATIVE
H, G, I = GEOTECHNICAL FIX-IN-PLACE REACH DESIGNATION

SCALE IN FEET
0 7500 15000 30000

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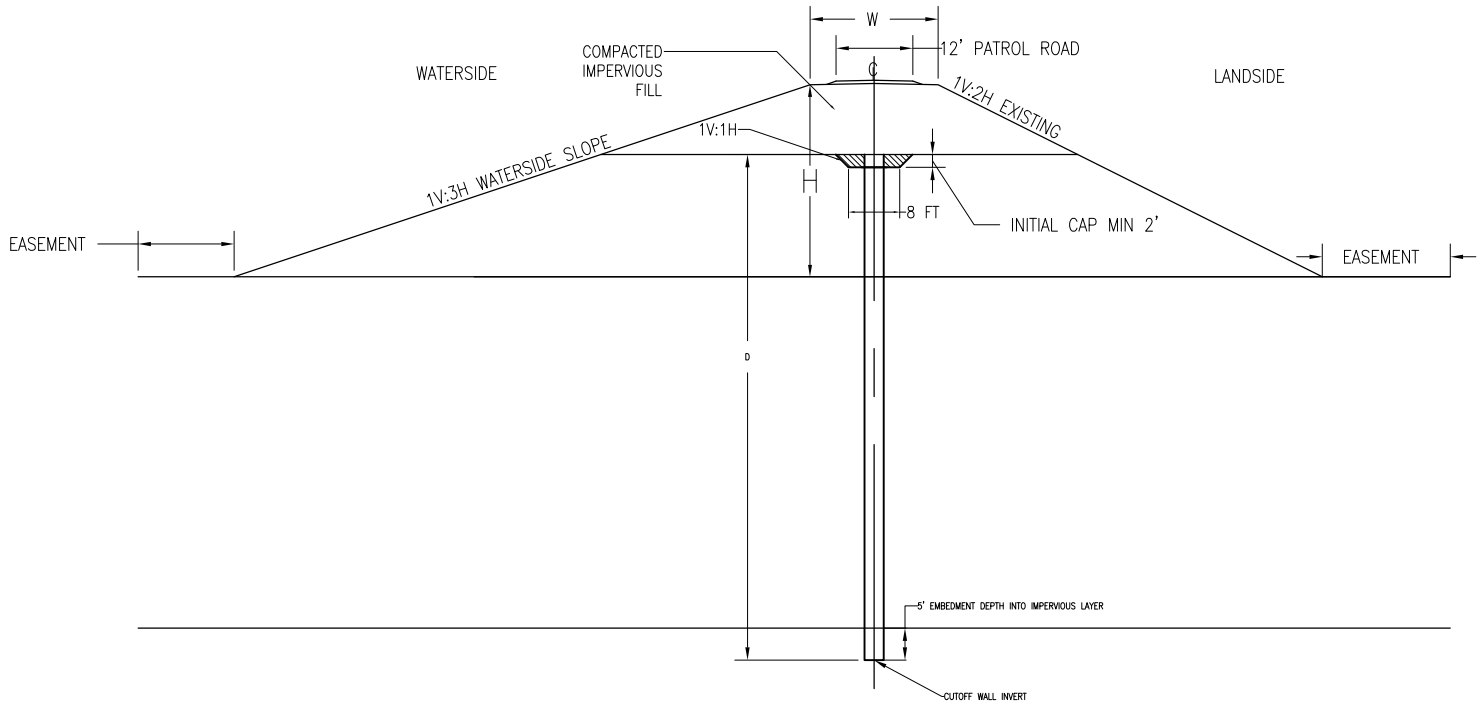
SUTTER FEASIBILITY STUDY
TECHNICAL MEMORANDUM FOR ALTERNATIVE EVALUATION

GEOTECHNICAL RECOMMENDATIONS
RING, SETBACK AND BYPASS ALTERNATIVES

DATE:	SCALE:	
5/30/12	1" = 15000'	MAP 2

TYPICAL DETAIL PLATES

TYPICAL LEVEE DETAILING-EXISTING LEVEE.dwg PLOT 1=30 EWJ 5/30/12



SUTTER BASIN

LEVEE REHABILITATION WITH CENTERLINE
SOIL-BENTONITE CUTOFF WALL
SLURRY METHOD

PARAMETERS:
D, CUTOFF DEPTH
H, LEVEE HEIGHT
H1, DEGRADE HEIGHT

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SUTTER BASIN
GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM

LEVEE REMEDIATION MEASURES
SB SLURRY METHOD CUTOFF WALL
TYPICAL SECTION

DATE:	SCALE:	
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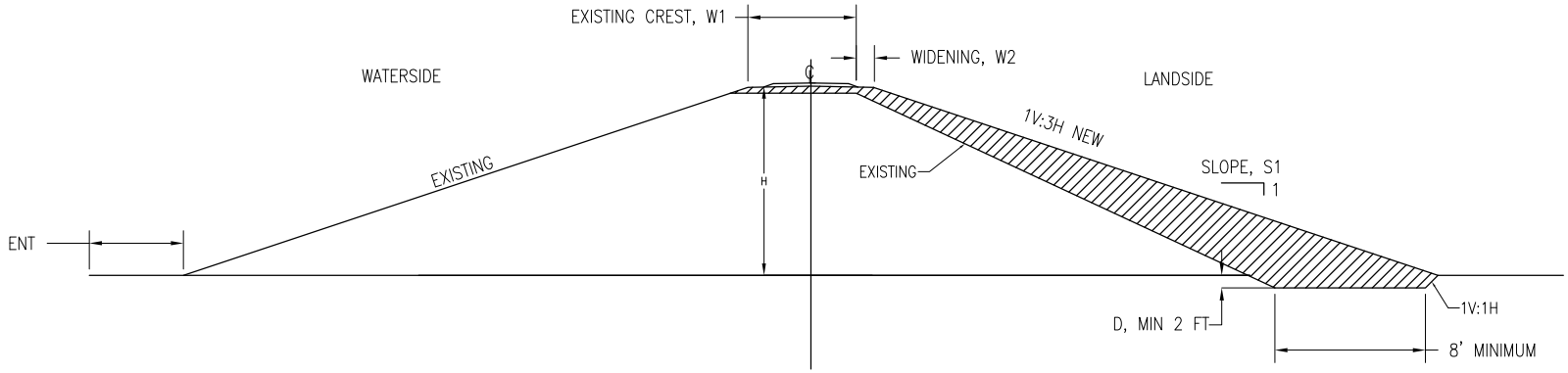
TYPICAL LEVEE DETAILING–EXISTING LEVEE.dwg PLOT 1=30 EWJ 5/30/12



SUTTER BASIN

LEVEE REHABILITATION
WIDENING AND SLOPE MODIFICATIONS

PARAMETERS:
D, KEY DEPTH
H, LEVEE HEIGHT
W1 EXISTING CREST WIDTH
W2, ADDITIONAL CREST
S1, SLOPE RUN PER 1' RISE

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SUTTER BASIN
GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM

LEVEE REMEDIATION MEASURES
WIDENING AND SLOPE MODIFICATIONS
TYPICAL SECTION

DATE:	SCALE:	
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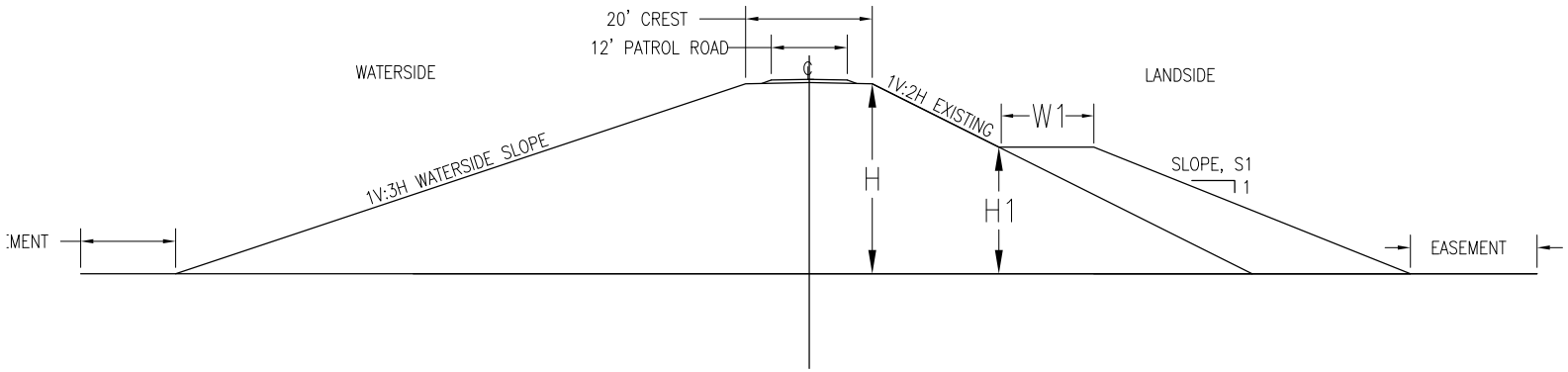
TYPICAL LEVEE DETAILING–EXISTING LEVEE.dwg PLOT 1=30 EWJ 5/30/12



SUTTER BASIN

LEVEE REHABILITATION WITH LANDSIDE STABILITY BERM

PARAMETERS:

H, LEVEE HEIGHT
H1, BERM HEIGHT
W1, BERM WIDTH
S1, SLOPE RUN PER 1' RISE

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GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM

LEVEE REMEDIATION MEASURES
STABILITY BERM
TYPICAL SECTION

DATE:	SCALE:	
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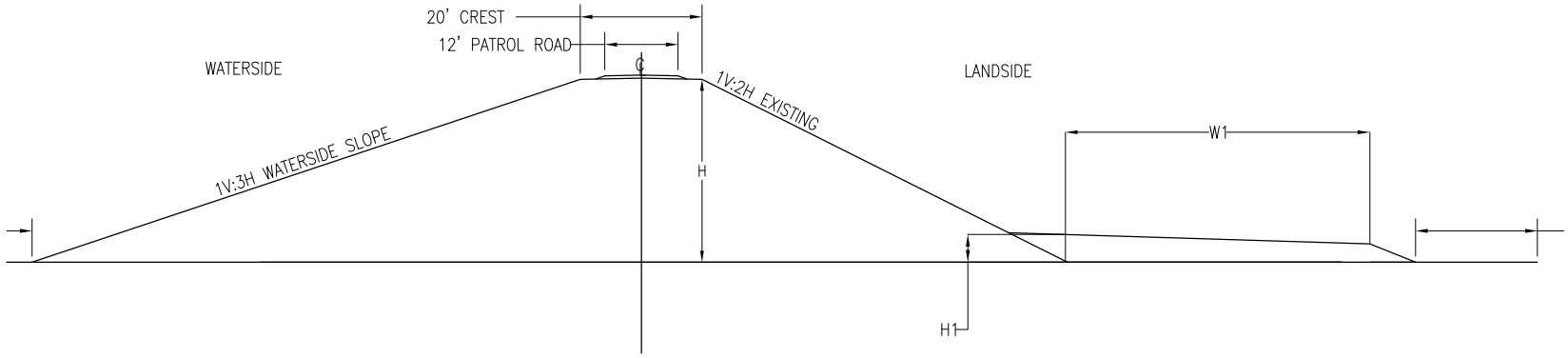

SUTTER BASIN

LEVEE REHABILITATION WITH SEEPAGE BERM

PARAMETERS:
H1, BERM HEIGHT
H2, BERM WIDTH
H, LEVEE HEIGHT

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SUTTER BASIN
GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM

LEVEE REMEDIATION MEASURES
SEEPAGE BERM
TYPICAL SECTION

DATE:	SCALE:	
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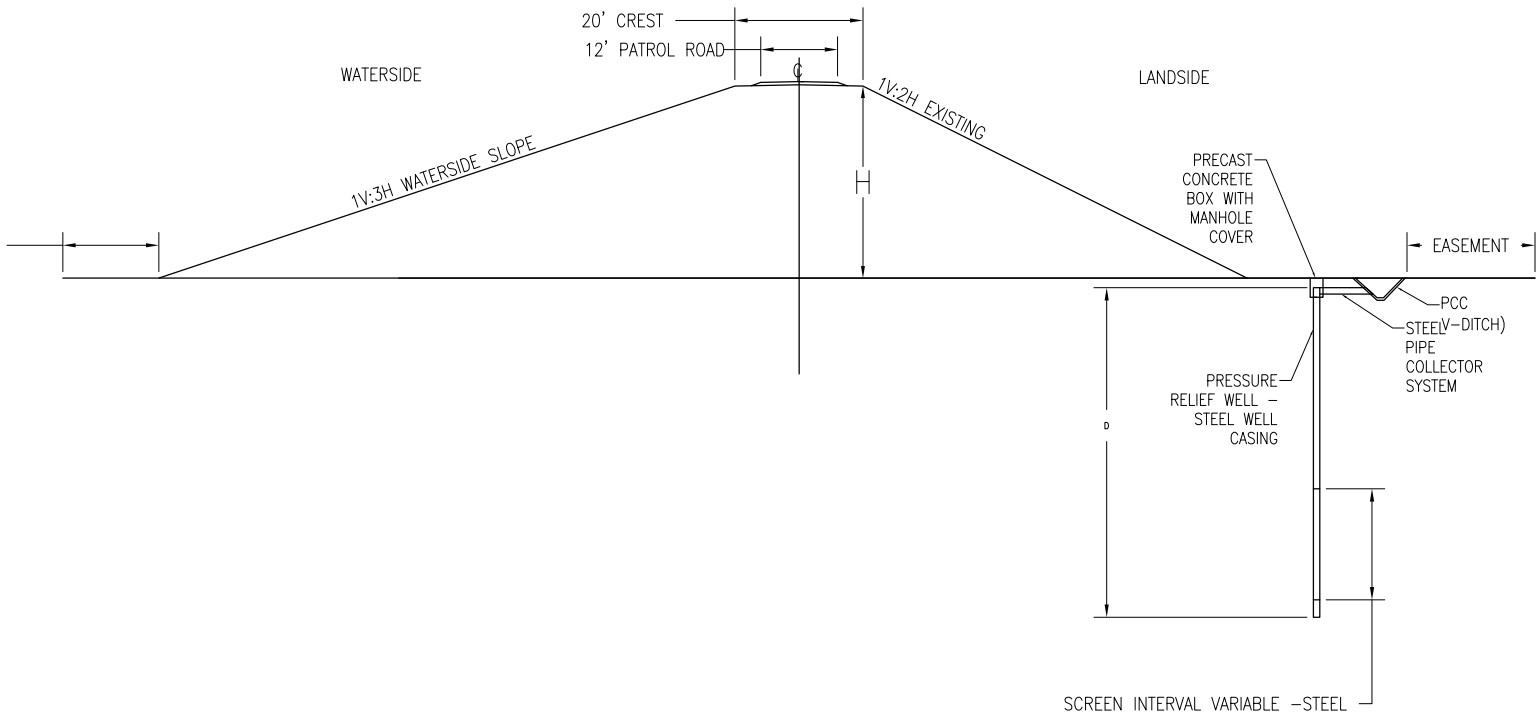
TYPICAL LEVEE DETAILING–EXISTING LEVEE.dwg PLOT 1=30 EWJ 5/30/12



SUTTER BASIN

LEVEE REHABILITATION WITH PRESSURE RELIEF WELLS AND COLLECTOR SYSTEM

PARAMETERS:
D, WELL DEPTH
H, LEVEE HEIGHT

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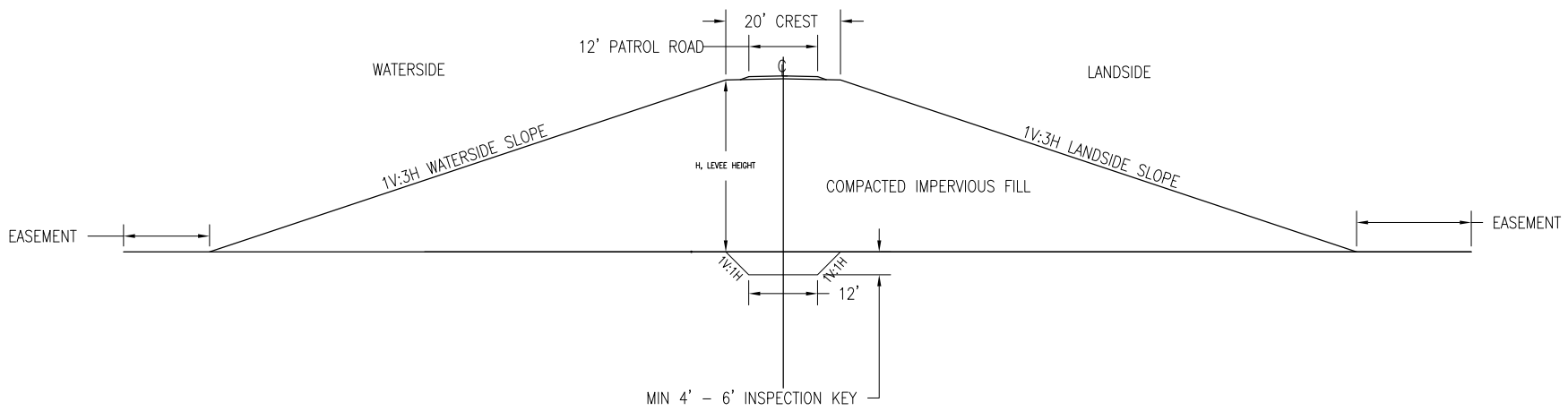
SUTTER AND BUTTE COUNTY — CALIFORNIA

SUTTER BASIN
GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM

LEVEE REMEDIATION MEASURES
PRESSURE RELIEF WELLS
TYPICAL SECTION

DATE:	SCALE:	
5/30/12	NO SCALE	TYP 5

TYPICAL DETAILING-NEW LEVEE.dwg PLOT 1=30 EWJ 5/30/12



SUTTER BASIN

NEW LEVEE – NO SEEPAGE CONTROL

PARAMETERS:
H, LEVEE HEIGHT

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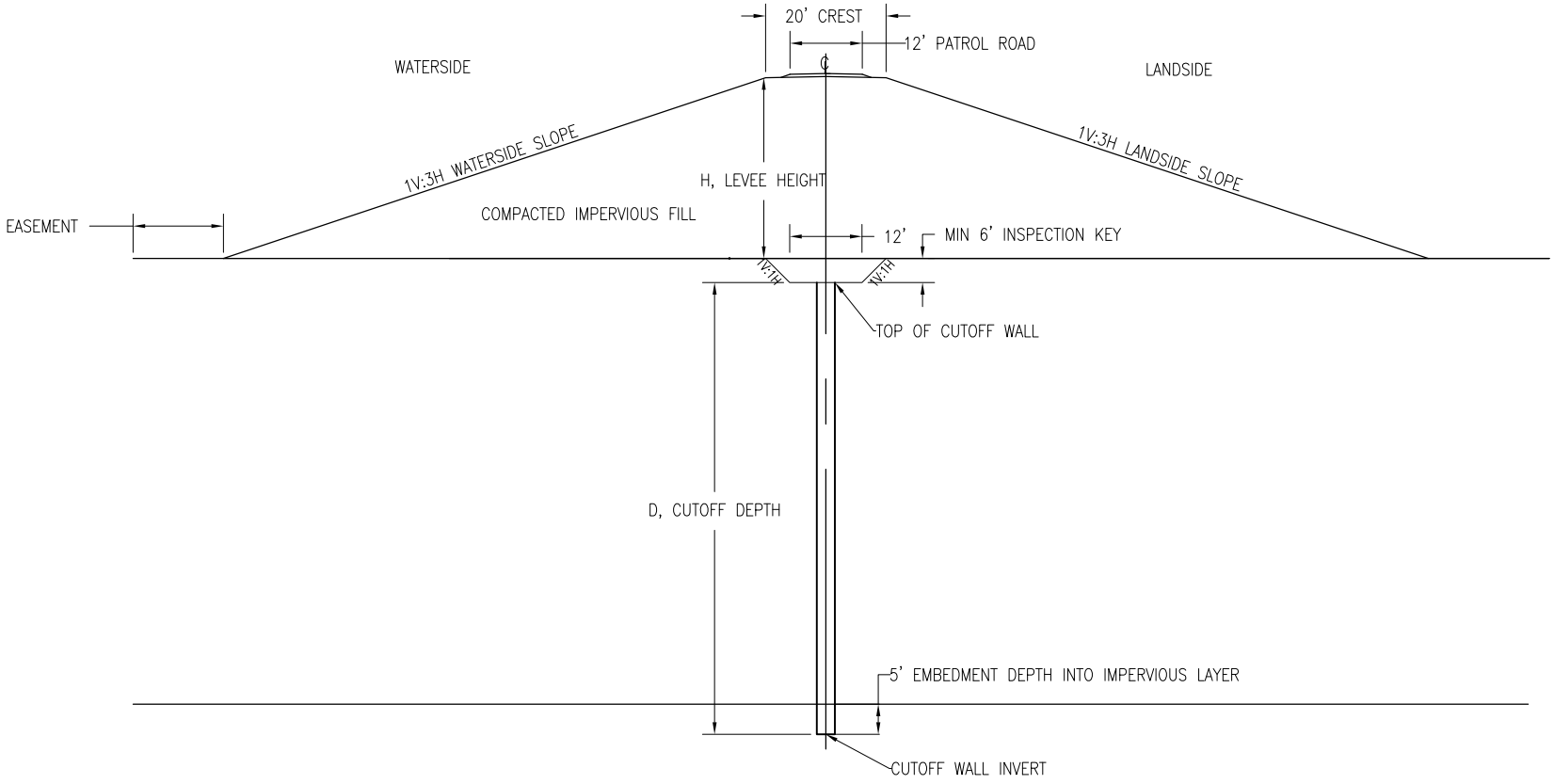
SUTTER ABD BUTTE COUNTIES CALIFORNIA

SUTTER BASIN
GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM

NEW LEVEE CONSTRUCTION
NO SEEPAGE CONTROL
TYPICAL SECTION

DATE:	SCALE:	
5/30/12	NO SCALE	TYP 6

TYPICAL DETAILING–NEW LEVEE.dwg PLOT 1=30 EWJ 5/30/12



SUTTER BASIN

NEW LEVEE – SOIL–BENTONTITE SLURRY WALL

PARAMETERS:
D, WELL DEPTH
H, LEVEE HEIGHT

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SACRAMENTO, CALIFORNIA

SUTTER ABD BUTTE COUNTIES — CALIFORNIA

SUTTER BASIN
GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM

NEW LEVEE CONSTRUCTION
SOIL–BENTONITE SLURRY WALL
TYPICAL SECTION

DATE:	SCALE:	
5/30/12	NO SCALE	TYP 7

ENCLOSURE I

VEGETATION ETL COMPLIANCE MEMORANDUM

CESPK-PD-R **15 June 2012**
Revised 24 February 2013

MEMORANDUM FOR FILE: Sutter Basin Pilot Feasibility Study

SUBJECT: Compliance with ETL 1110-2-571

1. REFERENCES

a. Engineering and Design: Guidelines for landscape planting and vegetation management at levees, floodwalls, embankment dams, and appurtenant structures. Engineer Technical Letter (ETL), April 10, 2009.
b. White paper, Sutter Basin Pilot Feasibility Study, Engineer Technical Letter 1110-2-251 Compliance, dated 8 February 2013.
c. Feather River Sutter Basin Protection Area Periodic Inspection January 2010, Report No. 1.
d. Memorandum for Record. Sutter Feasibility Study – Summary of vegetation concerns impacting Sutter Project identified in the Periodic Inspection, dated August 9, 2012.
e. Process for Requesting Variance from Vegetation Standards for Levees and Floodwalls, Federal Register Notice (Friday, February 17, 2012).
f. Sutter Basin Feasibility Study, Future-Without Project Conditions Report, December 2011.
g. Corps Memorandum, Reconstruction of U.S. Army Corps of Engineers Structural Flood Damage Reduction Projects for which Non-Federal Interests are Responsible for Operation, Maintenance, Repair, Rehabilitation and Replacement, August 16, 2005.
h. Pre-Design Formulation Report, Feather River West Levee Project, Sutter-Butte Flood Control Agency, August 2011.

2. PURPOSE

The purpose of this memorandum is to assess the extent of vegetation that is in non compliance with ETL 1110-2-571 (Reference a), to assess the magnitude of the mitigation that might be required, and to identify potential strategies in dealing with this issue. For the study alternatives, impact scale, study risk, and ETL variance and ETL mitigation costs are also identified.

3. BACKGROUND

USACE Vegetation Management.

USACE Engineer Technical Letter 1110-2-571, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures*, dated 10 April 2009, provides guidance for maintenance of said structures in order to maintain the authorized level of flood risk management. The ETL mandates

USACE will maintain a "vegetation free zone" (VFZ), a three dimensional zone surrounding all levees, floodwalls, embankment dams, and critical appurtenant structures in all flood damage reduction systems (shown below). The purpose of the vegetation-free-zone is to provide a reliable corridor of access to and along federally authorized and constructed flood risk management features for surveillance, inspection, maintenance, monitoring, and flood-fighting.

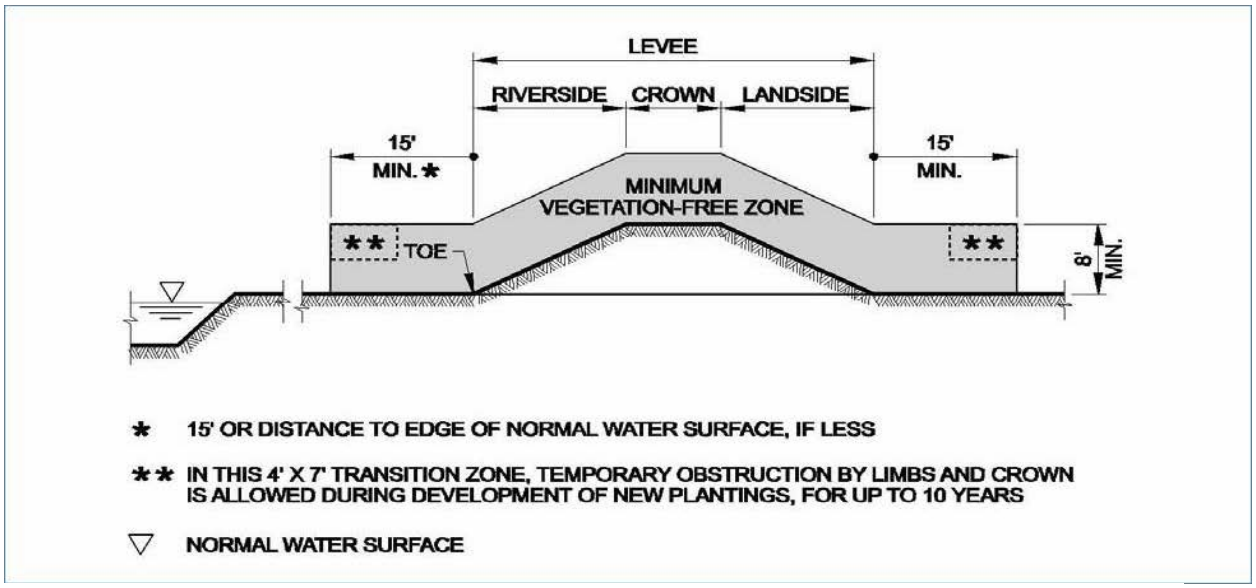

Illustration from Chapter 6, Engineering Technical Letter 1110-2-571, dated 10 April 2009

Existing Project OMRR&R Requirements.

The following description of existing OMRR&R was excerpted from Reference b.

The Sutter study area is fully contained with the Sacramento River Flood Control Project (SRFCP). The SRFCP OMRR&R requirements are contained within a standard manual for the entire SRFCP with supplements outlining more detailed requirements for each Unit within the project. The standard manual has been in place since 1955. In 1949, Headquarters U.S. Army Corps of Engineers approved a deviation from the vegetation standards in effect at the time. The sponsor is required to comply with the following vegetation standards contained within the standard manual for the SRFCP. "The Superintendent shall provide at all times such maintenance as may be required to insure serviceability of the structure at the time of floods. Measures shall be taken to exterminate burrowing animals and provide for clearing of brush, trees, and other wild growth from the levee crown and slopes. Brush and small trees may be retained on the waterward slope where desirable for the prevention of erosion and wave wash. Where practicable, measures shall be taken to retard bank erosion by the planting of willows or other suitable growths on areas riverward of the levees." In addition, each supplement applicable to the Sutter study

area may have more detailed vegetation maintenance standards. Project sponsors for completed levee projects are responsible for OMRR&R of the completed project as provided in the O&M manuals. Issuance of the ETL setting forth new or clarified vegetation and access standards for levee projects does not alter the project O&M requirements and responsibilities. Inspections are conducted to document whether the sponsor is fulfilling their OMRR&R obligations as outlined in the O&M manual and inspection checklist and to determine if continued PL 84-99 rehabilitation assistance is warranted based on the outcome of those inspections. Sponsors receiving an unacceptable inspection rating may choose to pursue a conditional extension to PL 84-99 rehabilitation program eligibility by using a System Wide Improvement Framework (SWIF) as outlined in 29 November 2011 policy subject: Policy for Development and Implementation of System-Wide Improvement Frameworks.

Periodic Inspection Report.

In January 2010, an Inspection of Completed Works (ICW) periodic inspection (PI) (Reference c) was completed of the project levees surrounding the study area (Cherokee canal was not included as is addressed in a separate report). The PI evaluated nine segments and rated seven levee segments as unacceptable and two segments as minimally acceptable due to a number of deficiencies, including vegetative growth. Figure 1 identifies the segments and responsible maintaining entities. The PI report stated that "unwanted vegetative growth" along with other issues "would not prevent the system from performing as intended during the next flood event."

4. EXISTING NONCOMPLIANT VEGETATION

Identification of noncompliant vegetation was determined based on two sources:

- 2010 Periodic Inspection Report
- Vegetation Surveys conducted in 2012

2010 Periodic Inspection (PI) Report.

The PI conducted in 2010, collected GIS-based data on noncompliant vegetation (Reference c). The PI team gathered and recorded data electronically in the field using a GPS enabled tablet PC and GIS software. Vegetation points and lines represent incidents of non-compliance with ETL 1110-2-571. Separate tables were created for the Sutter Bypass, Wadsworth Canal, and Feather River West levees (Reference d). The tables present the data organized by levee mile for the Sutter Bypass and Wadsworth Canal levees, and by SBFCA sub reaches for the Feather River levees. Figure 2 shows the reaches of the Feather River West Levee, and the reaches of the Sutter Bypass and Wadsworth Canal. The non-compliant vegetation (as defined by ETL 1110-2-571) was categorized as being located on the upper third, middle third or lower third of the waterside

slope, the landside slope, the crest, the waterside 15-ft easement or landside 15-ft easement. The purpose of the categories was to breakdown the incidents by degree of criticality.

The violations that were observed were either stands of vegetation or single trees or shrubs. Other reports prepared by ICF for SBFCA's Feather River West Levee Project (FRWLP) were also reviewed to further confirm the extent of vegetation.

The PI evaluation of vegetation assumes that at least a 15-foot ROW exists at the levee waterside and landside toe for levee maintenance and access. In some areas, the preexisting real estate interest may be less than 15 feet. The existing operations and maintenance manual permits brush and small trees to be present.

Existing vegetation is summarized below for the Feather River West Levee, Sutter Bypass East Levee, and Wadsworth Canal South Levee. Noncompliant vegetation is most abundant along the Feather River West Levee. Table 1 lists the significant vegetation identified based on the maintenance entities shown in Figure 1.

The following is a summary of vegetation concerns identified from the PI (Reference c).

West Feather River Levee

The West Feather River levee has 95 and 93 vegetation incidents located on the landside and waterside easements, respectively; and 79 vegetation incidents on the levee crest and slopes. Of the 79 incidents on the levee itself, 41 of them are at critical locations on the crest, landside slope and upper third of the waterside slopes. These critical incidents are concentrated in Levee District (LD) 1 of Sutter County, LD 9 of Sutter County, and State Maintenance Area (MA) 7/Hamilton Bend. These areas of greater critical vegetation impact are located within areas of significant (high percentage of reach) seepage mitigation, where cutoff wall construction is likely.

As shown in Figure 3, all 41 reaches, except one (reach 6), of the Feather River west levee, had at least one incident of noncompliant vegetation found within the VFZ. The number of incidents varied considerably between reaches; reach 16 had the most with 25 incidents, and 19 of the 41 reaches (46%) had less than 2 incidents.

Sutter Bypass Levee

For the Sutter bypass, the results are shown in Figure 4. Compared to the Feather River West Levee there was significantly less vegetation and of smaller size (primarily willows) on or near the levees. Sutter Bypass, with 82 vegetation incidents, 61 of them located on the waterside easement and 21 located on the landside easement and spread out over 18 miles, does not have a significant vegetation compliance problem with respect to ETL 1110-2-571.

Wadsworth Canal

Wadsworth Canal, with three vegetation incidents, all located on the waterside or landside easement and spread over 6 miles, does not have a significant vegetation compliance problem with respect to ETL 1110-2-571.

Vegetation Surveys.

To assess impacts to vegetation from alternatives in the final array, vegetation surveys were conducted in 2012 to identify the location of vegetation on and near the existing levees. The data was collected using GIS. The surveys identified approximately 7,600 trees, including riparian trees, orchards, and nonnative or ornamental trees, in the biological study area (200-foot corridor along the levee alignment).

5. ENVIRONMENTAL REQUIREMENTS

In accordance with Council on Environmental Quality (CEQ) Regulations for Implementing NEPA (40 CFR 1500-1508), and with Appendix C, paragraph C-3 of ER 1105-2-100, "Policy and Planning Guidance for Conducting Civil Works Planning Studies (Planning Guidance Notebook)", the planning of Corps projects must ensure that project-related adverse environmental impacts (i.e., impacts to fish and wildlife resources) have been avoided or minimized to the extent practicable, and that remaining unavoidable significant adverse impacts are compensated to the extent justified. Corps regulations stipulate that the Recommended Plan must contain sufficient mitigation measures to ensure that the plan selected will have no more than negligible net adverse impacts on fish and wildlife resources. Furthermore, a Cost Effectiveness Incremental Cost Analysis must be performed to identify the most cost-effective mitigation plan.

As part of the feasibility study, mitigation costs for vegetation impacts will have to be determined and a mitigation plan developed using incremental cost analysis and the recommendations of the USFWS and other resource agencies. Under WRDA 2007, Section 2036(a) , the Corps must fully develop a mitigation plan that includes the following: 1) monitoring until successful, 2) criteria for determining ecological success, 3) a description of available lands for mitigation and the basis for the determination of availability, 4) the development of contingency plans (i.e., adaptive management), 5) identification of the entity responsible for monitoring; and 6) establishing a consultation process with appropriate Federal and State agencies in determining the success of mitigation.

Significant vegetation losses that justify mitigation would either be mitigated through a commercial mitigation bank and/or a mitigation site acquired in the project vicinity. Mitigation site(s) selected would be located waterward of the project levees along the Feather River on lands currently in agricultural production and that could be restored to riparian habitat. Mitigation plans would be designed to avoid a net change in stage discharge relationships.

In regards to tree protection ordinances or policies that could affect construction, Sutter County does not currently have any specific ordinances or programs (heritage tree program) that protect native oaks in the County. The City of Yuba City protects trees through implementation of general plan policies, and with specific ordinances for street trees. General Plan Policy 8.4-G-3 states that heritage oaks would be preserved and enhanced in the City. Policy 8.4-I-2 requires preservation of oak trees and other native trees that are of significant size, by requiring site designs to incorporate these trees to the maximum extent feasible (Reference e). Butte County also has no specific ordinances or programs and no general plan policies concerning tree protection.

6. DISCUSSION

ETL variance guidance (Reference c) states "New federally authorized cost shared levee projects shall be designed to meet the current vegetation management standards." It is expected that any potential levee project will be required to meet ETL 1110-2-571 requirements for congressional authorization and appropriation.

ETL Variance Procedure.

Corps guidance identifies the situations in which a Corps district may submit a vegetation variance request. Corps guidance defines a variance "as alternative vegetation management standards to be applied to a levee system or portion thereof that provide for the same levee functionality as intended in ETL 1110–2–571" (Reference c). Variances may only be granted to allow the preservation of waterside vegetation below the upper third of the waterside slope. Per the draft variance request procedure, no variance requests will be approved for noncompliant landside vegetation: "To ensure the ability to implement floodfighting activities, such as placement of sandbags or other temporary floodfight measures near the waterside crown, and to see areas of distress on the landside during a flood event, typically the upper third of the waterside slope, the crown, the landside slope, and within 15 feet of the landside toe (subject to preexisting real estate interest) of the levee needs to remain vegetation free, as defined in ETL 1110–2–571" (paragraph 9(d)).

During construction, existing vegetation would be removed adjacent to the riverward and landside toes by root plowing or clearing and grubbing to create the vegetation free zone. Since the landward side of the levee is currently maintained as an access road, very little woody vegetation exists. Following construction, disturbed soils including levee side slopes will be seeded with native grass seed to prevent wind and water erosion. A 15-foot-wide vegetation management zone along the riverward and landside toe of the levee will be permanently maintained to be devoid of trees and shrubs.

A variance request may be applicable because the subject levees are existing federally authorized levees in which the existing O&M manual allows vegetation within the VFZ. The existing O&M manual for the SRFCP states that "Brush and small trees may be retained on the waterward slope where desirable for the prevention of erosion and wave

wash. Where practicable, measures shall be taken to retard bank erosion by the planting of willows or other suitable growths on areas riverward of the levees."

Also per the variance guidance (Reference c), a vegetation variance can be considered if one of the following applies:

a. Comply with applicable law concerning the environment, cultural or historic preservation;
b. Protect the right of Tribal Nations, pursuant to treaty, statute, or Executive Order;
c. Address a unique environmental consideration; and/or
d. Prior vegetation agreement in place.

Criteria (a), (c), and (d) may be an appropriate basis to consider a variance to retain vegetation. However, the guidance states that "even if one of the above criteria is met, life safety is still paramount and the vegetation variance must assure that the structural integrity and functionality of the levee are retained." The levee must still be accessible for maintenance, periodic inspection, monitoring during flood events, and access to perform flood-fighting if required. Because the application process, analysis and review time will be both lengthy and costly, a variance request should be considered in the preconstruction engineering and design phase.

6. ETL COMPLIANCE SCENARIOS

For the evaluation of initial alternatives, two scenarios or strategies were identified to address the ETL compliance issue for fix in place levee alternatives. The two scenarios provide for the full disclosure of environmental effects to vegetation from the extreme of: (1) removal of all (landside and waterside) levee vegetation, to the other extreme of (2) vegetation that is within the construction footprint that would be impacted by levee degrading and construction disturbance to construct the cutoff walls and/or seepage berms. The scale of impacts, the mitigation and variance costs, and the risk to the study was evaluated under each scenario for each alternative. The project alternatives are shown in Figures 5-11.

Scenario: Establish VFZ Per ETL. All vegetation, other than perennial grasses, would be removed from the levee slopes and out 15 feet from the waterside and landside levee toes (subject to preexisting real estate interest). Vegetation within the direct construction footprint will be removed.

a) Mitigation costs were estimated based on costs developed by SBFCA for the Feather River from Thermalito Afterbay to Star Bend (Reference h). The number of incidents for each alternative was compared to the SBFCA estimates, and used to develop an estimate of mitigation costs based on a ratio of incidents identified in the PI. The estimate assumes riparian habitat is mitigated at a ratio of 2 acres for each acre affected, using a mitigation bank cost of $100,000 to 140,000 per acre.

b) The study risk ranges from low to moderate risk depending on the amount of vegetation removal under each alternative. The associated risks are that a jeopardy opinion may be issued and that resource agency and public concerns could increase project costs, or delay compliance with applicable environmental laws. However, these risks could be substantially reduced by development of mitigation plan with the resource agencies to compensate for the loss of vegetation.

Scenario: Variance Per ETL. Corps approval of a variance would be obtained either as part of the pilot study or during the Preconstruction-Engineering and Design (PED) phase. The variance would retain all vegetation outside the immediate construction footprint located on the lower two thirds of the waterside levee slope and out 15 feet from the waterside levee toe; all other levee vegetation would still be removed in accordance with Corps policy.

a) Substantial engineering analysis would be required to support a variance request and to determine what reaches would likely receive variance approval during PED. This analysis would at a minimum entail identification of the tree species, size, root ball size, scour potential if trees fall, increase in seepage gradient, reduction in stability factor of safety, and conclusions regarding rationale for variance approval.

b) Costs to conduct the engineering analyses to support a waterside variance are based on an assumed range of $10,000 to $30,000 per incident. Recent engineering analysis costs have varied significantly from $6,334 per site (PL84-99) to $162,500 per site (Natomas 408 ($1.3 million to evaluate 8 areas)).

c) The study risk ranges from low to moderate depending on the alternative. Alternatives with the most waterside vegetation retained by a variance would have the highest risk if a variance was not granted.

The two scenarios were applied to each of the study alternatives. The estimated costs and study risk are shown in Tables 2 and 3. As shown in Table 2 and 3, the assumed cost to obtain a variance for the alternatives ranges between about $220,000 (SB-3, Ring Levee) to $5.8 million (SB-6, Sutter Bypass) while the assumed mitigation cost of a VFZ is between $1.8 (SB-3 Ring Levee) to $20.9 million (SB-6, Sutter Bypass). The noncompliant vegetation located on the waterside of the levee could be retained if a variance was granted.

7. FINAL ARRAY OF ALTERNATIVES

The planning study evaluated the initial study alternatives based on FRM benefits and costs and determined a final array of alternatives. Alternatives SB-7 and SB-7 were carried forward to the final array. The GIS-based vegetation land cover survey data was then used to more accurately determine vegetation impacts and mitigation costs. Tables 4, 5, and 6 show the results for SB-7 and SB-8. Total mitigation costs are $4.32 million for SB-7, and $9.01 million for SB-8 (Table 6). SB-7 would impact 25.07 acres of riparian forest, 1.30 acres of oak woodland and cause the loss of 129 elderberry shrubs. SB-8 would impact 41.68 acres of riparian forest and scrub shrub, 6.7 acres of oak woodland, and cause the loss of 217 elderberry shrubs. Of the total estimated costs, VFZ requirements account for $1.73 million (40%) for SB-7 and $4.50 million (50%) for SB-8.

8. RECOMMENDED APPROACH

The following recommended approach follows the recommendations provided in Reference b.

a. Future without project condition will assume that project sponsors have maintained the levee in accordance with the O&M manual or that deficiencies in maintaining the levee to the requirements of the O&M manual are being or will be addressed in an approved SWIF(As of this writing, the sponsor has submitted a SWIF draft Letter of Intent).

b. With-project condition will include work, including required mitigation, necessary to comply with access and vegetation requirements of the ETL, including the full 15-foot access (O&M) corridor/vegetation free easement extending from the toe of the levee. Removal or an approved vegetation variance will be considered as being in compliance with the ETL. However, a vegetation variance will not be issued until the design phase of the project. For the feasibility study a vegetation variance will generally not be assumed.

c. For levee segments where a new levee alignment is being proposed (e.g. setback levee), the project as formulated will be in compliance with the ETL (vegetation and access) and all costs associated with ETL compliance will be project costs subject to cost sharing .

d. For levee segments where measures to strengthen existing levees are fix- in-place recommendations (e.g. slurry wall, berms) the following will apply:

    i. If local maintenance has been in compliance with the O&M manual (no deferred maintenance) then all costs associated with ETL compliance, including access of additional real estate interests as may be necessary, will be project costs subject to cost sharing.

ii. If local maintenance has not been in compliance with the O&M manual, project sponsors are responsible for achieving compliance with the O&M manual and required costs to do so are non-federal, non-project costs (Reference g). If a SWIF has been approved, the deferred maintenance may be accomplished in accordance with the terms of the SWIF except that deferred maintenance within the footprint of the new construction must be completed by the sponsors before construction or during construction by the government contractor.

e. During feasibility investigations sufficient information may not be available to distinguish between deferred maintenance costs and new costs to achieve ETL compliance; therefore for the feasibility effort all vegetation clearing and associated mitigation within the construction footprint will be assumed to be a project costs subject to cost sharing.

Matt Davis
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U.S. Army Corps of Engineers

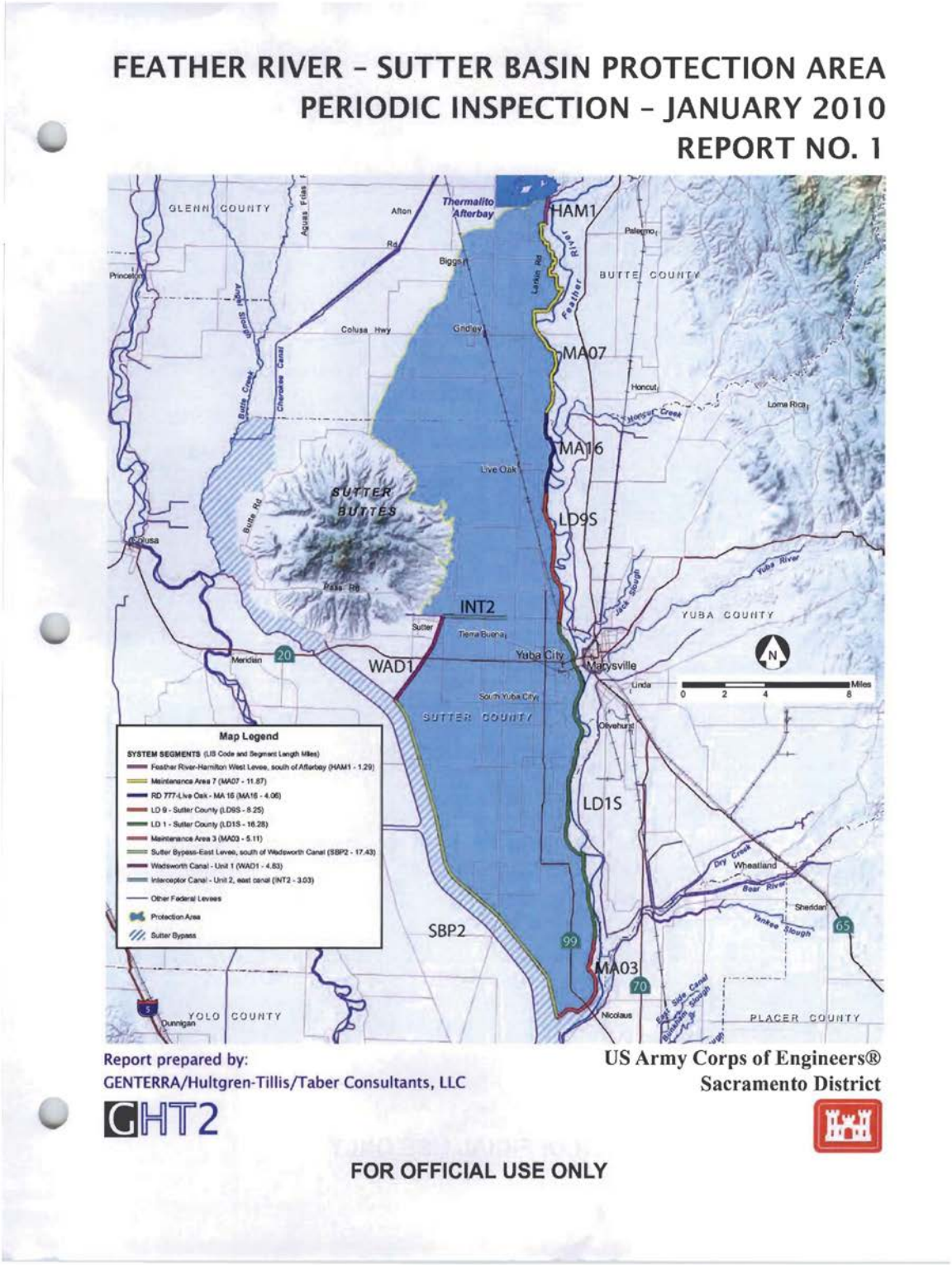

Figure 1. Segments and Responsible Maintaining Entities

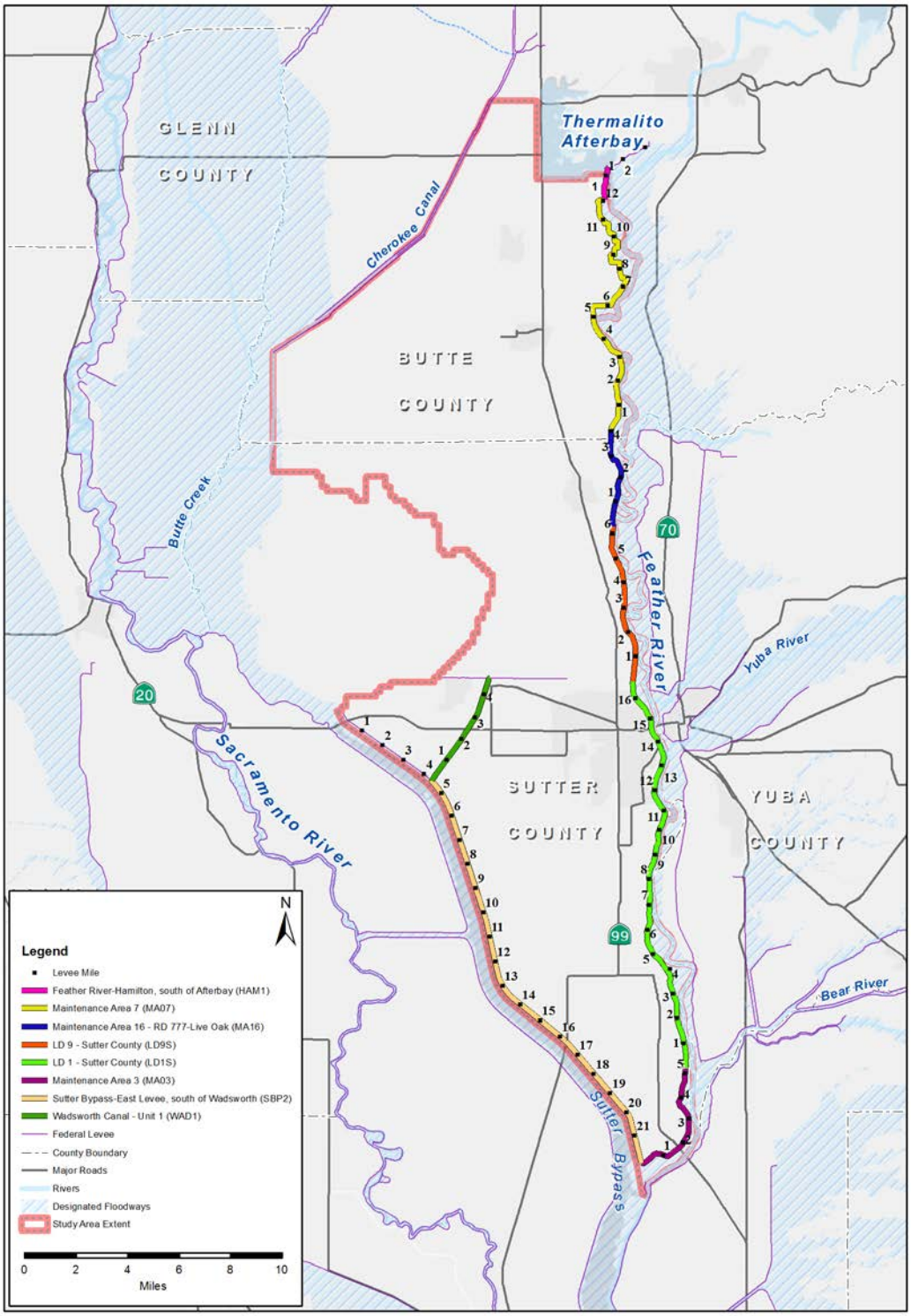

Figure 2. Feather River, Sutter Bypass, and Wadsworth Canal

Table 1. Sutter ETL Vegetation Inventory Summary

Feather River Afterbay
13 sites out of 18 with veg potentially not conforming to ETL
4 sites with large trees on crest (24”-30”)

LD1
36 sites out of 64 with potential ETL issues
1 site with 48" walnut in the landside toe
1 site with 72" cottonwood at WS toe
2 sites with 48" trees at the LS toe
6 sites with numerous unknown (30" & 48") at WS slope and 15' easement
8 sites with oaks (30" & 48)" at WS slope and 15' easement

LD9
5 sites out of 19 with potential ETL issues
1 site with 48" walnut in the landside toe
1 site with unknown 72"+ at WS slope and 15' easement
1 site with oaks 30" at WS slope and 15' easement

MA 3
9 sites out of 31 with potential ETL issues
3 sites with 30"-48"/7 total at WS slope and 15' easement
1 site with unknown 36" on LS easement over seepage berm
1 site with unknown 24" on LS toe

MA7
27 sites out of 76 with potential ETL issues
10 sites with 30"-60" (numerous unknown) at WS slope and 15' easement
14 sites with 30"-60" (numerous unknown) at LS easement

MA 16
14 sites out of 29 with potential ETL issues
4 sites with 30"-48" (numerous unknown) at WS slope and 15' easement
3 site with 30"-60" (numerous unknown) at LS easement

Sutter Bypass
21 sites out of 79 with potential ETL issues
26 sites with 24"-48" (numerous unknown) at WS slope and 15' easement
8 site with 24" (numerous unknown) at LS easement

Wadsworth Canal
2 sites out of 3 with potential ETL issues

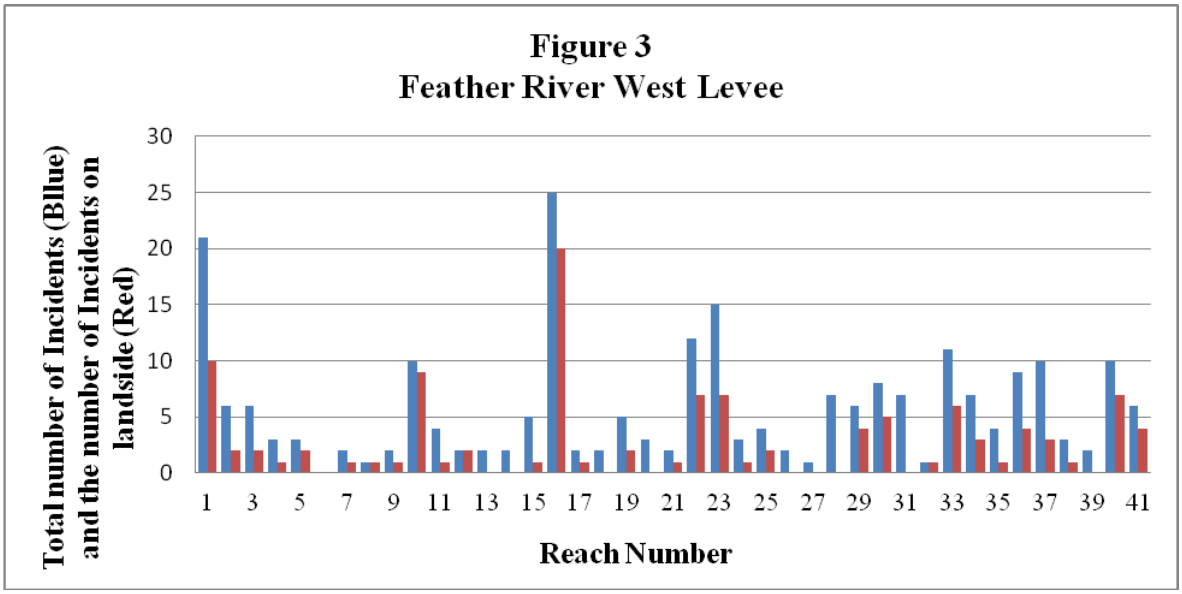
Figure 3
Feather River West Levee
Total number of Incidents (Blue) and the number of Incidents on landside (Red)
30
25
20
15
10
5
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41
Reach Number

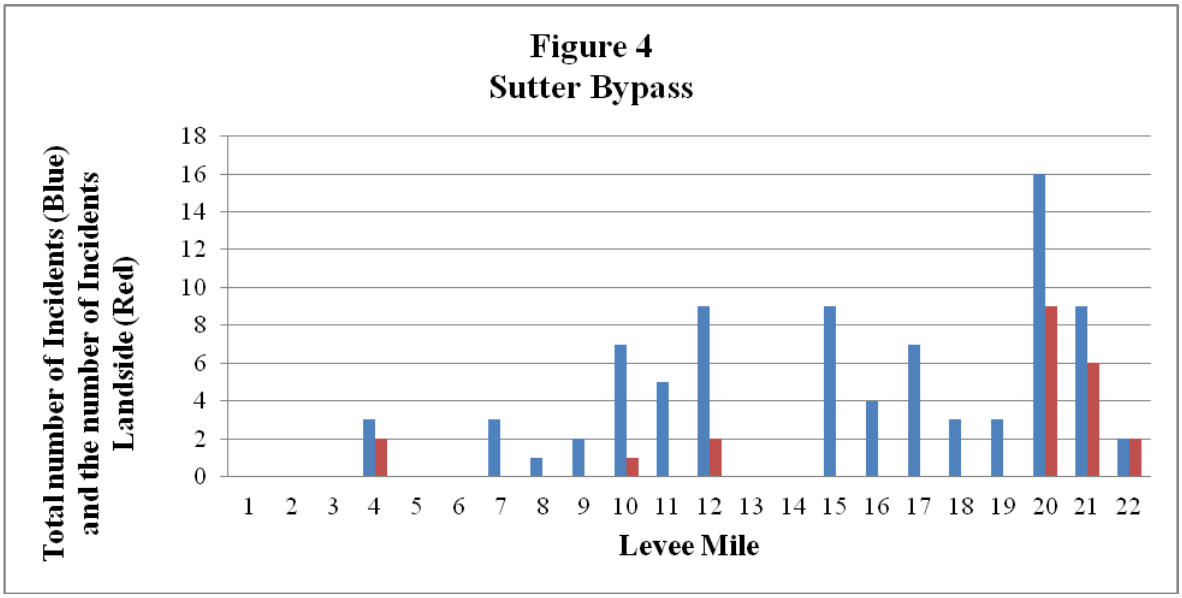
Figure 4
Sutter Bypass
Total number of Incidents (Blue) and the number of Incidents Landside (Red)
18
16
14
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Levee Mile

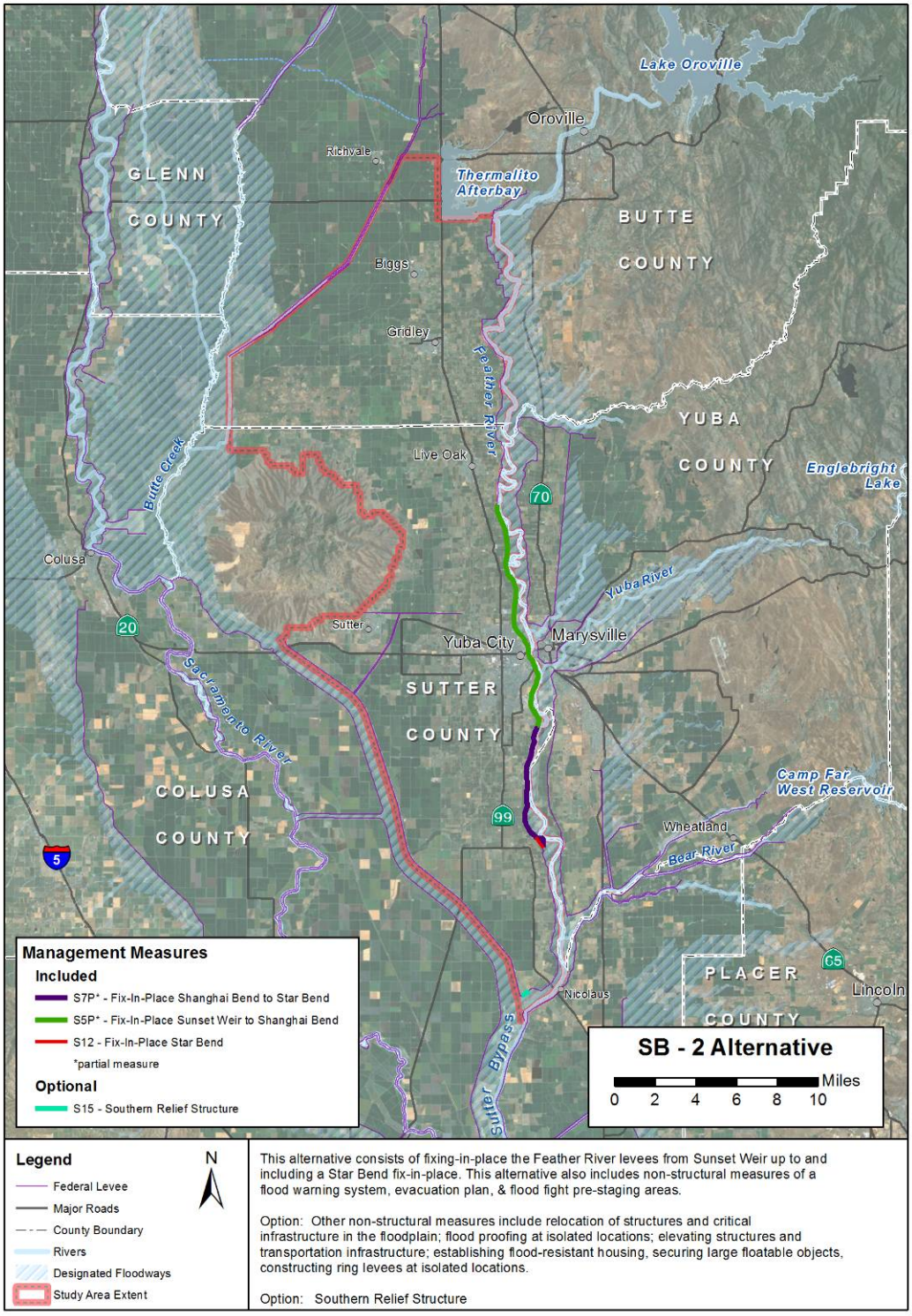

Figure 5. SB – 2 Alternative

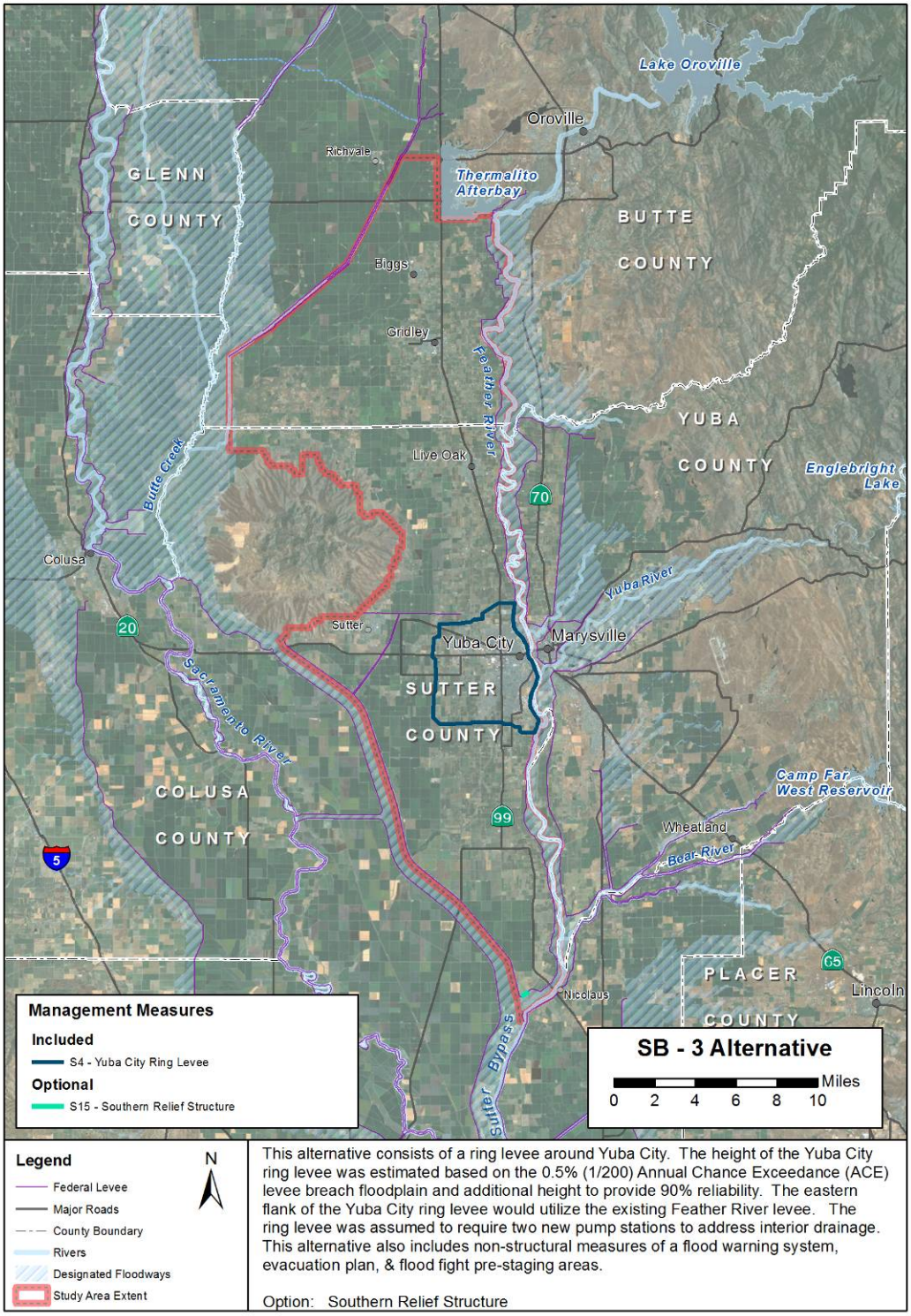

Figure 6. SB – 3 Alternative

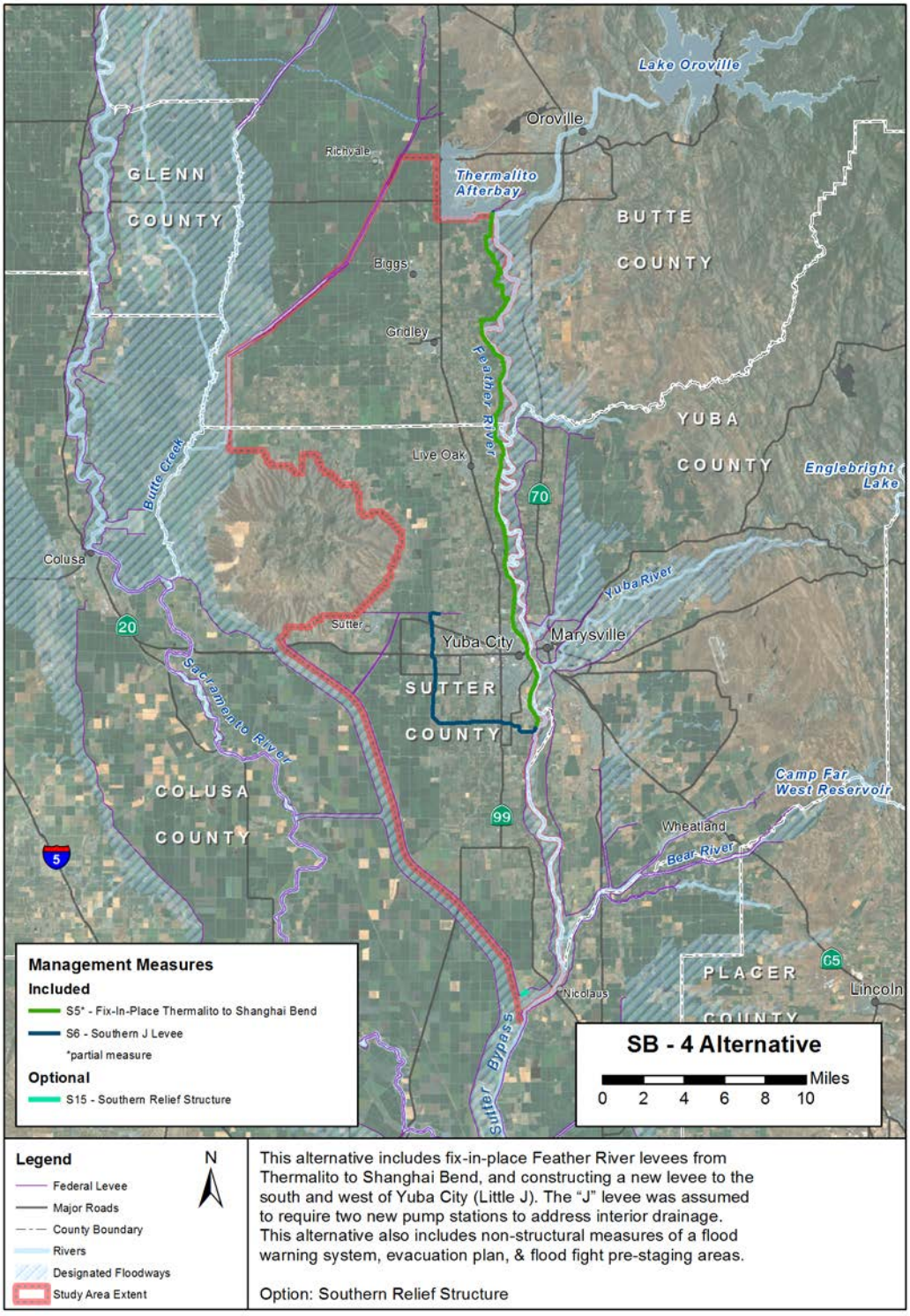

Figure 7. SB – 4 Alternative

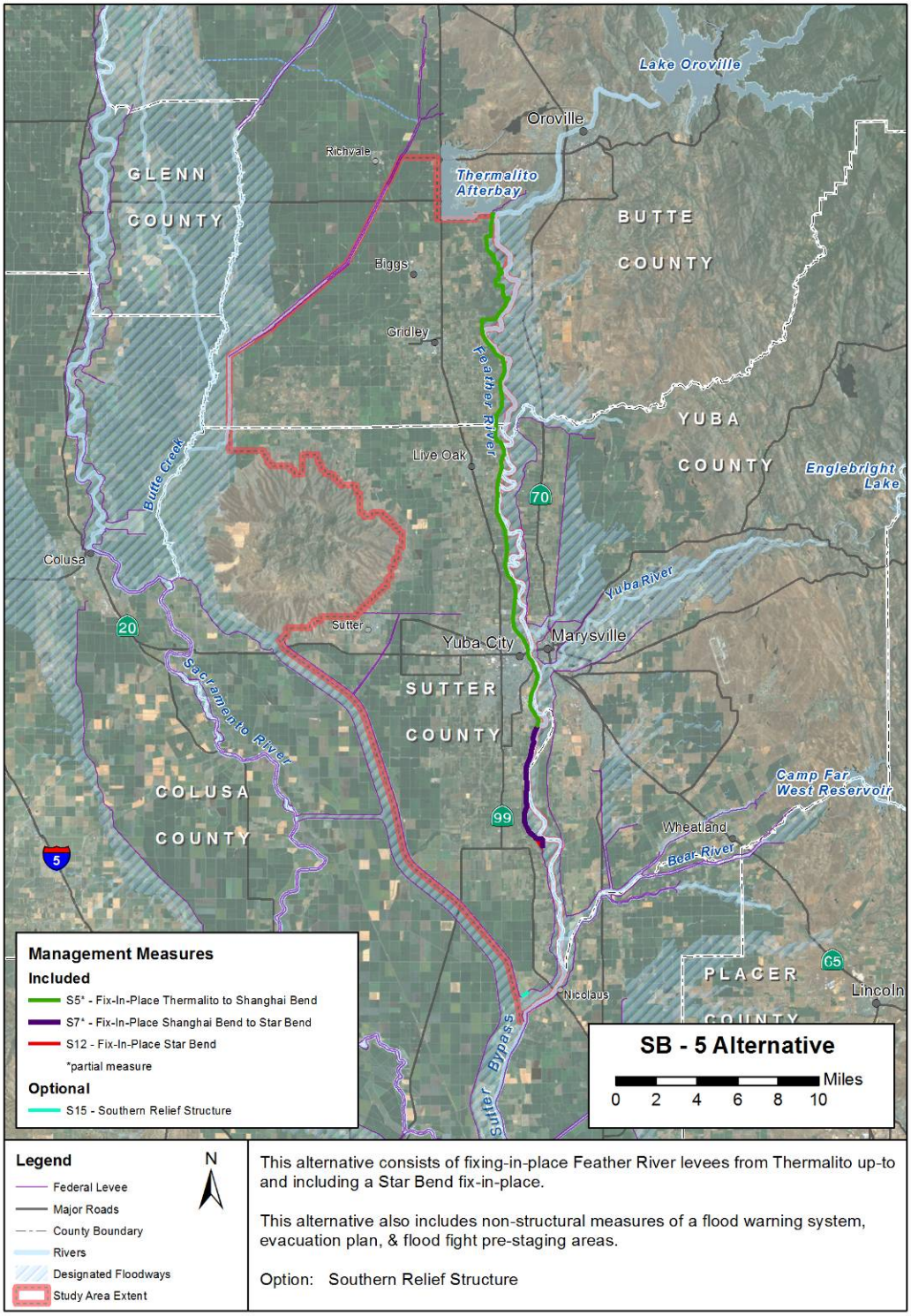

Figure 8. SB 5 Alternative

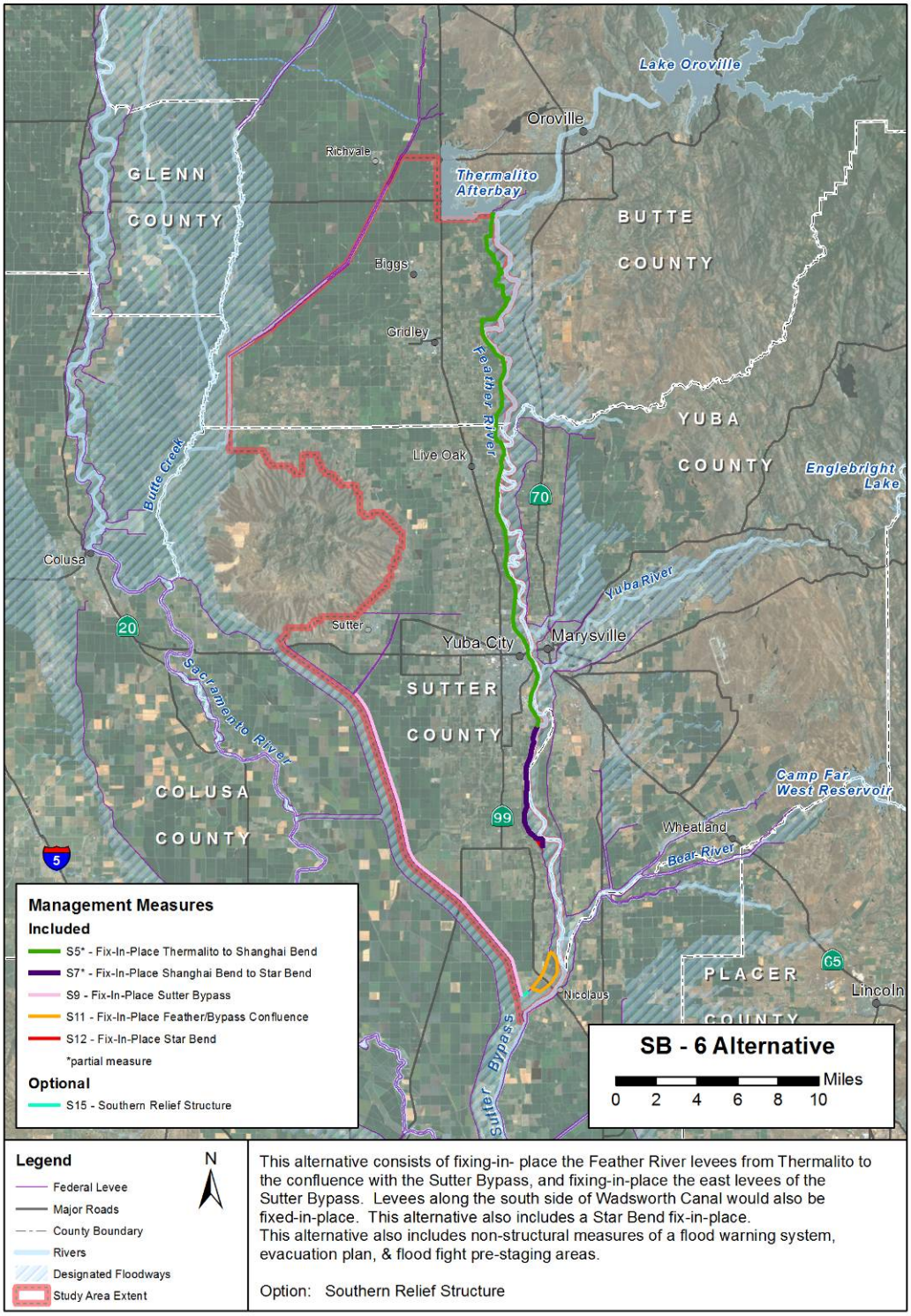

Figure 9. SB – 6 Alternative

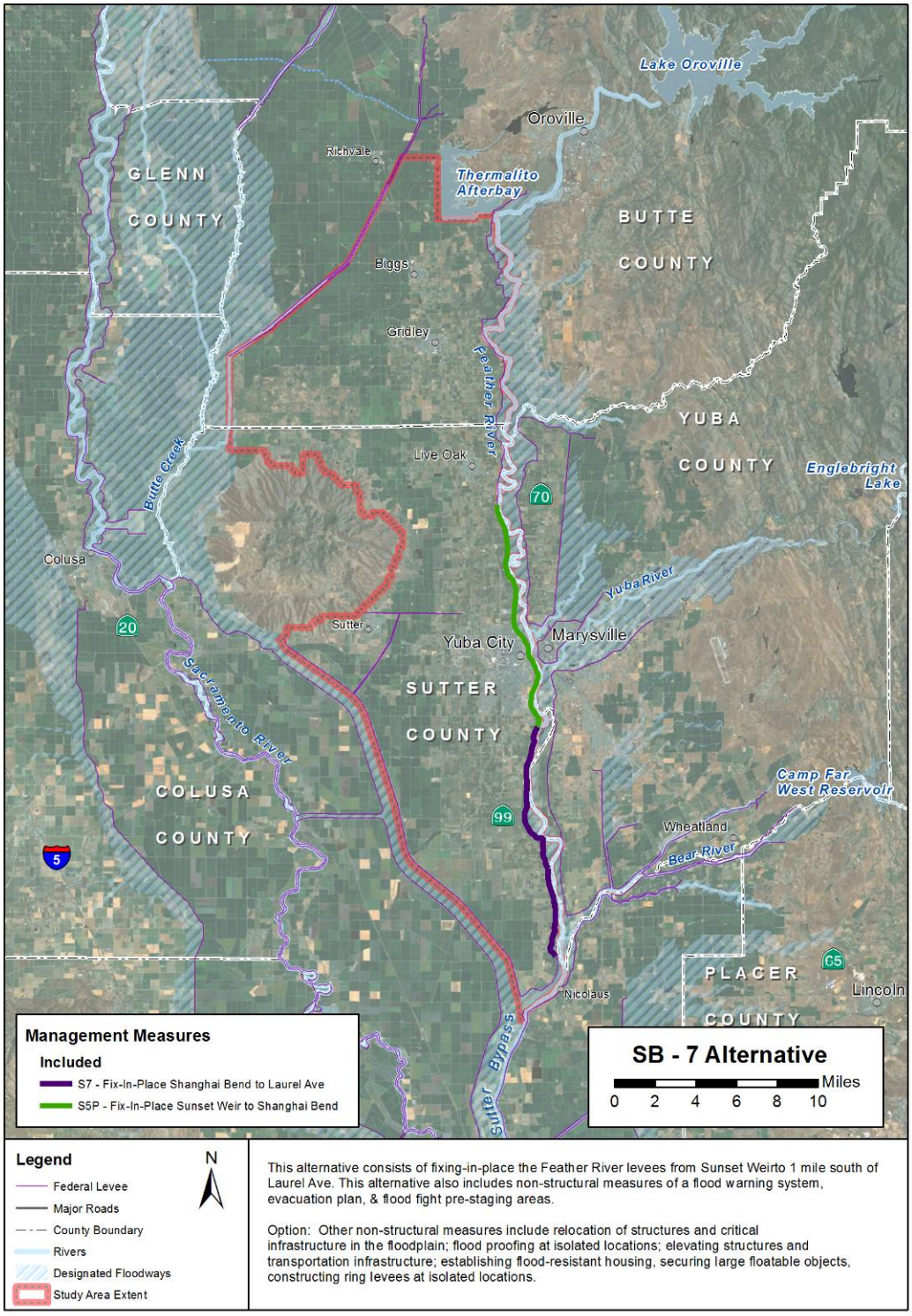

Figure 10. SB-7 Alternative

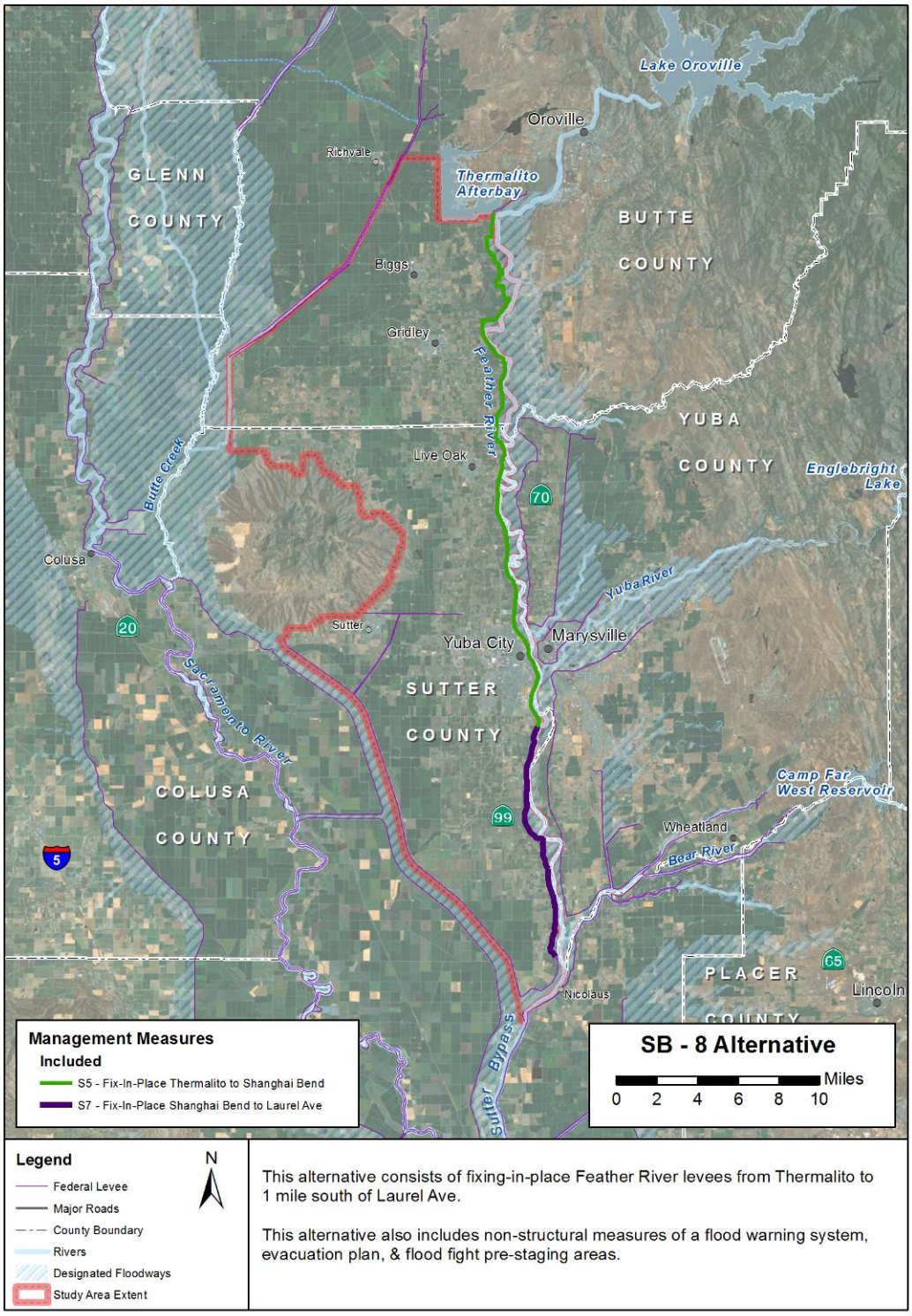

Figure 11. SB-8 Alternative

Table 2
Scenario: Establish VFZ Per ETL

Alternative	Number of Incidents	Mitigation Cost	Study Risk
SB-2, Minimal-Fix-in-Place (Feather reaches 6-21)	71	$3,301,911 to $4,627,675	Low-Moderate. Extent of vegetation removal is less than SB-5 and SB-6 but more than SB-3 and SB-4. Lower risk for jeopardy opinion and resource agency and public concerns.
SB-3, Ring Levee (Feather reaches 12-18)	38	$1,767,220 to $2,474,108	Low. The least amount of vegetation removal compared to other alternatives and therefore the least potential for a jeopardy opinion and project delays.
SB-4, Little J (Feather reaches 12-41)	179	$8,324,536 to $11,654,350	Moderate. Same as SB-5.
SB-5, Fix-in-Place, Thermalito to Star Bend (Feather reaches 6-41)	200	$9,301,158 to $13,021,621	Moderate. Substantial vegetation removal. Along with SB-6, most potential for a jeopardy opinion and permit delays. Compensatory mitigation would substantially reduce identified risk.
SB-6, Sutter Bypass (Feather reaches 1-41, Sutter Bypass LM 0-22, Wadsworth Canal LM 0-3)	321	$14,928,359 to $20,899,702	Moderate. Most vegetation loss and the most potential risk due to greater risk of a jeopardy opinion and permit delays. Compensatory mitigation would substantially reduce identified risk.
SB-7, Fix-In-Place, Feather River, Sunset Weir to south of Laurel Ave (Feather reaches 2-21)	87	$4,046,003 to $5,670,531	Low-Moderate. Same as SB-2.
SB-8, Fix-In-Place, Feather River, Thermalito to south of Laurel Ave (Feather reaches 2-41)	216	$10,045,250 to $14,078,560	Moderate. Similar as SB-5.

Table 3
Scenario: Variance Per ETL

Alternative	Number of Waterside Incidents	Cost to Obtain Variance	Study Risk
SB-2, Minimal Fix-in-Place (Feather reaches 6-21)	38	$380,000 to $1,140,000	Low. Additional ESA consultation and NEPA compliance could be required if a variance is not granted. Mitigation costs would increase but not significantly affect total project costs.
SB-3, Ring Levee (Feather reaches 12-18)	22	$220,000 to $660,000	Low. Similar to SB-2. Least amount of vegetation removal compared to other alternatives and therefore the least potential impact from not obtaining a variance.
SB-4, Little J (Feather reaches 12-41)	103	$1,030,000 to $3,090,000	Moderate. Same as SB-5.
SB-5, Fix-in-Place, Thermalito to Star Bend (Feather reaches 6-41)	111	$1,110,000 to $3,330,000	Moderate. In addition to the risks for other alternatives, this and alternative SB-6 have the most vegetation removal and thus the most potential for a jeopardy opinion and project delays if a variance is not obtained.
SB-6, Sutter Bypass (Feather reaches 1-41, Sutter Bypass LM 0-22, Wadsworth Canal LM 0-3)	193	$1,930,000 to $5,790,000	Moderate. Most vegetation loss and therefore the most potential risk to study if a variance is not granted.
SB-7, Fix-In-Place, Feather River, Sunset Weir to south of Laurel Ave (Feather reaches 2-21)	46	$460,000 to $1,380,000	Low. Same as SB-2.
SB-8, Fix-In-Place, Feather River, Thermalito to south of Laurel Ave (Feather reaches 2-41)	119	$1,190,000 to $3,570,000	Moderate. Same as SB-5.

Table 4. Effects on Land Cover Types for Alternatives SB-7 and SB-8

Land Cover Types	Alt SB-7 (acres)	Alt SB-8 (acres)
Riparian forest		
Construction footprint	14.16	20.63
VFZ Requirement	9.61	14.00
Subtotal	23.77	34.63
Riparian scrub-shrub		
Construction footprint	NA	0.32
VFZ Requirement	NA	NA
Subtotal	NA	0.32
Oak woodland		
Construction footprint	NA	NA
VFZ Requirement	1.30	6.73
Subtotal	1.30	6.73
Total	25.07	41.68

Table 5. Elderberry Shrub Impacts for Alternatives SB-7 and SB-8

Land Cover Types	Alt SB-7 (number of shrubs)	Alt SB-8 (number of shrubs)
Elderberry Shrub Loss		
Construction footprint	31	52
VFZ Requirement	98	165
Total	129	217

Table 6. Mitigation Cost Estimate for Alternatives SB-7 and SB-8

Land Cover Types	Alt SB-7 (X $1 Million)	Alt SB-8 (X $1 Million)
Riparian forest		
Construction footprint	2.83	4.13
VFZ Requirement	1.92	2.80
Subtotal	4.75	6.93
Riparian scrub-shrub		
Construction footprint	NA	0.06
VFZ Requirement	NA	NA
Subtotal	NA	0.06
Oak woodland		
Construction footprint	NA	NA
VFZ Requirement	0.26	1.35
Subtotal	0.26	1.35
Elderberry Shrub Loss		
Construction footprint	0.42	0.70
VFZ Requirement	1.58	2.66
Subtotal	2.00	3.36
Construction footprint Total	3.25	4.89
VFZ Requirement Total	3.76	6.81
*Grand Total**	4.32	9.01

* Reduced to reflect VELB compensation providing riparian and oak woodland compensation.

Cost Assumptions: (1) Compensation ratio of 2:1 for all cover types
(2) Star Bend Mitigation Site is limited to 28.5 acres of available area at a cost of $125,000 per acre;
(3) Elderberry mitigation would occur at Star Bend and would compensate for riparian impacts in addition to VELB impacts;
(4) Mitigation needs not met at Star Bend would be addressed at a mitigation bank at cost of $100,000 per acre; and
(5) VELB mitigation requirements based on the USFWS conservation guidelines.

ENCLOSURE J

SBFCA EXISTING CONDITIONS SEEPAGE RESULTS

Table 4-4. Seepage Gradient Criteria
Feather River West Levee Rehabilitation Early Implementation Project - Task Order 1

Levee Condition	Location	WSE Condition	Maximum Average Exit Gradient
Existing Conditions	Landside levee toe	DWSE	0.5
		HTOL	0.6
	Bottom of empty ditch at landside toe	DWSE	0.5
		HTOL	0.6
	Bottom of ditch and landside field between toe and 150 feet from toe	DWSE	linear interpolation between 0.5 and 0.8
		HTOL	linear interpolation between 0.6 and 0.9
With Rehabilitation Measures	Landside levee toe, without berm (e.g., with cutoff wall)	DWSE + 1 foot	0.5
		HTOL + 1 foot	0.6
	Landside levee toe with relief wells	DWSE + 1 foot	0.5
		HTOL + 1 foot	0.6
	Bottom of empty ditch at landside toe (without berm)	DWSE + 1 foot	0.5
		HTOL + 1 foot	0.6
	Bottom of empty ditch ≥ 150 feet from toe, with or without berm	DWSE + 1 foot	0.8
		HTOL +1 foot	0.9
	Bottom of ditch between toe and 150 feet from toe, with or without berm	DWSE + 1 foot	linear interpolation between 0.5 and 0.8
		HTOL +1 foot	linear interpolation between 0.6 and 0.9
	Landside levee toe, with berm	DWSE + 1 foot	0.5
		HTOL +1 foot	0.6
	Toe of seepage berm, between landside toe and less than 100 feet from levee toe	DWSE + 1 foot	0.8
		HTOL + 1 foot	does not increase more than 20% from that determined for the DWSE
	Toe of seepage berm between 100 feet and 300 feet from landside levee toe	DWSE + 1 foot	0.8
		HTOL + 1 foot	use engineering judgment
	Toe of seepage berm at or greater than 300 feet from landside levee toe	DWSE + 1 foot	use engineering judgment
		HTOL +1 foot	use engineering judgment

WSE = water surface elevation
DWSE = design water surface elevation
HTOL = hydraulic top of levee

TABLE 5-1A: CHARACTERIZATION OF REACH 1
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
1	SBFCA 10+00 [DWR 2167+00]	SBFCA 129+66 [DWR 2286+00]	2.25	**Toe** CPT – 4 **Crown** CPT – 9 Borings – 6	**Crown Width** • 17 to 20 feet **Landside Slope** • 1.3H:1V to flatter than 2H:1V **Waterside Slope** • 2.2H:1V to flatter than 3H:1V	• **10+93 (2167+13) 1997:** Light seepage observed. • **29+13 (2185+34) 1997:** Light seepage observed. • **35+85 to 60+50 (2192+06 to 2216+73) 1997:** Severe sloughing due to wave erosion along approximately 1800 feet of waterside slope. • **40+52 to 43+88 (2196+79 to 2200+03) 1997:** Erosion along the waterside levee slope with a vertical face of 6 to 12 inches, half way up the levee. • **48+00 to 53+21 (2204+22 to 2209+44) 1955;** Levee cut to dewater the flooded area in December 1955. • **69+94 (2226+15) 1997:** An area where levee turns sharply to an east-west direction was eroded for about 150 feet. • **73+02 (2229+26) 1986:** A sinkhole approximately 30 feet long, ten feet wide, and ten feet deep right at waterside toe of the levee. This hole was discovered after the 1986 high water receded. There was no landside evidence of this sinkhole during high water. • **98+06 (2254+30) 2006:** Waterside erosion. • Based on DWR's Seepage Area map for the Feather River West Levee area, 100% of Reach 1 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 100% of Reach 1 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• **10+03 to 280+77 (2166+00 to 2437+00) 1963**: Levee stabilization construction (USACE Specification 2783, File Drawing 4-4-531). • **73+02 (2229+26) 1986**: Sinkhole at waterside toe filled with gravel. • **98+06 (2254+30) 2006**: Waterside erosion, emergency repair made.	• **Land Side:** Between Stations **10+93 and 54+13 (2167+13 and 2210+33)** Geomorphologic consists of Ra with isolated fingers of Rdc. Station **54+13 (2210+33)** to end of reach consist mainly of Ra with fingers of Hch, Rofc, and Rob. • **Water Side:** Mainly Ra along the levee toe with meandering Rch parallel with waterside ditch.	• **10+93 to 45+80 (2167+13 to 2202+00)**: Low to moderate resistivity within upper 15-20', low to very low resistivity to depth • **45+80 to 106+80 (2202+00 to 2263+00)**: High to very high resistivity (occasionally moderate) within upper 15-25' at 45+80 (2202+00) increasing in depth to greater than 50' between 93+80 (2250+00) and 106+80 (2263+00), possible anomalous deep high resistivity readings at depth from 68+80 (2225+00) to 178+80 (2335+00) on waterside due to bend in levee. • **106+80 to 129+76 (2263+00 to 2286+00)**: Moderate resistivity (occasionally high) within upper 15-25', high to very high below, possible anomalous deep high resistivity readings from 118+80 (2275+00) to 129+80 (2286+00) due to irrigation pipe crossings.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
• **Levee Fill:** Consists of variable lenses of clay, silt, sandy silt, silt sand and silty sand. • **Blanket:** Relatively consistent silt, clay, sandy silt and sandy clay blanket with thicknesses ranging from 45 to 60 ft. Isolated lenses (between 1 and 10 ft. thick) of sand and silty sand are shown within the blanket area at different elevations. Below an elevation of -20 ft. MSL, the logs show alternative thin layers of GM/SP/SM/CL.	1) DWR 2262+50 (SBFCA 106+10) = **100-yr, 52.1 ft** 2) Average Head = 13.7 ft	Parallel landside and waterside unlined ditches are present. Near Stations **45+80, 57+80, and 67+80 (2202+00, 2214+00, and 2224+00)** unlined perpendicular ditches tie into parallel ditch. Land side ditch shifts further away from levee toe near Station **57+80 (2214+00)**. Landside ditches ends near Station **67+80 (2224+00)**. Pump Station located in landside ditch near Station **51+80 (2208+00)**. High voltage power pole and line located near Station **72+80 (2229+00)** on waterside. Hwy 99 crosses levee at Station **97+80 (2254+00)**. Sacramento Ave intersects levee road at Station **106+80 (2263+00)**.	SBFCA Station 106+10.50 [DWR Station 2262]	1) WM0003_012B, SM0003_004C, CM0003_004H	Location of potential underseepage problem due to presence of deep sand layers. A ditch is also present at the landside toe, which increases underseepage potential.

TABLE 5-1B: ANALYSIS RESULTS FOR REACH 1
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 1
Analysis Station: 106+11

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.30 to 0.46		0.33 to 0.52	7 feet above toe	No	The high phreatic breakout point and granular levee fill indicate potential for through-seepage. Past performance records also indicate underseepage.
100-year + 3 feet	0.35 to 0.55		0.38 to 0.61	8.5 feet above toe	No	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
100-year	1.36		No	
100-year + 3 feet	1.26		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	
100-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

For Alternative Analysis, two different models were created using Station 106+11 surface geometry to represent the reach. One model was generated with the existing berm and irrigation ditch and another model was created without the berm or ditch. The analyses results for the cross-section without the berm and ditch are presented, because with the berm and ditch in place the toe gradients move to the bottom of the ditch due to the close proximity of the toe and ditch. Alternative 1 for Reach 1 is a soil-bentonite cutoff wall extending below relatively shallow silty sand layers into a less permeable clay layer. Alternative 2 for Reach 1 is a drained stability berm and an undrained seepage berm. These alternatives were selected to mitigate through-seepage and underseepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall.

Dimensions of Primary Features: **10+00 to 58+80** Cutoff Wall Tip Elevation 20 feet, **58+80 to 83+00** Cutoff Wall Tip Elevation 18 feet, **83+00 to 114+00** Cutoff Wall Tip Elevation 24 feet, **114+00 to 129+66** Cutoff Wall Tip Elevation 27 feet. Cutoff wall is 3 feet wide and requires 1/2 levee de-grade/re-grade.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	0.31 to 0.49	N/A	0.38 to 0.62	No breakout above toe	Yes	
100-year + 4 feet	0.37 to 0.57	N/A		No breakout above toe	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	1.93		Yes	
100-year + 4 feet	1.92		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Drained Stability Berm with Undrained Seepage Berm.

Dimensions of Primary Features: **10+00 to 129+66**, 8 feet tall Drained Stability Berm with 88 feet wide Undrained Seepage Berm. Assume 25% of reach will have an undrained seepage berm width extending to 100 feet due to taller levee at some locations. Stability berm is 10 feet wide at top, 2 feet thick drain, and 3H:1V slope. Seepage Berm thickness - 5 feet at levee toe and 3 feet at berm toe.

Seepage

WSE	Exit Gradient Levee Toe	Stability Berm Toe	Seepage Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot		0.16 to 0.23	0.39 to 0.62	Bottom of stability berm	Yes	
100-year + 4 feet		0.21 to 0.30	0.44 to 0.72	Bottom of stability berm	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	1.90		Yes	
100-year + 4 feet	1.80		Yes	

TABLE 5-2A: CHARACTERIZATION OF REACH 2
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
2	SBFCA 129+66 [DWR 2286+00]	SBFCA 218+66 [DWR 2375+00]	1.69	**Toe** CPT – 9 Borings – 7 **Crown** CPT – 8 Borings – 15 **Field** CPT – 3 Borings – 5	**Crown Width** • 15 to 20 feet **Landside Slope** • 1.5H:1V to flatter than 2H:1V **Waterside Slope** • 2H:1V to flatter than 3H:1V	• **130+27 to 181+83 (2286+46 to 2338+04) Previous Flood Events:** Excessive seepage occurs during high water between Sacramento Avenue and Laurel Avenue; • **132+87 (2289+07) 1997:** Heavy seepage running clear; • **139+46 (2295+67) 1997:** Heavy seepage running clear; • **144+63 to 146+73 (2300+84 to 2302+92) 1997:** Heavy seepage running clear; • **163+88 (2320+07) 1997:** Heavy seepage running clear; • **175+60 (2331+79) 1997:** Heavy seepage running clear; • **178+72 (2334+92) 1997:** Heavy seepage around tree, running clear; • **183+40 (2339+60) 1997:** Heavy seepage running clear; • **193+16 to 194+70 (2349+37 to 2350+92) 1997:** Heavy seepage running clear; • **197+97 (2354+07) 1986:** Boil 200 feet from landward toe, water was clear and did not carry material; • **201+92 (2358+13) 1997:** Heavy seepage running clear; • **198+42 (2354+62) 1986:** A landside boil occurred in a landside drainage ditch near the levee toe during the 1986 flood, an area of boils appeared at the landside toe and away from the toe, there appears to be a swale or old slough at this location, ditches were reported to be excavated on both sides of the levee to explore for the cause of the boils but no explanation found; • **206+15 to 242+00 (2362+13 to 2398+27) 1997:** Heavy seepage into existing ditch caused sloughing of the bank and the levee slope, clear seepage was entering the ditch. Particularly heavy seepage and sloughing at toe of levee at 2370 to 2374. • **203+77 to 218+79 (2360+00 to 2375+00):** Per B. Hampton of LD-1, this is area of old levee breach and reconstruction. Date unknown. • Based on DWR's Seepage Area map for the Feather River West Levee area, 100% of Reach 2 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 100% of Reach 2 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• **129+76 to 190+41 (2286+00 to 2346+55) 1962/1963**: Landside toe berm with 15'-deep drain present (constructed as part of 1962-63 USACE levee stabilization project); • **190+34 to 198+79 (2346+55 to 2355+00 and 2355+41 to 2366+00) 1998**: Toe drain and berm constructed under the Marysville/Yuba City Levee Reconstruction Project (F.R. Site B), 41-foot gap in berm at Laurel Avenue levee ramp access. Also, this is Site 11 (toe drain and berm planned) on project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3" (As-builts?); • **206+29 to 241+93 (2362+13 to 2398+27) 1998**: During 1997 flood, emergency stability berm constructed using sandbags placed on geotextile fabric in drainage ditch, later that year this was converted to a pervious toe drain under the Marysville/Yuba City Levee Reconstruction Project (F.R. Site B).	• **Landside:** Between Stations **129+76 to 190+41 (2286+00 and 2355+50)** Geomorphology consists of alternating Ra and Rofc. Between Stations **198+79 (2355+00)** and the end of the reach the Geomorphology consists predominantly of Ha with fingers of Rdc. • **Waterside:** Consists of Ra along reach.	• **129+76 to 173+80 (2286+00 to 2330+00)**: Moderate resistivity to depths of 20-40' followed by high resistivity to depths of 100-120'. Moderate resistivity at depths greater than 100-120'; • **173+80 to 218+31 (2330+00 to 2375+00):** Moderate resistivity to depths of 15 to 20 feet (high resistivity zones from **173+80 to 188+80 (2230+00 to 2345+00)** on land/water side), thick very high resistivity zone beneath to depths over 100'.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• **Levee Fill:** Consists of variable lenses of clay, silt, sandy silt, silt sand and silty sand. • **Blanket:** With the exception of two borings at Stations 151+80 and 170+05 (2308+00 and 2326+25), the Reach contains a relatively consistent clay and silty clay blanket between 10 and 25 ft thick. The blanket is overlain and underlain by silty sand and sandy silt of varying thicknesses. At Stations 151+80 and 170+05 (2308+00 and 2326+25) borings indicate levee is underlain by sandy silt to 25 feet below the levee toe elevation. Below an elevation of approximately 0 to 10 ft the borings show interbedded layers of CL/GW-GP/SP/SM/ML to the depths explored.	1) DWR 2337+50 (SBFCA 181+13) = **100-yr, 54.1 ft** 2) Average Head = 16.2 ft	Seepage berm with toe drain located along land side levee toe between Stations **129+76 and 210+30 (2286+00 and 2366+50)**. Irrigation pipe through levee crown at Station **199+80 (2365+00)**. Concrete ditch near end of Reach starting at Station **216+80 (2373+00)** continuing into Reach 3. Audubon Society dirt parking lot and metal structure located near the landslide toe at Station **199+80 (2365+00)**. Water side ditch along entire alignment.	SBFCA Station 181+13 [DWR 2337+50]	1) WM0003_034C, WM0003_035C, WM0003_003A, and WM0003_018C	Presence of sandy layers both in embankment and foundation. Potential thin blanket condition.

TABLE 5-2B: ANALYSIS RESULTS FOR REACH 2
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 2
Analysis Station: 181+13

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.51 to 1.83			4' above toe	No	Results are consistent with past performance of the reach, which consists of significant boils and sloughing at the toe of the levee.
100-year + 3 feet						

Landside Stability

WSE		Performance			Meets Criteria?	
100-year						

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	
100-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 2 is a soil-bentonite cutoff wall extending below sand/silty sand layers into a less permeable clay/silt layer. This alternative was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 2 includes the use of both stability berm with seepage berm and a shallow cutoff wall with a seepage berm. The seepage berm material type is lean clay, which is similar to the shallow near surface layers. The shallow cutoff wall reduces the potential for seepage through shallow near surface sandy layers and unacceptable gradients through the berm near the levee toe.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall.

Dimensions of Primary Features: **129+66 to 181+00** Cutoff Wall Tip Elevation 20 ft, **181+00 to 191+00** Cutoff Wall Tip Elevation (-10 feet), **191+00 to 218+66** Cutoff Wall Tip Elevation (-73 feet) with full levee de-grade/re-grade. Cutoff wall is 3 feet wide and requires 1/2 levee de-grade/re-grade except between station **191+00 and 218+66** where a full levee de-grade/re-grade is required.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	0.09 to 0.12	N/A		Toe	Yes	
100-year + 4 feet	0.15 to 0.13			Toe	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	1.78		Yes	
100-year + 4 feet	1.75		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Drained Stability Berm with Undrained Seepage Berm and Cutoff Wall with Undrained Seepage Berm

Dimensions of Primary Features: **129+66 to 181+00**, 8 feet tall Drained Stability Berm with 100 feet wide Undrained Seepage Berm, **181+00 to 218+66** Cutoff Wall Tip Elevation 30 feet with 100 feet wide Undrained Seepage Berm. Stability berm is 10 feet wide at top, 2 feet thick drain, and 3H:1V slope. Seepage Berm thickness - 5 feet at levee toe and 3 feet at berm toe. Cutoff wall is 3 feet wide and requires 1/2 levee de-grade/re-grade.

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	0.15	0.57		At the toe of the slope/top of the seepage berm	Yes	Remove thin CL Blanket and underlying SM (4 feet by 200 feet) and replace with Undrained Stability Berm material (CL).
100-year + 4 feet	0.22	0.66			Yes	Remove thin CL Blanket and underlying SM (4 feet by 200 feet) and replace with Undrained Stability Berm material (CL).

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	1.86		Yes	
100-year + 4 feet	1.81		Yes	

TABLE 5-3A: CHARACTERIZATION OF REACH 3
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
3	SBFCA 218+66 [DWR 2375+00]	SBFCA 300+66 [DWR 2457+00]	1.55	**Toe** CPT – 5 Borings – 9 **Crown** CPT – 9 Borings – 13 **Field** CPT – 3 Borings – 1	**Crown Width** • 17 to 20 feet **Landside Slope** • 1.5H:1V to flatter than 2H:1V **Waterside Slope** • 2H:1V to flatter than 3H:1V	• **206+15 to 242+00 (2362+13 to 2398+27) 1997**: Heavy seepage into existing ditch caused sloughing of the bank and the levee slope, clear seepage was entering the ditch. • **253+70 to 257+92 (2410+00 to 2414+00):** Per B. Hampton with LD-1, water level in landside pond rises with increasing water level behind levee, which leads to bank erosion in the pond. • Based on DWR's Seepage Area map for the Feather River West Levee area, 95% of Reach 3 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 90% of Reach 3 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• **206+29 to 241+93 (2362+13 to 2398+27) 1998**: During 1997 flood, emergency stability berm constructed using sandbags placed on geotextile fabric in drainage ditch, later that year this was converted to a pervious toe drain under the Marysville/Yuba City Levee Reconstruction Project (F.R. Site B). • **218+31 to 298+97 (2375+00 to 2455):** Drain consists of fabric-wrapped gravel placed in existing ditch and then backfilled. Concrete lined landside ditch on slightly elevated berm.	• **Landside:** Geomorphology along levee toe consists of alternating Ha and Rob units. One section of Rcs is shown against the levee toe between Stations **291+05 and 292+80 (2447+25 and 2449+00)**. • **Waterside:** Geomorphology consists of Ra.	• **218+31 to 241+80 (2375+00 to 2398+00)**: Low to moderate resistance throughout profile (low within upper 10-20' of this segment); • **241+80 to 288+80 (2398+00 to 2445+00)**: Alternating high to moderate resistivity zones within the upper 10-20' (waterside mainly high resistivity near-surface) followed by high to very high resistivity to depths of about 100', moderate resistivity below 100'; • **288+80 to 300+80 (2445+00 to 2457+00)**: Primarily high to very high resistivity to a depth of about 50', occasional moderate resistivity zones within the upper 10-20'.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• **Levee Fill:** Consists of variable lenses of clay, silt, sandy silt, silt sand and silty sand. • **Blanket:** ML and CL blanket is present below the levee toe at thicknesses ranging from 10 and 30 ft. The blanket is overlain by thin lenses (less than 5 ft) of silty sand and sand at a few of the boring locations. The blanket is underlain by 10 to 40 ft layers of sand and silty sand. Below an elevation of approximately -20 the borings show interbedded layers of CL/ML/GW/GP//SM to the depths explored.	1) DWR Station 2396+00 (SBFCA Station 239+78) = **100-yr 54.6 ft**, **100-yr + 3ft = 57.5 ft** 2) Average Head 100 yr = 10.6 ft, Average Head 100 yr + 3ft = 13.6 ft	Concrete lined ditch located on land side along entire reach. Pond located on land side near Station **255+80 (2412+00)**. Irrigation pump structure located on water side near Station **298+97 (2455+00)**. Irrigation piping from pump to farm travels through Levee crown near Station **298+97 (2455+00)**. Water side borrow ditch appears to end at Station **265+30 (2421+50)**.	SBFCA Station 239+78 [DWR Station 2396+00]	1) WM0003_022B, WM0003_008C, SM0003_008H	Presence of thin fine-grained blanket layer. The shallow sand and silty layer is about 50 feet thick.

TABLE 5-3B: ANALYSIS RESULTS FOR REACH 3
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 3
Analysis Station: 239+78

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.5	1.7	1.34	Toe	No	Results are consistent with past performance of significant seepage and sloughing at the levee toe.
100-year + 3 feet						

Landside Stability

WSE	FS	Performance			Meets Criteria?	Comments
100-year						

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	
100-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 3 is a soil-bentonite cutoff wall extending below sand/silty sand layers into a less permeable clay/silt layer. This alternative was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 3 consists of a stability berm with a seepage berm. The seepage berm material type is silty sand, which is similar to the shallow near surface layers. Alternative 2 mitigates underseepage and through seepage. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: **218+66 to 220+00** Cutoff Wall Tip Elevation (-73 feet), **220+00 to 230+00** Cutoff Wall Tip Elevation 20 feet, **230+00 to 250+00** Cutoff Wall Tip Elevation (-35 feet), **250+00 to 289+00** Cutoff Wall Tip Elevation (-20 feet), **289+00 to 300+66** Cutoff Wall Tip Elevation 15 feet. Cutoff wall is 3 feet wide and requires 1/2 levee de-grade/re-grade.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	0.08	0.48		At toe of the levee	Yes	
100-year + 4 feet	0.11	0.56		At toe of the levee	Yes	

Landside Stability

WSE	FS				Meets Criteria?	Comments
100-year + 1 foot	1.4				Yes	
100-year + 4 feet	1.4				Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Drained Stability Berm with Undrained Seepage Berm.

Dimensions of Primary Features: **218+66 to 300+66** 8 feet tall Drained Stability Berm with 300 feet Wide Undrained Seepage Berm with monitoring for seepage at the toe of the Undrained Seepage Berm. Drained Stability Berm is 10 feet wide at top, 2 feet thick drain, and 3H:1V slope. Undrained Seepage Berm thickness - 5 feet at levee toe and 3 feet at berm toe

Seepage

WSE	Exit Gradient Levee Toe	Stability Berm Toe	Seepage Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot		0.17	1.31	Bottom of stability berm/top of seepage	Yes	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
100-year + 4 feet		0.29	1.52		Yes	

Landside Stability

WSE	FS				Meets Criteria?	Comments
100-year + 1 foot	2.01				Yes	
100-year + 4 feet	2.00				Yes	

TABLE 5-4A: CHARACTERIZATION OF REACH 4
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
4	SBFCA 300+67 [DWR 2457+00]	SBFCA 410+67 [DWR 2567+00]	2.1	**Toe** CPT – 5 Borings – 1 **Crown** CPT – 11 Borings – 5 **Field** CPT - 1	**Crown Width** • 15 to 20 feet **Landside Slope** • 1.7H:1V to flatter than 2H:1V **Waterside Slope** • 1.5H:1V to flatter than 3H:1V	• **359+42 (2515+65) 1986**: During the 1986 flood, a crack formed in the levee. (F.R. Site C) This site is located 2.4 miles south of Star Bend (LM 1.5). • **362+10 to 370+02 (2518+29 to 2526+22) 1997**: During the 1997 flood, seepage occurred at the site (same location of 1986 crack). (F.R. Site C) • Based on DWR's Seepage Area map for the Feather River West Levee area, 85% of Reach 4 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 80% of Reach 4 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• **354+50 to 364+44 (2510+73 to 2520+67) 1998**: Toe Drain and Seepage/Stability Berm constructed. A pervious toe drain and seepage/stability berm have been constructed at this site under a PL 8499 action (F.R. Site C)	• **Landside:** Between **300+80 and 349+80** (**2457+00 and 2506+00)** Geomorphology consists of alternating Ra, Ha and Rcs. Between **349+80 and 385+80** (**2506+00 and 2542+00)**- Geomorphology consists of alternating Hob and Rcs. Between **385+80** (**2542+00) to the end of the reach** the Geomorphology consists of alternating layers of Rob and Qmu. • **Waterside**: Geomorphology consists of Ra from the **start of the reach to 311+80** (**2468+00)** and consists of Rb from **311+80 (2468+00) to the end of the reach**, with Rofc between Ra and Rb and the water.	• **0 - 10' bgs:** Generally low to moderate resistance crest and land side, high resistance water side. Exceptions: At crest: low resistance from 313+80 to 327+80, 351+80, 353+80, from 408+30 to 411+80 (**2470+00 to 2484+00, 2508+00, 2510+00, from 2564+50 to 2568+00)**; land side: low resistance from 312+80 to 315+30, 312+80 to 410+80 (**2469+00 to 2471+50, 2469+00 to 2567+00)**; water side - low resistance between 323+80 to 334+80 (**2480+00 to 2491+00)** and in between moderate zones at 320+30 to 337+80, 377+80 to 379+80 (**2476+50 to 2494+00, 2534+00 to 2536+00)**. Moderate resistance water side**:** 350+30 (**2506+50) to end of reach** with some high resistance near 393+80 and 406+80 (**2550+00 and 2563+00)**. • **10' - 40' (50' water side):** High resistance from 300+80 to 317+80 (**2457+00 to about 2474+00)** for water, land and crest. 317+80 (**2474+00) to end of reach**, moderate resistance crest and water side, with areas of low resistance along the crest, mainly low resistance land side. • **40' to 150':** moderate resistance for crest, land and water side except areas of low resistance land side from 319+80 to 337+80 and 406+80 to 410+80 (**2476+00 to 2494+00 and 2563+00 to 2567+00)**.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			• **Levee** materials generally consist of sandy silt and silty sand with lesser sand and clay layers between 300+80 and 363+80 (2457+00 and 2520+00), then predominately silt and clay between 363+80 and 410+80 (2520+00 and 2567+00). • **Blanket** generally consists of silt and clay that extends 25 to 40 feet below the base of the levee. Local soft layers are present 6 to 10 feet below the base of the levee. Isolated silty sand layers are present within the blanket between approximate 372+80 and 391+80 (2529+00 and 2548+00). Below about elev. 12 ft MSL, soil generally consists of alternating layers/lenses of silty sand, sand, gravel, silt, and clay of varying thickness.	1) DWR 2462+50 (SBFCA 306+33) **100-yr = 54.7 ft, 100 yr + 3 ft = 57.7 ft** 2) Average Head 100 yr = 12.5 ft, Average Head 100 yr + 3ft = 15.5 ft	At about **409+80 (2566+00)**, sump pond located at landside toe and pump station located at riverside toe with associated pipes crossing through levee. Otherwise the area adjacent to the landside levee is used for agricultural purposes.	SBFCA 306+33 [DWR 2462+50]	1) WL0001_023C: SL0001_001C: SL0001_001H	Shallow thin previous layers are present at this section, which is a good representation of this reach.	

*SBFCA station numbers based on 2156+20 subtracted from older DWR stations.
**SBFCA station numbers provided by WoodRodgers.

TABLE 5-4B: ANALYSIS RESULTS FOR REACH 4
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 4
Analysis Station: 306+33

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.17 to 0.46	N/A	0.2 to 0.52	5.8 feet above Toe	No	The high phreatic surface breakout point and granular fill indicate potential for through seepage. Past performance records also indicate underseepage.
100-year + 3 feet	0.22 to 0.59		0.26 to 0.64	7 feet above Toe	No	
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
100-year						
100-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	
100-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 4 is a soil-bentonite cutoff wall extending below sand/silty sand layers into a less permeable clay/silt layer. Alternative 2 for Reach 4 is a stability berm with a seepage berm. Both alternatives were selected to mitigate through-seepage and underseepage.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s):	Soil-Bentonite Cutoff Wall.					
Dimensions of Primary Features:	**300+66 to 349+00** Cutoff Wall Tip Elevation 15 feet, **349+00 to 368+00** Cutoff Wall Tip Elevation 10 feet, **368+00 to 410+67** Cutoff Wall Tip Elevation 20 feet. Cutoff wall is 3 feet wide and requires 1/2 levee de-grade/re-grade.					
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	See Reach 1				Yes	Subsurface conditions, past performance and Problem Identification seepage results are similar to Reach 1 and therefore mitigation is consistent with Reach 1 results.
100-year + 4 feet	See Reach 1				Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
100-year + 1 foot	See Reach 1				Yes	
100-year + 4 feet	See Reach 1				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s):	Drained Stability Berm with Undrained Seepage Berm					
Dimensions of Primary Features:	**300+66 to 410+67**, 8 feet tall Drained Stability Berm and 100 feet wide Undrained Seepage Berm. Stability berm is 10 feet wide at top, 2 feet thick drain, and 3H:1V slope. Seepage Berm thickness - 5 feet at levee toe and 3 feet at berm toe					
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	See Reach 1			Bottom of stability berm/top of seepage berm	Yes	Subsurface conditions, past performance and Problem Identification seepage results are similar to Reach 1 and therefore mitigation is consistent with Reach 1 results.
100-year + 4 feet	See Reach 1				Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
100-year + 1 foot	See Reach 1				Yes	
100-year + 4 feet	See Reach 1				Yes	

TABLE 5-5A: CHARACTERIZATION OF REACH 5
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)*	END STATION (SBFCA)*							
	[DWR ULE STATION]	[DWR ULE STATION]							
5	SBFCA 410+67 [DWR 2567+00]	SBFCA 478+67 [DWR 2635+00]	1.3	**Toe** CPT – 9 Borings – 3 **Crown** CPT – 7 Borings – 4 **Field** CPT - 2	**Crown Width** • 15 to 20 feet **Landside Slope** • 1.5H:1V to flatter than 2H:1V **Waterside Slope** • 2H:1V to flatter than 3H:1V	• **425+33 to 478+80** (**2581+57 to 2635+00) 1997**: Four boils at landside toe of levee. • **467+47 to 495+72 (2623+92 to 2650+22) 1986**: During the 1986 flood, boils carrying soil formed near the landside toe of the levee. The ground within approximately 100 feet of landside toe was very soft and wet. The peak floodwater was 5-6 feet below the top of the levee at this location. LDI personnel constructed sandbag rings around three of the worst boils. (F.R. Site D) • Based on DWR's Seepage Area map for the Feather River West Levee area, 100% of Reach 7 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 100% of Reach 7 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation.	• **242+80 to 478+80** (**2581+00 to 2635+00) unknown date**: An undrained stability berm was constructed at landside toe of levee.	• **Landside:** Between **410+80 (2567+00)** to the end of the reach Geomorphology consists predominantly of Rob with a finger of Qmu. • **Waterside**: Consists of Rb with Rofc between Rb and the water.	• Crest, LS, and WS Profiles similar. **0 - 150' bgs**: Generally alternating moderate to high resistance for entire reach to about 100' depth, high resistance depths greater than 100'. Exceptions: Low resistance noted from **410+80 to 420+80** (**2567+00 to 2577+00)**, and from **435+80 to 439+80** (**2592+00 to 2596+00)** at about 40' to 70' depth landside, and from **443+80 to 457+80** (**2600+00 to 2614+00)** from the ground surface to 10' and dipping to about 50' near **447+80 (2604+00)** landside.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			DWR ULE STATION (SBFCA STATION)		
• **Levee** materials generally consist of silt and clay with lenses of sandy silt at about Sta. 438+80 (2595+00). • **Blanket** generally consists of silt and clay that extends 5 to 20 feet below the base of the levee. A hardpan layer is generally present at a depth of 5 to 9 feet except at 416+80 (2573+00), 427+34 (2583+54), and 466+40 (2622+60). Sand and silty sand layers/lenses 4 to 10 feet thick are present at a depth of 5 to 20 feet below the base of the levee. Sand and gravel layer present at about 30 to 35 feet below the base of the levee that extends to the bottom of 110'- deep explorations.	1) DWR 2633+00 (SBFCA 477+01) **200-yr 64.0 ft** 2) Average Head 200yr = 13.4 ft	No significant constraints or features identified within this Reach. No landside ditches present. The area adjacent to the landside levee is used for agricultural purposes. Significant water-side excavations present along the entire reach.	1) DWR 2633+00 (SBFCA 477+01)	1) WL0001_020C: WL001-059C: WL0001_036C: B5-07 (BCI): B1-06 (BCI): SL0001_003C: SL0001- 003H	A relatively thick layer of sand and silty sand present at about 20 feet below the landside levee toe. The thickness of this layer increases landside based on the toe and field explorations.

TABLE 5-5B: ANALYSIS RESULTS FOR REACH 5
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 5
Analysis Station: 477+01

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.40 to 0.46	0.99 to 1.75		At Toe	No	Results are consistent with historic significant seepage and boils at the toe of the levee.
Landside Stability						
WSE		Performance			Meets Criteria?	
200-year						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	
200-year + 1 foot	typ. winter WSE					
Rationale for Selection of Two Alternatives for Analysis						
Alternative 1 for Reach 5 is a soil-bentonite cutoff wall and a soil-bentonite cutoff wall with a 200 feet seepage berm. Alternative 2 for Reach 5 is a seepage berm. The seepage berm material type is lean clay, which is similar to the shallow near surface layers. The alternative reduces the potential for seepage through shallow near surface sandy layers and unacceptable gradients. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.						
Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s):	Soil-Bentonite Cutoff Wall and Soil-Bentonite Cutoff Wall with Seepage Berm					
Dimensions of Primary Features:	**410+67 to 417+00** Cutoff Wall Tip Elevation 20 feet, **417+00 to 425+00** Cutoff Wall Tip Elevation 10 feet, **425+00 to 456+00** Cutoff Wall Tip Elevation 15 feet, **456+00 to 478+68** Cutoff Wall Tip Elevation 15 feet with 200 feet Wide Undrained Seepage Berm. Cutoff wall is 3 feet wide and requires 1/2 levee de-grade/re-grade. Undrained Seepage Berm thickness: 5 feet at levee toe and 3 feet at berm toe.					
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	See Reach 3				Yes	Subsurface conditions, past performance and Problem Identification seepage results are similar to Reach 3 and therefore mitigation is consistent with Reach 3 results.
200-year + 4 feet	See Reach 3				Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	See Reach 3				Yes	
200-year + 4 feet	See Reach 3				Yes	
Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s):	Undrained Seepage Berm					
Dimensions of Primary Features:	300 feet Wide Undrained Seepage Berm. Undrained Seepage Berm thickness: 5 feet at levee toe and 3 feet at berm toe.					
Seepage						
WSE	Exit Gradient Levee Toe	Seepage Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	See Reach 3				Yes	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
200-year + 4 feet	See Reach 3				Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	See Reach 3				Yes	
200-year + 4 feet	See Reach 3				Yes	

TABLE 5-6A: CHARACTERIZATION OF REACH 6
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)* [DWR ULE STATION]	END STATION (SBFCA)* [DWR ULE STATION]							
6	SBFCA 478+67 [DWR 2635+00]	SBFCA 510+37 [DWR 2676+00]	0.78		3:1 land-side and water-side slopes with minimum 20-foot-wide crown.	• Significant seepage prior to construction of setback levee and slurry wall. • Based on DWR's Seepage Area map for the Feather River West Levee area, 95% of Reach 6 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 95% of Reach 6 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• Setback levee with SB cutoff wall constructed in 2009 within this entire reach. Cutoff wall tie-ins are SCB and extend 125' north into the existing levee and 150' south into the existing levee. The SB cutoff wall is 40 to 45 feet deep at the north tie-in and 62 to 67 feet deep at the south tie-in. • The new levee was constructed of levee fill meeting USACE classification and compaction criteria. • The wall depths and cutoff clay layer depths were confirmed during construction. • Seepage, stability and settlement analyses were performed during design of the setback levee by Blackburn Consulting consistent with USACE criteria and results indicate all criteria was met with regards to seepage gradients, slope stability factors of safety and settlement magnitude.		
			GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] DWR ULE STATION (SBFCA STATION)	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]	
								New setback levee and SB cutoff wall along entire reach constructed in 2009 in accordance with USACE criteria. This reach will be "certified" under the Star Bend Setback Levee project close-out documentation, which will be referenced in the final FRWL design-level report.	

TABLE 5-7A: CHARACTERIZATION OF REACH 7
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)*	END STATION (SBFCA)*							
	[DWR ULE STATION]	[DWR ULE STATION]							
7	SBFCA 510+37 [DWR 2676+00]	SBFCA 598+87 [DWR 2765+00]	1.68	**Toe** CPT – 23 Borings – 11 **Crown** CPT – 30 Borings – 14 **Field** CPT – 4	**Crown Width** • 15 to 20 feet **Landside Slope** • 2H:1V to flatter than 2H:1V **Waterside Slope** • 3H:1V to flatter than 3H:1V	• **510+69 to 556+25 (2677+06 to 2722+50) 1995:** Seepage -- the site is located between Star Bend Road and Abott Road at approximate River Mile 18.1 and 19.0 (LM 4.1 to 5.0). During the 1995 flood, clear seepage exited the levee toe and the ground beyond the levee toe while the river level was approximately 12 to 15 feet below the top of levee. (F.R. Site E). • **510+69 to 556+25 (2677+06 to 2722+50) 1997:** Boils and seepage. During the 1997 flood, numerous boils occurred in a 200 linear foot stretch. Sandbag rings were constructed around the boils that were moving material. The following day, the sandbagged boils were flowing clear. (F.R. Site E) • **521+50 (2687+62) 1997:** Boil at landside levee toe. • **532+60 (2698+72) 1997:** Two boils at landside levee toe. • **534+71 (2700+83) 1997:** Three boils at landside levee toe. • **540+02 (2706+13) 1997:** Three boils at landside levee toe. • **543+20 to 547+58 (2709+28 to 2713+51) 1997:** Seventeen (17) boils at landside levee toe. • **563+00 to 568+74 (2729+00 to 2735+00) 1997:** Waterside slope instability due to rapid drawdown when levee breach occurred on east bank of Feather river. • **592+34 (2758+48) 1986:** Erosion, site located at LM 6.1 near Abbott Lake, north of O'Banion Road at approximately River Mile 19.7. During the 1986 flood, holes appeared at the top of waterside levee berm. It is believed that the holes were result of small trees growing on the berm. The berm slope down to natural ground was eroded. The water was within 5 feet of the top of the levee (F.R. Site F) 2006 - Boils reported in 2006 adjacent to and north of the relief well field. • Based on DWR's Seepage Area map for the Feather River West Levee area, 95% of Reach 7 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 95% of Reach 7 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• **510+87 to 555+88 (2677+00 to 2722+00) date unknown**: Toe Berm constructed from the north end of Star Bend Road to the south end of Abbott Lake Road. Project Plans entitled "PL 84-99 Phase III, Relief Wells - LD1, Feather River at Star Bend, dated 8/18/1997. USACE File No. 04-04-617" • **526+72 to 542+10 (2692+50 to 2708+20) 1997**: In 1997, the Corps of Engineers installed relief wells in this area to reduce seepage and instability of the levee under PL 84-99 contract. (F.R. Site E). A total of 25 relief wells from 1550 feet north of north end of Star Bend Road to 1380 feet south of the south end of Abbott Lake Road. Project Plans entitled "PL 84-99 Phase III, Relief Wells - LD1, Feather River at Star Bend, dated 8/18/1997. USACE File No. 04-04-617". Significant seepage continued (heavy in 2006) after wells were constructed. Top of wells and collection ditch appear to be too high to mitigate seepage and/or no confining layer present to force near-surface water into wells. • **563+05 to 568+76 (2729+00 to 2735+00 with an approximately 120 feet gap):** Waterside slope repair by USACE after the 1997 flood. A gap of about 120 feet was left unrepaired.	• **Landside:** Between **510.25 to 568+38** (**2676+00 to 2734+50)** Geomorphology consists of alternating Rcs, Rob, Qmu. From **568+38** (**2734+50) to the end of the reach**, Geomorphology consists of Qmu. • **Wateside**: Geomorphology consists of Rb from the beginning **of the reach to 517+88** (**2684+00)** and then consists of Ra to the end of the reach.	• **0 - 10' bgs:** Generally low resistance from **509+88 to 529+88** (**2676+00 to 2696+00)** with some moderate resistance interspersed. Alternating moderate and high resistance **529+88** (**2696+00) to the end of the reach**. • **10' - 40':** Moderate resistance land and crest, moderate to high resistance water side **509+88 to 535+88** (**2676+00 to 2702+00)**. Exception: low resistance from about **509+88 to 526+88** (**2676+00 to 2693+00)** land side. High resistance **526+88 to 580+88** (**2693+00 to 2747+00) 583+88 (2750+00 water side)**. Moderate resistance to end of reach. • **40' to 150':** Generally moderate resistance land and water side from **509+88 to 583+88** (**2676+00 to 2750+00)** except areas of low resistance land side from **555+88 to 558+38** (**2722+50 to 2724+50)** at about 120' to 150' depths and water side from **548+88 to 555+88** (**2715+00 to 2722+00)** at about 100' to 150' depths. High resistance water side from **beginning of reach to 528+88 (2695+00)** to depths of 60' and to **519+88** (**2686+00)** at greater depths. Crest - moderate resistance 40' to about 100', low resistance 100' to 150' (moderate resistance from **566+88 to 575+88** (**2733+00 to 2742+00**). From **583+88 to 598+88** (**2750+00 to 2765+00)**, moderate resistance from 40' to about 100' depths, low resistance from 100' to 150' depths.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			DWR ULE STATION (SBFCA STATION)		
• **Levee** materials generally consist of silt and clay with lenses of sandy silt. • **Blanket** generally consists of silt and clay that extends 7 to 10 feet below the base of the levee. A hardpan layer is locally present below the silt and clay. Locally, 1 to 2 foot thick lenses of sand and silty sand are present near the base of the levee. Sand and silty sand layers/lenses 5 to 35 feet thick are present at a depth of 7 to 10 feet below the base of the levee. 1' to 2' thick lenses of very soft, fine grained soil (sometimes organic) within the upper 5' of soil below levee and at the toe. This is likely old lakebed material.	1) DWR 2705+00 (SBFCA 539+30) **200-yr 65.9 ft** 2) Average Head = 18 ft	Landside lined ditch present at levee toe between approximate 511+88 and 555+88 (2678+00 and 2722+00) at levee toe. Relief wells present at levee toe between 526+38 to 542+08 (2692+50 to 2708+20). The area adjacent to the landside levee is used for agricultural purposes. Significant water-side excavation present within 50 to 100 feet of levee toe. Levee was constructed over old lakebed.	1) SBFCA 539+30 (DWR 2705+00)	1) WL0001_084C: WL0001_088B: WL0001_089B: SL0001_004C: SL0001_004H	Blanket layer is approximately 10 feet thick and underlain by sand and silty sand layers.

TABLE 5-7B: ANALYSIS RESULTS FOR REACH 7
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 7
Analysis Station: 539+30

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.55	N/A	2.7	11.5 feet above Toe	No	Results are consistent with significant historic seepage and boils.

Landside Stability

WSE		Performance			Meets Criteria?	
200-year						

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 7 is a soil-bentonite cutoff wall extending below sand/silty sand layers into a less permeable clay/silt layer. This alternative was selected as an in-place alternative to mitigate both through-seepage and underseepage. Alternative 2 for Reach 7 consists of a stability berm with a seepage berm. The seepage berm material type is lean clay, which is similar to the shallow near surface layers. Alternative 2 mitigates underseepage and through seepage. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: **510+37 to 528+00** Cutoff Wall Tip Elevation 15 ft, **528+00 to 546+00** Cutoff Wall Tip Elevation (-10 ft), **546+00 to 565+00** Cutoff Wall Tip Elevation (-65 ft) with Full Levee Degrade, **565+00 to 576+00** Cutoff Wall Tip Elevation (-50 ft), **576+00 to 584+00** Cutoff Wall Tip Elevation (-10 ft), **584+00 to 598+87** Cutoff Wall Tip Elevation 20 ft. Cutoff wall is 3 ft wide and requires 1/2 levee de-grade/re-grade except between station **546+00 to 565+00** where a full levee de-grade/re-grade is required.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.05	N/A		Toe	Yes	
HTOL	0.05			Toe	Yes	

Landside Stability

WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.09				Yes	
HTOL	2.09				Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Drained Stability Berm with Undrained Seepage Berm

Dimensions of Primary Features: **510+37 to 598+87**, 9.5 feet tall, Drained Stability Berm with 300 feet Wide Undrained Seepage Berm with monitoring for seepage at the toe of the berm. Drained Stability Berm is 13 feet wide at top, 2 feet thick drain, and 3H:1V slope. Height of the Undrained Seepage Berm at Levee Toe is 7 feet tall due to high gradients across the seepage berm/blanket, 3 feet tall at berm toe.

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.47	1.39		Stability Berm Toe	No	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
HTOL	0.57	1.53		Stability Berm Toe	No	

Landside Stability

WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.77				Yes	
HTOL	1.57				Yes	

TABLE 5-8A: CHARACTERIZATION OF REACH 8
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
8	598+84 [2765+00]	654+75 [2821+00]	1.11	Total Number of Explorations = 19; Crest Explorations = 11 (SPT - 5, CPT - 6); Landside Toe Explorations = 6 (SPT - 3, CPT - 3); Landside Field Explorations = 2 (CPT - 2)	**Crown Width :** approximately 20 feet **Landside slope** approximately 2H:1V to flatter than 2H:1V **Waterside Slope** approximately 2H:1V to flatter than 3H:1V	602+88 [2769+01] to 640+32 [2806+45]: Twenty-six (26) sinkholes on waterside berm of levee (1997). According to Bill Hampton of LD1, these sinkholes were 3 feet to 6 feet deep and 2 feet to 4 feet in diameter and formed on the waterside berm, which was the original levee before it was raised. Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 2/3 rd of Reach 8 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 2/3 rd of Reach 8 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations.	602+88 [2769+01] to 640+32 [2806+45]: After the flood, 26 sinkholes were repaired by compacting soil (1997).	R_{SL} (Recent Slough deposits) R_a (Recent Alluvium) R_{ob} (Recent Overbank)	High resistivity soil layers present at approximately 10 feet below the embankment. The highly resistive layers extends to the ground surface occasionally.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: Sand (SP, SM), Silt and Clay **Foundation**: Near Surface layers include Sand (SP), Clay (CL). Landside toe and field explorations indicate shallow Sand layers. Hardpan and soft layers were encountered within shallow foundation layers.	**200 yr WSE** Head = approximately 18.8 feet at the analysis section	Mostly Agricultural. A pond is located on the landside of the levee between Sta. 646+86 [2813+00] and Sta. 648+86 [2815+00].	623+86 [2790+00]	WL0001_049B, WL0001_049C, 2F-91-10 (CREST), WL0001_074C, WL0001_061C, SL0001_005C (LANDSIDE TOE), WL0001_117C, 2F-91-10A, WL0001_110C (FIELD)	Presence of sand in levee embankment may indicate potential for through seepage; shallow sand layers in foundation and relatively thin fine-grained blanket may indicate potential for underseepage; deep sand layers encountered at approximately similar depths as other explorations within this reach.	

TABLE 5-8B: ANALYSIS RESULTS FOR REACH 8
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 623+86

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.77	N/A	N/A	1.0	No	The existing levee embankment material is silty sand underlain by approximately 5.2 feet of silty sand and 4.3 feet of clay blanket.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 8 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through seepage and underseepage potential. Alternative 2 for Reach 8 is a seepage berm with a shallow cutoff wall. The seepage berm material type is silty sand, which is similar to the shallow near surface layer. The shallow cutoff wall reduces the potential for seepage through shallow near surface sandy layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 3 feet wide and 45 feet deep cutoff wall starting at Elevation 60 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No breakout	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	<0.1	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.90		Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	1.89		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm and Shallow Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: Seepage Berm - 130 feet wide berm, 3 feet thick at berm toe and 5 feet thick at levee toe, berm soil type - silty sand
Shallow Cutoff Wall - 3 feet wide and 21.5 feet deep cutoff wall starting at Elevation 60 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.27	0.63	N/A	No Breakout	Yes	Seepage berm and shallow cutoff wall alternative meets criteria both at levee toe and berm toe.
200-year + 4 feet	0.34	0.70	N/A	No Breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.86		Yes	Seepage berm and shallow cutoff wall alternative meets criteria both at levee toe and berm toe.
200-year + 4 feet	1.81		Yes	

TABLE 5-9A: CHARACTERIZATION OF REACH 9
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
9	654+75 [2821+00]	706+50 [2872+75]	0.98	Total Number of Explorations = 17; Crest Explorations = 10 (SPT - 5, CPT - 5); Landside Toe Explorations = 6 (SPT - 4, CPT - 2); Landside Field Explorations = 1 (CPT - 1)	**Crown Width :** approximately 10 feet to 20 feet **Landside slope** Approximately 2H:1V or flatter than 2H:1V **Waterside Slope** Approximately 3H:1V to flatter than 3H:1V	• 655+57 [2821+72] to 279+10 [2845+25]: Waterside bank erosion encroaching on the levee section. (F.R. Site G) (Unknown Year). The site is located near Messick Road at approximate River Mile 21.2 (LM 7.3). • 677+72 [2843+88]: Scour on waterside berm of levee (1997) • 692+50 [2858+65]: This site is at the Boyd Pump Boat Ramp at LM 8, between Messick Road and Oswald Avenue at approximate RM 21.7. During the 1986 flood, portions of the boat ramp parking lot and subgrade and portions of the levee toe were eroded. (F.R. Site H) (1986) • 699+35 [2865+51]: Bank erosion at pump structure at waterside levee (1997) Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 1/4 th of Reach 9 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 1/2 of Reach 9 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations.	655+83 [2820+78] to 706+50 [2872+50]: In 1998, the Corps raised the levee 1-foot and installed a pervious toe drain and seepage/stability berm at the site under the Marysville/Yuba City Levee Reconstruction Project. (F.R. Site H). Site 9: Toe drain and berm from LM 7.28 to LM 8.26. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001.	R_{SL} (Recent Slough deposits) R_a (Recent Alluvium) R_{ofc} (Recent Overflow Channels) BP (Borrow Pit present in 1937) SP (Spoils present in 1937)	High resistivity soil layers present at approximately 10 ft below the embankment. The resistive layer extends to the ground surface occasionally.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Sand (SP, SM) and Silt (ML). Sand encountered in the entire levee embankment (from levee crown to levee toe) in several explorations. **Foundation**: Near Surface layers include Sand (SP-SM), Clay (CL), and Silt (ML). Thick porous layers are present in multiple layers.	**200 yr WSE** Head = approximately 17.6 feet at the analysis section	Mostly Agricultural. Scattered houses and Sheds observed from aerial maps.	705+84 [2872+00]	WL0001_010S, 2F-91-14 (CREST), WL0001_079C, WL0001_004B, 2F-91-14A (TOE), WL0001_111C (FIELD)	Sand and silty sand in levee embankment may indicate potential for through seepage; sandy foundation layer present near the surface indicate potential for shallow seepage (leaking layer); fine-grained layer below surface sandy layer create potential blanket condition for underseepage; deep sand/gravel layers also present.

TABLE 5-9B: ANALYSIS RESULTS FOR REACH 9
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 705+84

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.59	N/A	N/A	3.7	No	High breakout point, which is an indication of through seepage potential is due to sandy materials in the embankment.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 9 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 9 is seepage berm with shallow cutoff wall. Seepage berm material type is silty sand, which is similar to shallow near surface layers. The shallow cutoff wall reduces the potential for seepage through shallow near surface sandy layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 3 feet wide and 45.5 feet deep cutoff wall starting at Elevation 64.5 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.08	N/A	N/A	At the landside levee toe	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	0.10	N/A	N/A	At the landside levee toe	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.37		Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	2.28		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm and Shallow Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: Seepage Berm - 110 feet wide berm, 3 feet thick at berm toe and 5 feet thick at levee toe, and berm soil type - silty sand
Shallow Cutoff Wall - 3 feet wide and 29.5 feet deep cutoff wall starting at Elevation 64.5 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.15	0.49	N/A	At the landside levee toe	Yes	Seepage berm and shallow cutoff wall alternative meets criteria both at levee toe and berm toe.
200-year + 4 feet	0.21	0.54	N/A	At the landside levee toe	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.45		Yes	Seepage berm and shallow cutoff wall alternative meets criteria both at levee toe and berm toe.
200-year + 4 feet	2.39		Yes	

TABLE 5-10A: CHARACTERIZATION OF REACH 10
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
10	706+50 [2872+75]	774+00 [2940+25]	1.28	Total Number of Explorations = 20; Crest Explorations = 11 (SPT - 6, CPT - 5); Landside Toe Explorations = 8 (SPT - 5, CPT - 3); Landside Field Explorations = 1 (CPT - 1)	**Crown Width :** approximately 18 feet to 20 feet **Landside Slope** approximately 2H:1V to flatter 2H:1V **Waterside Slope** approximately 3H:1V to flatter than 3H:1V	No documentation of past performance problems were found in the reviewed documents or site walk with LD1 representative. However, based on DWR's Seepage Area map for the Feather River West Levee area, approximately 7/10 th of Reach 10 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 3/5 th of Reach 10 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations.	No documentation of existing levee improvements were found in the reviewed documents or site walk with LD1 representative.	R_{ob} (Recent Overbank) H_a (Holocene Alluvium) H_{ofc} (Holocene Overflow Channels)	Approximately 60 feet thick, continuous, high resistivity soil layer is present at approximately 10 feet below the embankment from 706+65 [2872+65] to 739+92 [2906+00]. The high resistive layer is not observed beyond Sta. 739+92 [2906+00] to the end of the Reach.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: Sand (SP, SP-SM, SC). Foundation: Near Surface layers include SM, CL, ML. Thick (~ 25 feet) pervious zones was encountered at about 25 feet below the embankment in crest explorations. Blanket thins at the toe explorations.	**200 yr WSE** Head = approximately 17.6 feet at the analysis section	Garden highway runs parallel along 1200 feet of this Reach.	733+84 [2900+00]	2F-91-15, CF-88-9, WL0001_057C, WL0001_058C (CREST), 2F-91-15A and SL0001_001B (LANDSIDE TOE)	Sandy layers in levee embankment may indicate potential for through seepage; Location coincide with high resistivity soils shown in HEM differential resistivity profiles; Moderately thick fine-grained blanket layer (about 30 feet thick) encountered in the explorations within this reach in the crest explorations, however blanket thins based on the landside toe explorations.	

TABLE 5-10B: ANALYSIS RESULTS FOR REACH 10
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 733+84

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.86	N/A	N/A	5.8	No	High breakout point due to sandy materials in the embankment.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 10 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 10 is seepage berm with shallow cutoff wall. Seepage berm material type is silt, which is similar to shallow near surface layers. The shallow cutoff wall reduces the potential for seepage through shallow near surface sandy layers. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 3 feet wide and 68.5 feet deep cutoff wall starting at Elevation 64.9 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.99		Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	1.99		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm and Shallow Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: Seepage Berm - 300 feet wide berm, 3 feet thick at berm toe and 7.2 feet thick at levee toe, and berm soil type - silt
Shallow Cutoff Wall - 3 feet wide and 35 feet deep cutoff wall starting at Elevation 65 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.29	0.89	N/A	0	Meets criteria at levee toe. See Comments on berm toe.	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
200-year + 4 feet	0.38	1.0	N/A	0		

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.00		Yes	
200-year + 4 feet	1.99		Yes	

TABLE 5-11A: CHARACTERIZATION OF REACH 11
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
11	774+00 [2940+25]	830+00 [2996+25]	1.06	Total Number of Explorations = 15; Crest Explorations = 9 (SPT - 6, CPT - 3); Landside Toe Explorations = 4 (SPT - 2, CPT - 2); Landside Field Explorations = 2 (CPT - 2)	**Crown Width :** approximately 15 feet to 20 feet **Landside slope** approximately 2H:1V to flatter than 2H:1V **Waterside Slope** approximately 3H:1V to flatter than 3H:1V	812+50 [2978+75]: During 1997 flood, a boil developed around a tree. Clean water was coming out. Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 2/3 rd of Reach 11 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 2/3 rd of Reach 11 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations.	No documentation of existing levee improvements were found in the reviewed documents or site walk with LD1 representative.	R_{ob} (Recent Overbank) R_a (Recent Alluvium)	Approximately 50 feet thick, continuous, high resistivity soil layer is present immediately below the embankment in this Reach.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: SP, SM, ML, CL **Foundation**: Fine-grained blanket less than 10 feet thick underlain by approximately 10 to 30 feet thick pervious layers.	**200 yr WSE** Head = approximately 14.8 feet at the analysis section	Mostly agricultural with scattered residential houses. Mostly urban in the northern 700 feet (approximately) of the reach (Yuba City)	808+85 [2975+00]	2F-07-01 (CREST), SL0001_008C (TOE), CPT-11 (FIELD)	Thin fine-grained blanket encountered in the boring and CPT underlain by thick pervious layers may indicate potential for underseepage; Approximately 30 feet thick pervious zone (SP layer) below the fine-grained blanket was encountered in both crest and landside toe explorations approximately at the same elevations.	

TABLE 5-11B: ANALYSIS RESULTS FOR REACH 11
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 808+85

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.38	N/A	N/A	8.4 feet above LS toe	No	High breakout point due to presence of silt layer in the levee.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 11 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 11 is seepage berm with drained stability berm. Seepage berm material type is sandy silt, which is similar to shallow near surface layers. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 3 feet wide and 73 feet deep cutoff wall starting at Elevation 67.5 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.56		Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	1.54		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm and Drained Stability Berm

Dimensions of Primary Features: Seepage Berm - 300 feet wide berm, 3 feet thick at berm toe and 7.2 feet thick at levee toe, berm soil type - sandy silt
Drained Stability Berm - 7.5 feet tall, 10 feet wide at top, 2 feet thick drain, and 3H:1V landside slope

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.34	1.41	N/A	0	Meets criteria at levee toe. See Comments on berm toe.	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
200-year + 4 feet	0.49	1.67	N/A	0		

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.19		Yes	
200-year + 4 feet	1.91		Yes	

TABLE 5-12A: CHARACTERIZATION OF REACH 12
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
12	830+00 [2996+25]	845+00 [3011+25]	0.28	Total Number of Explorations = 7; Crest Explorations = 5 (SPT - 3, CPT - 2); Waterside Field Explorations = 2 (SPT - 2)	**Crown Width :** approximately 20 feet **Landside slope** approximately 2H:1V to flatter 2H:1V **Waterside Slope** approximately 3H:1V to flatter than 3H:1V	834+39 [3009+39]: The site is located at Shanghai Bend at approximate River Mile 25.0 (LM 10.8). Seepage occurred at this site during the previous flood events. (F.R. Site I). 839+71 [3005+86] to 908+21 [3074+31]: The site is located between Shanghai Bend and Yuba City Airport between approximate River Miles 25.1 and 26.5 (LM 11.0 and 12.4). 842+22 [3009+39]: Seepage and a boil occurred just beyond the berm toe during the 1995 high water. (F.R. Site I) Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 12 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 12 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	829+85 [2996+00] to 846+20 [3012+50]: Shanghai Bend setback levee with cutoff wall. Additional site investigation report and Star Bend borrow site report for the Project "PL 84-99 Cost Shared, Basin No. 18, Feather River, Shanghai Bend, dated 1999. USACE Drawing File No. 4-4-620" were available during preparation of this report.	R_{ob} (Recent Overbank)	High resistivity soil layer is not present for most of this Reach. The high resistivity layer starts towards the northern end 843+61 [3010+00], immediately below the ground surface.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: ML, SC, CL **Foundation**: Shallow Sand layer (potentially cutoff by slurry wall). Deep thick sand layer present approximately 30 feet below embankment.	**200 yr WSE** Head = approximately 16.9 feet at the analysis section	Urban Area (Yuba City)	830+59 [2996+70]	WL0001_064B, WL0001_065C (CREST), SL0001_009C, (LANDSIDE TOE), CPT-11 (FIELD)	Recently built setback levee includes a shallow cutoff wall. Available explorations in the area indicate that the cutoff wall tip embedded within fine-grained soil (fully penetrating cutoff wall); Analysis to evaluate effect of the deep sand and gravel layers.

TABLE 5-12B: ANALYSIS RESULTS FOR REACH 12
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 830+59

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	< 0.1	N/A	N/A	No Breakout	Yes	Shanghai Bend setback levee with cutoff wall. Available explorations indicate that the cutoff wall toe embedded in fine-grained soil layer.
200-year + 3 feet	< 0.1	N/A	N/A	No Breakout	Yes	
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year	1.78				Yes	Shanghai Bend setback levee with cutoff wall. Available explorations indicate that the cutoff wall toe embedded in fine-grained soil layer.
200-year + 3 feet	1.78				Yes	
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

TABLE 5-13A: CHARACTERIZATION OF REACH 13
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
13	845+00 [3011+25]	927+00 [3093+25]	1.55	Total Number of Explorations = 70; Crest Explorations = 19 (SPT - 10, CPT - 9); Landside Toe Explorations = 2 (SPT - 1, CPT - 1); Landside Field Explorations = 45 (SPT - 7, CPT - 38); Waterside Field Explorations = 4 (SPT - 4)	**Crown Width** approximately 15 feet to 20 feet **Landside Slope** 1.8 H:1V to flatter than 2H:1V **Waterside Slope** 2.5H:1V to flatter than 3H:1V	839+71 [3005+86] to 908+21 [3074+31]: The site is located between Shanghai Bend and Yuba City Airport between approximate River Miles 25.1 and 26.5 (LM 11.0 and 12.4). The levee broke in this area during the 1909, 1911, and 1955. (F.R. Site J). Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 13 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 13 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	845+71 [3012+00] to 926+51 [3092+65]: In 1957, the USACE reconstructed the levee to the LS of it's previous loc. and installed a row of relief wells near the LS levee toe. Water from the relief wells is pumped to the Feather River (FR). (F.R. Site J). Note: The actual LMs for this improv. meas. are from LM 11.3 to LM 12.8. Relief wells are spaced at 200 feet intervals. Plans are available in the doc. entitled "Emergency Levee Repairs, Relief Wells - Right Bank FR, Shanghai Bend, Sutter County, Ca, USACE File 4-4-435". 845+71 [3012+00] to 926+15 [3092+65]: In 1990, the City of Yuba City installed a seepage interceptor system in the southern part of this site. The interceptor system consists of a perforated pipeline and filter 12-18 feet below ground surface to extract shallow seepage, and relief wells placed between the 1957 relief wells to extract deeper seepage. All water collected is pumped into the Feather River separately from the water collected by the 1957 relief wells. (F.R. Site J). Note: According to Bill Hampton of LD1, this interceptor system cont. up to 3092+65.	R_{ch} (Recent Channels) Ra (Recent Alluvium) R_{ms} (Channel meander scroll deposits) W_{37} (Water)	Approximately 50 feet thick, continuous, high resistivity soil layer is present immediately below the embankment from 845+71 [3012+00] to 893+90 [3060+00]. Beyond 893+90 [3060+00], the layer is present 10 ft below the foundation.
						845+71 [3012+00] to 926+15 [3092+65]: During the 1986 flood, volunteers sandbagged several boils in this area. (F.R. Site J). Site 3: At the downstream of Shanghai Bend, an area of concentrated seepage produced boils during the 1986 high water. These boils were controlled with sack rings. Site 3: According to LD 1 Engineer Mr. Von Geldern, Relief wells in Shanghai Bend area produced 3 gallons per minute during the 1986 high water. Additional seepage occurred in fields adjacent to the levee. Seepage appeared in this area up to several hundred feet away from the levee toe (1986). 893+89 [3060+16] to 902+77 [3069+06]: Heavy seepage near landside toe of levee south of Burns Drive (1997)	845+71 [3012+00] to 926+15 [3092+65]: In 1993, and inspection of the shallow drain perforated pipeline discovered unacceptable deflections over large portions of the pipeline. The deformed plastic pipeline was removed and replaced with a perforated clay pipeline. (F.R. Site J). 829+44 [3058+59] to 926+50 [3092+65]: In 2001, the Corps of Engineers rehabilitated the original 1957 relief wells under a PL 84-99 contract. (F.R. Site J). Project plans entitled "PL 84-99 Cost Shared Added Sites Sacramento Basin No. 18 Relief Well Improvements," dated 7/31/2000. USACE Design File No. 4-04-625. **During the site visit in November 2010, relief wells at a spacing of 100 feet were observed from station 845+61 [3012+00] to 926+15 [3092+65]**		

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Sand (SP, SP-SM, SM) **Foundation**: Near Surface Layers SM, ML, SC. Thick layers of pervious zones (sand and gravel) present at shallow and deep layers.	**200 yr WSE** Head = approximately 22.3 feet at the analysis section	Urban Area (Yuba City)	861+33 [3027+50]	WL0001_067B, WL0001_067C, B-40 (CREST); CPT 22, CPT 23, SL0001_002B (LANDSIDE TOE); B-33 and B-57 (LANDSIDE FIELD); B-51 and B-52 (WATERSIDE TOE AND FIELD)	Near surface layer consists of sand or sandy layers. Shallow silty sand and sandy silt layer overlying a thick porous zone may create a thin blanket condition and potential for underseepage. HEM differential resistivity profiles indicate presence of thick layer of high resistivity soils from ground surface; Sandy layers in levee embankment may indicate potential for through seepage. Levee embankment at this section have SP-SM materials.

TABLE 5-13B: ANALYSIS RESULTS FOR REACH 13
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 861+33

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.21	N/A	1.38	9.2 feet above LS toe	No	High breakout point due to presence of sand layers (<10% fine contents) in the levee embankment.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative 1 for Reach 13 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 13 is relief wells with shallow cutoff wall. Existing relief wells have 100 feet spacing and alternatively 20 feet (installed after 1955 flood) and 50 feet deep (installed in 1990s). Analysis indicated 100 feet wide spacing, however considering presence of existing deep (50 feet deep) relief wells, recommended spacing is 200 feet.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall						
Dimensions of Primary Features:	3 feet wide and 97 feet deep cutoff wall starting at Elevation 68.8 (half levee degrade)					
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.69				Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	1.68				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Shallow Soil-Bentonite Cutoff Wall and Relief Well						
Dimensions of Primary Features:	Shallow Cutoff Wall - 3 feet wide and 32 feet deep cutoff wall starting at Elevation 68.8 (half levee degrade) Relief Well - 200 feet Spacing and 65 feet Deep. Existing relief wells have 100 feet spacing and alternatively 20 feet (installed after 1955 flood) and 50 feet deep (installed in 1990s). Analysis indicated 100 feet wide spacing, however considering presence of existing deep (50 feet deep) relief wells, recommended spacing is 200 feet.					
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	Shallow cutoff wall and relief well system meet criteria
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.69				Yes	Shallow cutoff wall and relief well system meet criteria
200-year + 4 feet	1.69				Yes	

TABLE 5-14A: CHARACTERIZATION OF REACH 14
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
14	927+00 [3093+25]	954+40 [3120+25]	0.52	Total Number of Explorations = 10; Crest Explorations = 9 (SPT - 2, CPT - 2, TP - 5); Landside Toe Explorations = 1 (CPT - 1)	**Crown Width :** approximately 18 feet to 20 feet **Landside slope** approximately 2H:1V to flatter then 2H:1V **Waterside Slope** approximately 3H:1V to flatter than 3H:1V	No documentation of past performance problems were found in the reviewed documents or site walk with LD1 representative. However, based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 14 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 14 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	Site 8: Slurry walls from LM 12.76 to LM 13.28. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001.	R_a (Recent Alluvium)	Approximately 40 feet thick, continuous, high resistivity soil layer is present immediately below the embankment in this Reach.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: Silty sand and silt (SM, ML) **Foundation**: Near Surface layer silty sand and silt (SM, ML). Thick layers of sand and silt sand (SP, SM) and Gravel (GP).	**200 yr WSE** Head = approximately 13.2 feet at the analysis section	Urban Area, Airport (Yuba City)	939+33 [3105+50]	2F-07-02, WL0001_073C (CREST) and SL0001_011C (LANDSIDE TOE)	Based on the design drawings, slurry wall tip in SP/SM layer (potential partially penetrating cutoff wall). Silty sand encountered at toe location at ground surface. However, based on information provided by Bill Hampton of LD1 during a November 2010 site visit the cutoff wall depth varied to embed tipin fine-grained soil. The model is developed using a deeper cutoff wall than depth shown on design drawings. However, specification requirements and as-built documents should be evaluated or excavation should be performed to investigate the depths and conditions of the cutoff walls in this Reach.	

TABLE 5-14B: ANALYSIS RESULTS FOR REACH 14
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 939+33

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.07	N/A	0.3 (approximately 55 feet from landside toe)	No Breakout	Yes	The design drawings for this section indicates that the proposed cutoff wall depth is 40 feet. A sensitivity analysis using 40 feet cutoff wall depth did not meet seepage criteria for 200 year and 200+3 feet WSE as the tip of the cutoff wall was in coarse-grained soil layer. Based on discussion with Bill Hampton of LD1 during a site visit in November, 2010, the cutoff wall depths in this area were varied to embed the tip in fine-grained soil layers. Therefore, the analysis model was developed with an assumed cutoff wall depth of approximately 50 feet i.e. cutoff wall tip embedded in fine-grained soil. Specification requirement and as-built drawings should be evaluated or excavation should be performed to investigate the conditions of the cutoff wall. Moreover, a sensitivity study using a $K_h = 10^{-5}$ cm/sec in the top 15 feet of the cutoff wall (for 50 feet deep cutoff wall section) was performed to evaluate effect of potential cracking in the upper portion of the wall. The sensitivity analyses meet criteria.
200-year + 3 feet	0.16	N/A	0.4 (approximately 55 feet from landside toe)	No Breakout	Yes	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	2.0		Yes	
200-year + 3 feet	1.93		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-15A: CHARACTERIZATION OF REACH 15
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
15	954+40 [3120+25]	968+50 [3134+50]	0.27	Total Number of Explorations = 8; Crest Explorations = 3 (SPT - 2, CPT - 1); Landside Toe Explorations = 4 (SPT - 2, CPT - 2); Landside Field Explorations = 1 (CPT - 1)	**Crown Width :** approximately 15 feet to 20 feet **Landside slope** 1.5 H:1V to flatter than 2H:1V **Waterside Slope** 1.7H:1V to flatter than 3H:1V	No documentation of past performance problems were found in the reviewed documents or site walk with LD1 representative. However, based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 15 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 15 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	Site 8: Toe drain and berm from LM 12.26 to LM 13.57. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001. **NOTE: DURING A SITE VISIT ON NOVEMBER 2010, NO BERM WAS FOUND. ACCORDING TO BILL HAMPTON OF LD1, A CUTOFF WALL WAS CONSTRUCTED IN THIS AREA.**	R_a (Recent Alluvium) R_{cs} (Recent Crevasse Splay)	Approximately 40 feet thick, high resistivity soil layer is present immediately below the embankment from 953+80 [3120+00] to 958+80 [3125+00] in this Reach. Beyond this station resistive layer was not observed.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: Silty clay, silty sand, and silt (CL, SM, ML) **Foundation**: Near Surface layer consists of silty sand and silt (SM, ML). Sand and Gravel (SP, GM) are present at shallow at deep layers.	**200 yr WSE** Head = approximately 12.4 feet at the analysis section	Urban Area, Airport, Police Station, Baseball Field (Yuba City)	958+83 [3125+00]	WL0001_073C, WL0001_074B, 4F-88-7 (CREST), 2F-88-9A, WL0001_003B, WL0001_103C, WL0001_105C (TOE), and WL0001_108C (LANDSIDE FIELD)	Sand and silty sand in levee embankment may indicate potential for through seepage; Shallow and deep sand/gravel layers may indicate potential for underseepage.	

TABLE 5-15B: ANALYSIS RESULTS FOR REACH 15
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 958+83

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.6	N/A	1.15 (at 25 feet from LS toe)	2.4	No	A toe berm and drain was designed for this section by USACE. However, no berm was found during a field visit in November 2010. According to Bill Hampton of LD 1, a cutoff wall was installed in this segment. As-built documents or verification study is needed to investigate the presence and conditions of the cutoff wall.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year	19 feet drop from 200yr WSE	2.14	A drop of 19 feet was estimated from evaluation of 1986 and 1997 flood levels at gage station "YUB," which is located near Yuba city. The duration of drop considered was 7 days.	Yes	

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 15 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through seepage and underseepage potential. Alternative 2 for Reach 15 is a shallow cutoff wall and relief well system. The seepage berm alternative was not considered because this Reach is located near an urban area.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 3 feet wide and 64 feet deep cutoff wall starting at Elevation 73 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.09		Yes	
200-year + 4 feet	2.07		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Shallow Cutoff Wall and Relief Wells

Dimensions of Primary Features: Relief Wells: 23 feet spacing and 51.5 feet deep.
Shallow Cutoff Wall: 3 feet wide and 36 feet deep cutoff wall starting at Elevation 73 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	Relief wells are modeled to meet an average exit gradient of 0.5 at the center of two relief wells. The head drop at the relief well location and between the relief well and midpoint between relief wells should be higher i.e. gradients should be lower than 0.5. The analyses was performed in accordance with USACE EM 1110-2-1914.
200-year + 4 feet					Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.9		Yes	
200-year + 4 feet	1.87		Yes	

TABLE 5-16A: CHARACTERIZATION OF REACH 16
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
16	968+50 [3134+50]	1080+00 [3246+25]	2.11	Total Number of Explorations = 48; Crest Explorations = 34 (SPT - 24, CPT - 10); Landside Toe Explorations = 4 (SPT - 3, CPT - 1); Landside Field Explorations = 7 (SPT - 7); Waterside Field Explorations = 4 (SPT - 3)	**Crown Width :** approximately 15 feet to 20 feet **Landside slope** 1.6 H:1V to flatter than 2H:1V **Waterside Slope** 1.4H:1V to flatter than 3H:1V	Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 16 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 16 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps. 971+00 [3137+19] The site is located near the Yuba City Airport at approximate River Mile 27.0 (LM 13.6). Seepage occurs at the site during high water. (F.R. Site K). 991+94 [3158+16] to 1070+74 [3236+83]The site is located in Yuba City from Garden Highway north to the Drive-In Cinema between approximate River Miles 27.4 to 29.3 (LM 14.0 to LM 15.5). During the 1955 flood, seepage was observed near the 10th Street Bridge. (F.R. Site L). 991+94 [3158+16] to 1070+74 [3236+83]: During the 1986 flood, the landside slope became saturated and unstable and bulged slightly in the area of the Corporation Yard. Water also flowed up through cracks in the parking lot pavement and the floor slab of an auto body shop on Teegarden Avenue. (F.R. Site L).	Site 8: 927+08 [3093+19] to 968+31 [3170+25] Slurry walls from LM 12.76 to LM 13.28. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001. 1019+75 [3186+85] to 1080+25 [3246+40] with gap in HWY-20: Slurry wall from LM 14.56 to LM 15.68. Plans entitled "PL 84-99 Cost Shared/Added Sites Sacramento Basin No. 18 LD1 Slurry Wall, undated, USACE Design File No. 4-25-625." Note: Based on Doc. 3045 and 946, an approximately 135 feet gap between slurry walls from two projects. PL 84-99 calls for an overlap between the slurry walls.	R_a (Recent Alluvium) R_{cs} (Recent Crevasse Splay) H_{ch} (Holocene Channel) R_{ob} (Recent Overbank) R_{ch} (Recent Channel) (along almost the entire reach - Gilsizer Slough)	High Resistivity soil layers are present intermittently along the Reach, immediately below the embankment.
						991+96 [3158+16] to 1070+69 [3236+83]: Site 1: This is a reach of levee extending 4000 feet through downtown Yuba City. During the 1986 flood, this area showed considerable wetness on landside slope. (1986). 1041+99 [3208+07] to 1073+59 [3239+44]: During the 1997 flood, heavy seepage north of 10th Street Bridge. Heavy seepage near two City drainage pipes. 1005+95 [3172+25] to 1021+87 [3188+10]: During the 1986 flood, Erosion of the waterside levee toe occurred in the areas immediately upstream and downstream of the Fifth Street Bridge. (F.R. Site L). 1005+95 [3172+25] to 1021+87 [3188+10]: During the 1997 flood - this is an area of waterside erosion which extends for several hundred feet upstream and downstream of the Fifth Avenue Bridge (Site 2). This erosion occurred mostly low down on the slope and had cut into the levee section causing a steepening of the lower levee slope. Bank and levee erosion south of the 5th Street Bridge. Bank erosion between 5th Street Bridge and 10th Street Bridge (1997).	991+96 [3158+16] to 1025+84 [3224+00]: Yuba City constructed a berm along the landside toe as an emergency action. A permanent seepage/stability berm was later constructed from the Fifth Street Bridge extending northward to about 2500 feet beyond the 10th Street Bridge. An impermeable cutoff wall was also constructed in this area (See F.R. Site K). (F.R. Site L). 991+96 [3158+16] to 1025+84 [3224+00]: Temporary toe drain/berm: Site 1: In 1986, this area was upgraded by placing a landside berm on the slope with an internal drain protected by filter fabric which extends into the toe. Drainage from this system can be monitored at drain pipes.		

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Silty sand and silt (SM, ML), thin layers of silty clay (CL) **Foundation**: Shallow layers of CL, SM, ML, SC. Sand layers are approximately 10 feet thick and interlayered with CL, ML.	**200 yr WSE** Head = approximately 17.1 feet at the analysis section 993+80 and approximately 21.3 feet at the analysis section 1043+88	Urban Area (Yuba City)	993+80 [3160+00] and 1043+88 [3210+00]	SECTION 993+80: 2F-07-03 (CREST), SL0001_012C (LANDSIDE TOE) SECTION 1043+88: WL0001_081B, WL0001_081C, DH-4C, DH-4A (CREST); DH-4D, DH-4B (LANDSIDE TOE)	Location of mapped old Gilsizer Slough. Location of existing slurry wall.

TABLE 5-16B: ANALYSIS RESULTS FOR REACH 16 (ANALYSIS SECTION 1)
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 993+80

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	<0.1	N/A	N/A	No Breakout	Yes	A sensitivity study using a $K_h = 10^{-5}$ cm/sec in the upper 20 feet of the cutoff wall was performed to evaluate effect of potential cracking in the upper portion of the wall. The sensitivity analyses meet criteria. Specification requirement and as-built drawings should be evaluated or excavation should be performed to investigate the conditions of the existing cutoff walls.
200-year + 3 feet	<0.1	N/A	N/A	No Breakout	Yes	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	1.48		Yes	
200-year + 3 feet	1.47		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year	19 feet drop from 200yr WSE	0.94	A drop of 19 feet was estimated from evaluation of 1986 and 1997 flood levels at gage station "YUB," which is located near Yuba city. The duration of drop considered was 7 days.	No	This section does not meet Rapid Drawdown criteria due to a steep waterside slope (~1.6H:1V).

Rationale for Selection of Two Alternatives for Analysis

Typical alternative section with 3H:1V waterside slope and clay embankment satisfies the criteria. Typical section includes 20 feet wide crest, and 3H:1V waterside slope.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-16C: ANALYSIS RESULTS FOR REACH 16 (ANALYSIS SECTION 2)
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1043+88

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	<0.1	N/A	0.4 (280 feet from LS toe)	No Breakout	Yes	A sensitivity study using a $K_h = 10^{-5}$ cm/sec in the upper 20 feet of the cutoff wall was performed to evaluate effect of potential cracking in the upper portion of the wall. The sensitivity analyses meet criteria. Specification requirement and as-built drawings should be evaluated or excavation should be performed to investigate the conditions of the existing cutoff walls.
200-year + 3 feet	<0.1	N/A	0.42 (280 feet from LS toe)	No Breakout	Yes	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	2.17		Yes	
200-year + 3 feet	2.14		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-17A: CHARACTERIZATION OF REACH 17
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
17	1080+00 [3235+00]	1130+86 [3297+00]	0.96	Total Number of Explorations = 17; Crest Explorations = 8 (SPT - 6, CPT - 2); Landside Toe Explorations = 2 (SPT - 1, CPT - 1); Landside Field Explorations = 5 (SPT - 4, CPT - 1); Waterside Toe Explorations = 1 (CPT - 1); Waterside Field Explorations = 1 (SPT - 1)	**Crown Width :** approximately 15 feet to 20 feet **Landside slope** approximately 1.8H:1V to flatter than 2H:1V **Waterside Slope** approximately 2.5H:1V to flatter than 3H:1V	No documentation of past performance problems were found in the reviewed documents or site walk with LD1 representative. However, based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 17 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 17 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	No documentation of existing levee improvements were found in the reviewed documents or site walk with LD1 representative.	R_a (Recent Alluvium) R_{ob} (Recent Overbank) BP (Borrow Pit Present in 1937)	High resistivity soil layers are present immediately below the embankment, occasionally.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: Silty clay, silty sand, and silt (CL, SM, ML) **Foundation**: Near Surface layer consists of silty sand and silt (SM, ML). Silty sand and silt (SM, ML) are present at shallow at deep layers.	**200 yr WSE** Head = approximately 17.7 feet at the analysis section	Urban Area (Yuba City)	1108+86 [3275+00]	2F-07-05 (CREST), WL0001_003C (WS TOE), WL0001_002C, WL0001_002B (LS TOE), AND WL0001_106C (LANDSIDE FIELD)	A swale or depression is present near the landside toe. Interbedding of ML and CL layers in the levee embankment and foundation. Boring 2F-07-05 encountered sand in foundation.

TABLE 5-17B: ANALYSIS RESULTS FOR REACH 17
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1108+86

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.13	N/A	N/A	5.9	No	
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 17 is soil-bentonite cutoff wall and fill-in of the landside ditch/swale, which was selected as an in-place alternative to mitigate both through seepage and underseepage potential. Alternative 2 for Reach 17 is shallow cutoff wall with relief well system. The seepage berm alternative was not considered because this Reach is located near an urban area.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall and fill-in ditch

Dimensions of Primary Features: 3 feet wide and 39 feet deep cutoff wall starting at Elevation 74 (half levee degrade)
Soil type of the ditch/swale fill in - sandy silt

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.46	0.29 (soil filled-in ditch)	N/A	3.0	Yes	Considering the cutoff wall and levee degrade and rebuild criteria, the section meets through seepage criteria.
200-year + 4 feet	0.58	0.33 (soil filled-in ditch)	N/A	4.1	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.43			
200-year + 4 feet	1.33			

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Relief Wells and Shallow Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: Relief wells - 45 feet spacing and 40 feet deep.
Shallow Cutoff Wall - 3 feet wide and 16 feet deep cutoff wall starting at Elevation 74 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	Shallow cutoff wall and relief well system meet criteria. Relief wells are modeled to meet an average exit gradient of 0.5 at the center of two relief wells. The head drop at the relief well location and between the relief well and midpoint between relief wells should be higher i.e. gradients should be lower than 0.5. The analyses was performed in accordance with USACE EM 1110-2-1914.
200-year + 4 feet					Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.69		Yes	Shallow cutoff wall and relief well system meet criteria
200-year + 4 feet	1.69		Yes	

TABLE 5-18A : CHARACTERIZATION FOR REACH 18
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
18	1130+86 [3297+00]	1213+85 [3380+00]	1.6	Crest:8 Borings 7 CPTs Landside: 2 Borings 6 CPTs 2 Hand augers Waterside: Not available	Levee Height: 20 feet Crown Width: 22 feet Landside Slope: 2.0H:1V Waterside Slope: 3.0H:1V at analysis section	• Seepage reported during storms of late 1996 from 1135+00 to 1214+24 [3299+00 to 3380+44]. • Sinkholes observed on riverside toe of levee in Winter of 1966 from 1136+32 to 1153+14 [3302+46 to 3319+28], repaired in Spring of 1966. • Sinkhole in 1986 at 1173+78 [3339+92]. • Heavy seepage reported in 1997 from 1131+08 to 1199+60 [3297+21 to 3365+74]. • Based on DWR's Seepage Area map for the Feather River West Levee area, 20% of Reach 18 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 25% of Reach 18 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• Repair of sinkholes on riverside toe of levee in Spring 1966. Note: As-Constructed Drawings not available.	Rob (Recent Overbank) Qmu (Pleistocene Modesto Formation - Upper) Rofc (Recent Overflow Channel) Ra (Recent Alluvium) Rch (Recent Channel)	Shallow higher resistivity zone near downstream end of reach

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 19 to 20 feet of sandy silt to lean clay with minor silty sand. • Foundation: 2 to 20 feet of sandy silt to lean clay. • 4 to 27 feet of sand to silty sand with localized silt. • 10 to 40 feet of silty sand to fat clay with minor silty sand and clayey sand. • 3 to 16 feet of poorly-graded gravel to poorly-graded sand with lean clay. • 4 to 23 feet of silty sand to fat clay.	200 Year 13 feet	LS and WS orchards along most of reach, Agricultural buildings at 1179+86 [3346+00]	1138+86 [3305+00]	WL0009_001S (crest), WL0009_008C (crest), WL0009_005C (landside toe), WL0009_004C (landside toe), WL0009_003H (landside), WL009_007A (landside toe)	Thinner blanket over sand layer more susceptible to underseepage.

TABLE 5-18B ANALYSIS RESULTS FOR REACH 18
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1138+86

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.32	N/A	N/A	8.0	No	The reach has reported seepage deficiencies including seepage reported in 1965 and 1996, and heavy seepage reported in 1997.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 18 is undrained seepage berm with relief wells. Seepage berm material type is silt having similar hydraulic conductivity as the clay blanket. Relief wells and/or a drainage system could be used to reduce high gradient. Alternative 2 for Reach 18 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate underseepage potential. The cutoff wall will block the flow through the existing thick aquifer, and effectively control the underseepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Relief Wells

Dimensions of Primary Features: 300 feet wide seepage berm, seepage berm thickness at the levee toe = 7.0 feet, thickness at the berm toe = 3 feet; Relief wells: depth = 30 feet and spacing = 100 feet.

Seepage

WSE	Exit Gradient Levee Toe	Berm (near berm toe)	Berm Toe	Phreatic Surface Breakout Point above Berm	Meets Criteria?	Comments
200-year + 1 foot	0.38	0.69	1.31	3.2	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Levee prism mainly consists of clayey soils; Drainage berm not required for through seepage.
200-year + 4 feet	0.55	0.89	1.58	6.0	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Levee prism mainly consists of clayey soils; Drainage berm not required for through seepage.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.59		Yes	
200-year + 4 feet	1.23		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 1130+86 to 1149+50 Cutoff Wall Tip Elevation 0, 1149+50 to 1190+00 Cutoff Wall Tip Elevation 30, 1190+00 to 1213+85 Cutoff Wall Tip Elevation 40.

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis performed; Alternative 2 of Reach 19 was used in the evaluation; for details see Figures B19-A5 through B19-A8.
200-year + 4 feet					Yes	No separate analysis performed; Alternative 2 of Reach 19 was used in the evaluation; for details see Figures B19-A5 through B19-A8.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot			Yes	No separate analysis performed; Alternative 2 of Reach 19 was used in the evaluation; for details see Figures B19-A5 through B19-A8.
200-year + 4 feet			Yes	No separate analysis performed; Alternative 2 of Reach 19 was used in the evaluation; for details see Figures B19-A5 through B19-A8.

TABLE 5-19A : CHARACTERIZATION FOR REACH 19
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
19	1213+85 [3380+00]	1297+83 [3464+00]	1.6	Crest:14 Borings 4 CPTs Landside: 5 Borings 6 CPTs 1 Hand auger Waterside: 1 Boring	Levee Height: 20 feet Crown Width: 18 feet Landside Slope: 2.1H:1V Waterside Slope: 2.9H:1V at analysis section	• Boil and piping observed on landside of levee at 1242+86 [3409+01], landward half of levee excavated and recompacted with gravel filter in 1955. • Heavy levee saturation reported by Levee District 9 from 1259+63 to 1267+66 [3425+73 to 3433+88] (year unknown, awaiting information). • Pinhole boils observed on landside of levee in 1997 from 1288+24 to 1296+34 [3454+40 to 3462+52]. • Heavy seepage and boils on landside at 1278+82 to 1293+07 [3444+99 to 3459+25] in 1997 with river near 3 feet freeboard.	• Landward half of levee excavated and recompacted with gravel filter at 1242+86 [3409+01] in 1955. • Bank protection using rock was placed at 1266+45 to 1269+18 [3432+60 to 3435+35] in 1974. • Levee rock slope protection place at 1271+00 [3437+17] in 1974 • Drained toe berm repair was proposed near 1293+82 [3460+00] in 1998. Note: As-Constructed Drawings not available.	Ra (Recent Alluvium) Rofc (Recent Overflow Channel) Rob (Recent Overbank) Rcs (Recent Crevasse Splay) Qmu (Pleistocene Modesto Formation - Upper)	Shallow higher resistivity zone upstream of 1228+85 [3395+00]. Higher resistivity zone thickest from 1228+85 to 1238+85 [3395+00 to 3405+00].
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			• Levee: 18 to 20 feet of sandy silt to lean clay with minor well-graded gravel and clayey sand lenses. • Foundation: 14 to 46 feet of silty sand to fat clay with minor well-graded sand with silt to clayey sand. • 17 to 63 feet of poorly-graded gravel to poorly-graded sand with silt with minor silty sand and clayey sand. • 6 to 58 feet of silty sand to fat clay.	200 Year 13 feet	LS and WS orchards along much of reach, River at levee toe near 1267+84 [3434+00]	1238+85 [3405+00]	WL009_003S (crest), 2F-88-7 (crest), WL009_016C (landside toe), WL009_009A (landside toe), WL009_014C (landside toe), WL009_008A (landside toe)	Thin blanket over sand layer with underlying gravel susceptible to underseepage, near 1955 seepage area	

TABLE 5-19B ANALYSIS RESULTS FOR REACH 19
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1238+85

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	2.32	N/A	N/A	7.0	No	The reach has reported seepage deficiencies including heavy seepage and boils reported in 1997.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 19 is undrained seepage berm with relief wells and drained stability berm. Seepage berm material type is silt having similar hydraulic conductivity as the clay blanket. Relief wells provided at the berm toe to reduce high gradient. The drained stability berm is to control through seepage. Alternative 2 for Reach 19 is soil-bentonite cutoff wall, which was selected as an in-place alternative to effectively mitigate both through seepage and underseepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Relief Wells, and Drained Stability Berm

Dimensions of Primary Features: 300 feet wide seepage berm, thickness at the levee toe = 7.0 feet, thickness at the berm toe = 3 feet; Relief wells: depth = 50 feet and spacing = 100 feet; stability berm height = 10 feet above seepage berm.

Seepage

WSE	Exit Gradient Levee Toe	Berm (near berm toe)	Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.36	0.76	2.13	No breakout	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Drainage stability berm controls through seepage.
200-year + 4 feet	0.57	1.03	2.59	No breakout	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Drainage stability berm controls through seepage.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.56		Yes	
200-year + 4 feet	2.15		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 1213+85 to 1224+00 Cutoff Wall Tip Elevation 40, 1224+00 to 1240+00 Cutoff Wall Tip Elevation -27 , 1240+00 to 1269+00 Cutoff Wall Tip Elevation 5, 1269+00 to 1297+83 Cutoff Wall Tip Elevation 35.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	< 0.05	N/A	N/A	No breakout	Yes	
200-year + 4 feet	< 0.05	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.88		Yes	
200-year + 4 feet	1.86		Yes	

TABLE 5-20A : CHARACTERIZATION FOR REACH 20
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
20	1297+83 [3464+00]	1374+33 [3540+50]	1.4	Crest:9 Borings 9 CPTs Landside: 2 Borings 8 CPTs Waterside: 1 CPT	Levee Height: 16 feet Crown Width: 15 feet Landside Slope: 2.1H:1V Waterside Slope: 3.3H:1V at analysis section	• Heavy levee saturation reported by Levee District 9 from 1316+46 to 1320+70 [3482+64 to 3486+88] (year unknown). • Boil and piping observed on landside of levee at 1321+07 [3487+25], landward half of levee excavated and recompacted with fill in 1955. • Seepage and boil observed on landside of levee at 1328+73 [3495+06] in 1986. • Heavy seepage and boils about 20 feet from levee toe in 1997 at 1368+41 to 1410+63 [3534+58 to 3576+80] • Seepage and boils occur near the landside levee toe during high water at 1336+73 to 1410+70 [3502+94 to 3576+80]	• Landward half of levee excavated and recompacted with fill in 1955 at 1321+07 [3487+25].	Rcs (Recent Crevasse Splay) Rofc (Recent Overflow Channel) Qmu (Pleistocene Modesto Formation - Upper) Rob (Recent Overbank)	Shallow higher resistivity zone upstream of 1348+83 [3515+00].

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 12 to 18 feet of silty sand to lean clay. • Foundation: 4 to 13 feet of sandy lean clay to lean clay. • 1 to 10 feet of poorly-graded sand with silt to silty sand. • 20 to 43 feet of sandy silt to fat clay with minor poorly-graded sand with silt and silty sand. • 4 to 30 feet of poorly-graded sand with silt to silty sand with minor clayey sand to silt. • 44 to 74 feet of sandy silt to lean clay with minor silty sand and clayey sand.	200 Year 10 feet	Orchards in portions of reach, Agricultural buildings at 1348+33 [3514+50]	1338+83 [3505+00]	WL009_025C (crest), WL009_003A (landside toe), WL009_030C (200 ft landside)	10 feet of silty clayey sand (SC-SM) at toe overlying poorly graded sand with silt (SP-SM) susceptible to underseepage

TABLE 5-20B ANALYSIS RESULTS FOR REACH 20
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1338+83

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.72	NA	NA	3.0	No	The reach has reported seepage deficiencies including heavy seepage and boils reported in 1986 and 1997, and seepage and boils reported during high water.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 20 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through seepage and underseepage potential. Alternative 2 for Reach 20 is undrained seepage berm with drained stability berm on Top. Seepage berm material type is SC-SM, which is similar to shallow near surface layer. The drained stability berm is to control through seepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 1297+83 to 1359+00 Cutoff Wall Tip Elevation 50, 1359+00 to 1369+00 Cutoff Wall Tip Elevation 40, 1369+00 to 1374+33 Cutoff Wall Tip Elevation 50.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	< 0.05	N/A	N/A	No breakout	Yes	
200-year + 4 feet	< 0.05	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.64				Yes	
200-year + 4 feet	1.64				Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Drained Stability Berm on Top

Dimensions of Primary Features: 70 feet wide seepage berm, seepage berm thickness at the levee toe = 5 feet, thickness at the berm toe = 3 feet; 1297+83 to 1309+00 stability berm height = 8.5 feet above seepage berm, 1320+00 to 1374+33 stability berm height = 8.5 feet above seepage berm.

Seepage

WSE	Exit Gradient Levee Toe	Berm (near berm toe)	Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.14	0.09	0.65	No breakout	Yes	
200-year + 4 feet	0.30	0.20	0.79	No breakout	Yes	

Landside Stability

WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.09				Yes	
200-year + 4 feet	1.90				Yes	

TABLE 5-21A : CHARACTERIZATION FOR REACH 21
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
21	1374+33 [3540+50]	1433+83 [3600+00]	1.1	Crest:5 Borings 9 CPTs Landside: 4 Borings 5 CPTs 2 Hand augers Waterside: 3 Borings	Levee Height: 15 feet Crown Width: 20 feet Landside Slope: 2.1H:1V Waterside Slope: 2.5H:1V at analysis section	• "Seasonal seepage" noted in 1957 by Levee District 9 from 1375+34 to 1390+17 [3541+54 to 3556+37]. • Boil observed on landside of levee in 1986 at 1401+58 [3567+75]. • Landside embankment distress in 1997. • Heavy seepage and boils in 1997 at [3444+99 to 3559+25] • Heavy seepage and sloughing in 1997 at [3584+13 to 3595+20] • Heavy seepage and boils in 1997 at [3534+58 to 3576+80] • Boils in 1955 at 1385+01 [3551+17] • Seepage and boils occur near the landside levee toe during high water at 1336+73 to 1410+70 [3502+94 to 3576+80]	• Corps plans indicate relocation of an open drainage ditch away from the toe of the levee. Plans call for 5374 feet of landside irrigation ditch back-filled from1375+58 to 1429+32 [3541+75 to 3595+49] (Site 3, completion unknown - awaiting construction documents, USACE Plans dated July, 1997). • Relief well on the landward side of the levee at 1385+83 [3552+00]. • Backfilling of irrigation canal with crushed rock and gravel in 1997 as emergency measure at 1417+95 to 1429+03 [3584+13 to 3595+20]. Note: As-Constructed Drawings not available. Canal observed in field at the landside toe of the levee in November 2010.	Ra (Recent Alluvium) Rch (Recent Channel) Qmu (Pleistocene Modesto Formation - Upper) Rcs (Recent Crevasse Splay) Qml (Pleistocene Modesto Formation - Lower)	Shallow higher resistivity in most of reach

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 10 to 12 feet of silty sand to lean clay with minor silty gravel. • Foundation: 9 to 14 feet of silty sand to lean clay. • 10 to 24 feet of well-graded sand to poorly-graded sand with minor silty and lean clay. • 23 to 36 feet of silty sand to fat clay.	200 Year 10 feet	Orchards on landside, unlined landside ditches	1378+83 [3545+00]	WL009_28C (crest), WL009_006A (landside toe), WL009_004H (260 ft landside), B-3 (crest)	8.5 feet of clay (CL) and silt (ML) at toe over silty sand (SM) and poorly graded sand with silt (SP-SM) susceptible to underseepage

TABLE 5-21B ANALYSIS RESULTS FOR REACH 21
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1378+83

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.17	2.79	1.0	NA	No	The reach has reported seepage deficiencies including heavy seepage and boils reported in 1986 and 1997, and seepage and boils reported during high water.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 21 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through seepage and underseepage potential. Alternative 2 for Reach 21 is undrained seepage berm with relief wells and drained stability berm. Seepage berm material type is silt, which is similar to shallow near surface layer. The drained stability berm is to control through seepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 1374+33 to 1379+00 Cutoff Wall Tip Elevation 40, 1379+00 to 1389+00 Cutoff Wall Tip Elevation 50, 1389+00 to 1409+00 Cutoff Wall Tip Elevation 60, 1409+00 to 1433+83 Cutoff Wall Tip Elevation 40.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	0.46	N/A	No breakout	Yes	
200-year + 4 feet	No exit of water	0.46	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.33		Yes	
200-year + 4 feet	2.33		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Relief Wells, and Drained Stability Berm

Dimensions of Primary Features: 300 feet wide seepage berm, seepage berm thickness at the levee toe = 6-1/2 feet, thickness at the berm toe = 3 feet; Relief wells: depth = 20 feet and spacing = 100 feet;
stability berm height = 8 feet above seepage berm.

Seepage

WSE	Exit Gradient Levee Toe	Berm (near berm toe)	Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.12	0.23	0.96	No breakout	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Drainage stability berm controls through seepage.
200-year + 4 feet	0.32	0.36	1.18	No breakout	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Drainage stability berm controls through seepage.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.88		Yes	
200-year + 4 feet	2.66		Yes	

TABLE 5-22A : CHARACTERIZATION FOR REACH 22
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
22	1433+83 [3600+00]	1503+83 [3670+00]	1.3	Crest:4 Borings 8 CPTs Landside: 1 Boring 2 CPTs Waterside: Not available	Levee Height: 12 feet Crown Width: 15 feet Landside Slope: 2.0H:1V Waterside Slope: 2.7H:1V at analysis section	Severe animal burrows in levee at 1433+83 to 1459+77 [3600+00 to 3626+00]; extremely severe burrowing at north end of LD-9 observed in 2010	• No known mitigation measures.	Qml (Pleistocene Modesto Formation - Lower) Rob (Recent Overbank) Ra (Recent Alluvium) Rch (Recent Channel) Rcs (Recent Crevasse Splay) Rofc (Recent Overflow Channel)	Shallow higher resistivity in most of reach
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			• Levee: 7 to 10 feet of silty sand to lean clay. • Foundation: 0 to 15 feet of silt to lean clay. • 5 to 15 feet of poorly-graded sand with silt to silty sand. • 10 to 15 feet of sandy silt to lean clay. • 25 to 50 feet of silty sand to lean clay.	200 Year 7 feet 10 feet in ditch	Orchards on landside, unlined landside ditch	1468+83 [3635+00]	WM0016_001A (crest), WM0016_008C (crest), WM0016011C (landside toe)	Thin blanket over thick sand layer susceptible to underseepage	

TABLE 5-22B: ANALYSIS RESULTS FOR REACH 22
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1468+83

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.27	1.34	NA	1.5	No	The reach has extremely severe burrowing at north end of LD-9 observed in 2010; No other reported deficiencies have been identified; For empty ditch condition, the gradient at the bottom of the ditch did not meet criteria.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 22 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 22 is fill canal and drained stability berm/levee reconstruction. Fill canal option would mitigate the estimated high gradient at the ditch. The drained stability berm/levee reconstruction is to control through seepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 1433+83 to 1449+00 Cutoff Wall Tip Elevation 40, 1449+00 to 1469+00 Cutoff Wall Tip Elevation 50, 1469+00 to 1503+83 Cutoff Wall Tip Elevation 55 plus full degrade/reconstruct from 1433+83 to 1459+77 due to severe burrowing.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	0.18	NA	No breakout	Yes	
200-year + 4 feet	No exit of water	0.24	NA	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.23		Yes	
200-year + 4 feet	2.23		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Fill Canal and Drained Stability Berm

Dimensions of Primary Features: Fill canal to top (adj grade); stability berm from sta 1459+77 to 1503+83, height = 10 feet; full degrade/reconstruct from sta 1433+83 to 1459+77 due to severe burrowing.

Seepage

WSE	Exit Gradient Levee Toe	Filled Ditch	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.34	0.30	N/A	No breakout	Yes	
200-year + 4 feet	0.56	0.53	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.15		Yes	
200-year + 4 feet	1.79		Yes	

TABLE 5-23A : CHARACTERIZATION FOR REACH 23
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
23	1503+83 [3670+00]	1609.37 [3775+50]	2.0	Crest:7 Borings 7 CPTs Landside: 1 Boring 1 CPT Waterside: Not available	Levee Height: 11 feet Crown Width: 18 feet Landside Slope: 2.2H:1V Waterside Slope: 3.0H:1V at analysis section	• "Levee erosion" noted by citizens at 1521+05 to 1532+55 [3687+24 to 3698+82] in 1991.	• Landside drainage ditch constructed by USACE from 1521+03 to 1532+83 [3687+20 to 3699+00] in 1968. • Grouted rip-rap placed from 1515+63 to 1527+32 [3681+80 to 3693+49] by USACE in 1968 adjacent to levee and in the river channel for bank protection. • Bank protection placed at 1516+02 to 1534+67 [3682+19 to 3700+84] in 1965. Note: As-Constructed Drawings not available.	Qml (Pleistocene Modesto Formation - Lower) Rofc (Recent Overflow Channel) Rob (Recent Overbank) Rcs (Recent Crevasse Splay) Rch (Recent Channel)	Shallow higher resistivity in most of the reach
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			• Levee: 7 to 10 feet of silty sand to sandy lean clay. • Foundation: 0 to 25 feet of sandy silt to lean clay. • 5 to 60 feet of poorly-graded sand to silty and clayey sand with significant localized silt to clay.	200 Year 4 feet 10 feet in ditch @ ~250 ft LS of toe	Orchards on both sides, unlined ditch about 200 to 600 feet landside of levee, buildings near 1558+83 [3725+00]	1508+33 [3674+50]	WM0016_011B (crest) SM0016_002C (landside)	Silt to clay levee may be susceptible to through seepage; Thin blanket over sand layer susceptible to underseepage.	

TABLE 5-23B: ANALYSIS RESULTS FOR REACH 23
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1508+33

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.32	NA	NA	0.9	Yes	
200-year	0.60	NA	NA	1.8	No	No reported seepage or landside stability deficiencies have been identified; However, the reach has thin clay blanket underlain by shallow sand aquifer (high potential for underseepage); Sand aquifer is exposed on the riverside.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
100-year	2.05		Yes	
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 23 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate underseepage potential. Alternative 2 for Reach 23 is undrained seepage berm. Seepage berm material type is silt, which has similar hydraulic conductivity as the shallow near surface clay blanket layer. Seepage analysis indicate high exit gradients at the toe of the seepage berm at HTOL WSE. Therefore, monitoring at the toe of the berm for seepage is recommended during the hig water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 1503+83 to 1509+00 Cutoff Wall Tip Elevation 55, 1509+00 to 1529+00 Cutoff Wall Tip Elevation 60, 1529+00 to 1566+00 Cutoff Wall Tip Elevation 55, 1566+00 to 1589+00 Cutoff Wall Tip Elevation 60, 1589+00 to 1609+37 Cutoff Wall Tip Elevation 40.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	< 0.05	N/A	N/A	No breakout	Yes	
200-year + 4 feet	< 0.05	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.25		Yes	
200-year + 4 feet	2.23		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm

Dimensions of Primary Features: 100 feet wide seepage berm, seepage berm thickness at the levee toe = 5 feet, thickness at the berm toe = 3 feet.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	0.52	No breakout	Yes	As the berm width is 100 feet and the exit gradient meets criteria at DWSE, judgment was used for HTOL. Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
200-year + 4 feet	0.20	N/A	0.89	No breakout	Yes	

Landside Stability

WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.83				Yes	
200-year + 4 feet	1.47				Yes	

TABLE 5-24A : CHARACTERIZATION FOR REACH 24
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
24	1609.37 [3775+50]	1623+86 [3790+00]	0.3	Crest:1 Boring 1 CPTs Landside: 1 CPT Waterside: Not available	Levee Height: 9 feet Crown Width: 20 feet Landside Slope: 3.2H:1V Waterside Slope: 2.7H:1V at analysis section	• No reported deficiencies have been identified.	• No known mitigation measures.	Rch (Recent Channel) Rob (Recent Overbank) Rcs (Recent Crevasse Splay) Qml (Pleistocene Modesto Formation - Lower)	Shallow higher resistivity zone
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			• Levee: 7 to 10 feet sandy silt to lean silty clay. • Foundation: 5 to 10 feet of sandy lean clay with silt. • 10 to 15 feet of well-graded with silt. • 5 to 10 feet of sandy silt to lean clay. • 20 to 25 feet of clayey sand to silty sand.	200 Year 2 feet 7 feet in ditch	LS and WS orchards along most of reach, building at 1610+36 [3776+50]	1615+62 [3781+75]	WL0016_020B (crest) WL0016_006C (landside)	Silt to clay levee; waterside levee toe drops to low elevation; shallow SW-SM acquifer exposed at the bottom of the ditch; wide landside toe ditch, susceptible to through seepage and underseepage	

TABLE 5-24B: ANALYSIS RESULTS FOR REACH 24
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1615+62

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.20	4.14	NA	NA	No	No reported seepage or landside stability deficiencies have been identified; For empty ditch condition, the gradient at the bottom of the ditch did not meet criteria.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative1 for Reach 24 is fill canal. Fill canal option would mitigate the estimated high gradient at the ditch. Alternative 2 for Reach 24 is cutoff wall plus excavate and place 4.5-foot thick compacted clay fill at the bottom of ditch. The cutoff wall and clayey fill below the bottom of the canal will significantly reduce the flow into the canal and thus reduce the exit gradient at the canal bottom.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Fill Canal						
Dimensions of Primary Features: Fill canal to top (elev 90ft, 40ft wide x 10ft deep).						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	0.38	No breakout	Yes	
200-year + 4 feet	0.27	N/A	0.69	1.0	Yes	Levee prism mainly consists of clayey soils; Drainage berm not required for through seepage.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.95				Yes	
200-year + 4 feet	2.21				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): 1609+37 to 1623+86 Cutoff Wall Tip Elevation 64, plus excavate and place 4.5-foot thick compacted clay fill at the bottom of ditch.						
Dimensions of Primary Features: 30ft-deep cutoff wall.						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	0.44	N/A	No breakout	Yes	
200-year + 4 feet	No exit of water	0.58	N/A	No breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.82				Yes	
200-year + 4 feet	1.70				Yes	

TABLE 5-25A : CHARACTERIZATION FOR REACH 25
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
25	1623+86 [3790+00]	1674+37 [3840+50]	1.0	Crest:4 Borings 2 CPTs Landside: Not available Waterside: Not available	Levee Height: 9 feet Crown Width: 23 feet Landside Slope: 1.6H:1V Waterside Slope: 2.5H:1V at analysis section	• No reported deficiencies have been identified.	• No known mitigation measures.	Qml (Pleistocene Modesto Formation - Lower) Rch (Recent Channel) Rcs (Recent Crevasse Splay)	Shallow higher resistivity zone
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			• Levee: 5 to 10 feet of sandy silt to lean clay. • Foundation: 10 to 20 feet of sandy silt to lean clay with localized clayey sand. • 0 to 20 feet of poorly-graded sand with silt. • 10 to 20 feet of clayey sand to clayey silty sand. • 0 to 15 feet of well-graded gravel with silt to silty sand.	200 Year 1 foot	Orchards on both LS and WS, building at 1664+37 [3830+50]	1645+86 [3812+00]	WL0016_022S (crest) WL0016_021B (crest)	Silt to clay levee; waterside levee toe drops to low elevation more susceptible to underseepage	

TABLE 5-25B: ANALYSIS RESULTS FOR REACH 25
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1645+86

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.15	NA	NA	No breakout	Yes	No reported deficiencies have been identified.
200-year + 3 feet	0.43	NA	NA	1.6	Yes	No reported deficiencies have been identified.; Portion of levee prism below the water surface elevation mainly consists of clay; Drainage berm not required for through seepage.
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year	2.25				Yes	No reported deficiencies have been identified.
200-year + 3 feet	1.93				Yes	No reported deficiencies have been identified.
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
N/A

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE					Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

TABLE 5-26A : CHARACTERIZATION FOR REACH 26
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
26	1674+37 [3840+50]	1707+11 [3873+25]	0.6	Crest:1 Boring 3 CPTs Landside: 1 CPT Waterside: Not available	Levee Height: 7 feet Crown Width: 19 feet Landside Slope: 1.5H:1V Waterside Slope: 2.6H:1V at analysis section	• Waterside seepage observed during irrigation season from 1677+84 to 1721+90 [3843+98 to 3888+07]. • Sloughing and oversteepening of canal slope at landside toe of levee observed in 2010 at 1689+87 [3856+00]	• No known mitigation measures.	Rob (Recent Overbank) Ra (Recent Alluvium) Rcs (Recent Crevasse Splay) Rch (Recent Channel) Qml (Pleistocene Modesto Formation - Lower)	Shallow higher resistivity zone
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			• Levee: 5 to 8 feet of sandy silt to lean clay. • Foundation: 5 to 20 feet of sandy silt to lean clay. • 5 to 20 feet of poorly-graded sand to clayey silty sand with localized silt to clay. • 5 to 15 feet of gravel with silt to silty sand.	200 Year 4 feet in ditch	Orchards on both LS and WS, Unlined landside ditch	1698+85 [3865+00]	WM0007_018C (crest)	Silt to clay levee, shallow SP-SM acquifer exposed at the bottom of the ditch; wide landside toe ditch susceptible to underseepage	

TABLE 5-26B: ANALYSIS RESULTS FOR REACH 26
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1698+85

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	No exit of water	N/A	N/A	NA	No	Waterside seepage observed during irrigation season; Sloughing and oversteepening of canal slope at landside toe of levee observed in 2010; Based on interpreted soil profile, the section has shallow foundation sand layer which leads to through seepage into the canal.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative1 for Reach 26 is fill canal, which would mitigate the through seepage into the canal. Alternative 2 for Reach 26 is cutoff wall and reconstruct the landside slope. The cutoff wall is to block the through seepage into the canal. The reconstruction of the landside slope is to mitigate the steep slopes observed along the canal and thus improve slope instability.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Fill Canal						
Dimensions of Primary Features: Fill canal to top (adj grade, 30ft wide x 5ft deep).						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis was performed; Alternative 1 of Reach 27 was used for evaluation; for details see Figures B27-A1 through B27-A4.
200-year + 4 feet					Yes	No separate analysis was performed; Alternative 1 of Reach 27 was used for evaluation; for details see Figures B27-A1 through B27-A4.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis was performed; Alternative 1 of Reach 27 was used for evaluation; for details see Figures B27-A1 through B27-A4.
200-year + 4 feet					Yes	No separate analysis was performed; Alternative 1 of Reach 27 was used for evaluation; for details see Figures B27-A1 through B27-A4.

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Cutoff Wall and Reconstruct the Landside Slope						
Dimensions of Primary Features: 1674+37 to 1686+00 Cutoff Wall Tip Elevation 75, 1686+00 to 1707+11 Cutoff Wall Tip Elevation 65; plus Reconstruct the Landside Slope						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis was performed; Alternative 2 of Reach 27 was used for evaluation; for details see Figures B27-A5 through B27-A8.
200-year + 4 feet					Yes	No separate analysis was performed; Alternative 2 of Reach 27 was used for evaluation; for details see Figures B27-A5 through B27-A8.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis was performed; Alternative 2 of Reach 27 was used for evaluation; for details see Figures B27-A5 through B27-A8.
200-year + 4 feet					Yes	No separate analysis was performed; Alternative 2 of Reach 27 was used for evaluation; for details see Figures B28-A5 through B27-A7.

TABLE 5-27A : CHARACTERIZATION FOR REACH 27
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
27	1707+11 [3873+25]	1721+60 [3887+75]	0.3	Crest:1 Boring 2 CPTs Landside: Not available Waterside: Not available	Levee Height: 6 feet Crown Width: 20 feet Landside Slope: 1.3H:1V Waterside Slope: 3.0H:1V at analysis section	• Waterside seepage observed during irrigation season from 1677+84 to 1721+90 [3843+98 to 3888+07]. • Large voids behind the apron at the Campbell Weir. • Voids in levee during construction of bentonite-tire slurry wall in 1999 from 1707+11 to 1721+62 [3873+25 to 3887+75]	• Bentonite-tire slurry wall installed in 1999 from 1707+11 to 1721+62 [3873+25 to 3887+75] • Waterside monitoring piezometers installed in 2005. Piezometers indicate continuing seepage after installation of wall. Note: As-Constructed Drawings for Slurry Wall not available. Construction report available.	Rob (Recent Overbank) Ra (Recent Alluvium) Rch (Recent Channel)	Shallow higher resistivity zone
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			• Levee: 4 to 7 feet of lean clay. • Foundation: 10 to 15 feet of lean clay. • 5 to 10 feet of poorly-graded sand to silt. • 25 to 30 feet of clayey sand to fat clay with localized sand and silt.	200 Year 4 feet in ditch	Orchards on both LS and WS, Unlined landside ditch	1708+87 [3875+00]	WM0007_019B (crest), WM0007_019C (crest) WM0007_020C (crest)	Clayey levee; thin CL blanket underlain by SP; wide landside toe ditch; Bentonite-tire slurry wall susceptible to underseepage if wall is not performing well	

TABLE 5-27B: ANALYSIS RESULTS FOR REACH 27
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1708+87

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	No exit of water	0.57	N/A	No breakout	No	Waterside seepage observed during irrigation season; Voids in levee were observed during construction of cutoff wall in 1999; Based on interpreted soil profile, levee is underlain by soft clay; Note that the existing bentonite-tire slurry cutoff wall was not considered as effective in controlling the flow, and was not modeled in the analyses; For empty ditch condition, the gradient at the bottom of the ditch did not meet criteria.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 27 is fill canal, which would mitigate the high exit gradient at the canal bottom. Alternative 2 for Reach 27 is cutoff wall and reconstruct the landside slope. The cutoff wall is to block the flow into the canal, and reduce the gradient at ditch bottom. The reconstruction of the landside slope is to improve landside slope instability.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Fill Canal

Dimensions of Primary Features: Fill canal to top (adj grade, 30ft wide x 5ft deep).

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.01	N/A	N/A	No breakout	Yes	
200-year + 4 feet	0.16	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.40		Yes	
200-year + 4 feet	1.94		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Cutoff Wall and Reconstruct the Landside Slope

Dimensions of Primary Features: 1707+11 to 1721+60 Cutoff Wall Tip Elevation 65; plus Reconstruct the Landside Slope.

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.22	N/A	N/A	No breakout	Yes	
200-year + 4 feet	0.35	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.76		Yes	
200-year + 4 feet	1.68		Yes	

TABLE 5-28A : CHARACTERIZATION FOR REACH 28
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
28	1721+60 [3887+75]	1769+31 [3935+50]	0.9	Crest:3 Borings 5 CPTs Landside: Not available Waterside: Not available	Levee Height: 6 feet Crown Width: 23 feet Landside Slope: 1.4H:1V Waterside Slope: 2.4H:1V at analysis section	• No reported deficiencies have been identified.	• No known mitigation measures.	Ra (Recent Alluvium) Qml (Pleistocene Modesto Formation - Lower) Rob (Recent Overbank) Rcs (Recent Crevasse Splay)	Localized shallow higher resistivity zones
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			• Levee: 4 to 8 feet of silt to lean clay. • Foundation: 0 to 20 feet of sandy silt to lean clay with localized clayey sand to silty sand. • 0 to 10 feet of sand to sand with silt. • 10 to 40 feet of silt to lean clay.	200 Year 5 feet in ditch	Orchards on both LS and WS along much of reach, Agricultural buildings at 1738+87 and 1744+87 [3905+00 and 3911+00], Unlined landside ditch	1760+87 [3927+00]	WM0007_024B (crest) WM0007_025C (crest)	Clayey levee; CL blanket underlain by SC/SC-SM; wide landside toe ditch susceptible to underseepage	

TABLE 5-28B: ANALYSIS RESULTS FOR REACH 28
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1760+87

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	No exit of water	0.38	N/A	No breakout	Yes	No reported deficiencies have been identified; Based on interpreted soil profile, levee is underlain by soft clay; The canal is located at the landside levee toe; For empty ditch condition, the gradient at the bottom of the ditch did not meet criteria.
200-year + 3 feet	No exit of water	0.61	N/A	No breakout	No	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	1.10		No	
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 28 is fill canal, which would mitigate the high exit gradient at the canal bottom. Alternative 2 for Reach 28 is cutoff wall and reconstruct the landside slope. The cutoff wall is to block the flow into the canal, and reduce the gradient at ditch bottom. The reconstruction of the landside slope is to improve landside slope instability.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Fill Canal

Dimensions of Primary Features: Fill canal to top (adj grade, 30ft wide x 5ft deep).

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	N/A	No breakout	Yes	
200-year + 4 feet	0.15	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.94	Yes	
200-year + 4 feet	1.67	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Cutoff Wall and Reconstruct the Landside Slope

Dimensions of Primary Features: 1721+60 to 1728+00 Cutoff Wall Tip Elevation 65, 1728+00 to 1749+00 Cutoff Wall Tip Elevation 80, 1749+00 to 1769+31 Cutoff Wall Tip Elevation 45; Plus Reconstruct the Landside Slope.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	0.16	NA	No breakout	Yes	
200-year + 4 feet	No exit of water	0.23	NA	No breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.85	Yes	
200-year + 4 feet	1.80	Yes	

TABLE 5-29A : CHARACTERIZATION FOR REACH 29
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
29	1769+31 [3935+50]	1813+33 [3979+50]	0.8	Crest:5 Borings 1 CPT Landside: Not available Waterside: Not available	Levee Height: 4 feet Crown Width: 20 feet Landside Slope: 3.5H:1V Waterside Slope: 2.7H:1V at analysis section	• No reported deficiencies have been identified.	• No known mitigation measures.	Ra (Recent Alluvium) Rcu (Recent Crevasse Splay Cutoff Channel) Rob (Recent Overbank)	~ 50 feet thick low resistivity zone below the ground surface
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			• Levee: 4 to 7 feet of silty sand to lean clay. • Foundation: 0 to 20 feet of sandy silt to lean clay with localized surficial clayey sand to silty sand. • 0 to 25 feet of fat clay. • 0 to 10 feet of clayey sand to silty sand with localized clayey gravel to silty gravel. • 10 to 40 feet of lean sandy silt to lean clay.	200 Year N/A	Orchards on both LS and WS along much of reach, Agricultural buildings at 1782+81 and 1786+81 [3949+00 and 3953+00]	1788+81 [3955+00]	WM0007_026B (crest) WM0007_027S (crest)	Clayey levee; low blowcount SC-SM shallow foundation layer susceptible to underseepage	

TABLE 5-29B: ANALYSIS RESULTS FOR REACH 29
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1788+81

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	N/A	N/A	N/A	N/A	Yes	Water surface elevation is lower than the landside toe elevation; Seepage analysis performed for pore pressure input to slope stability; No reported deficiencies have been identified.
200-year + 3 feet	N/A	N/A	N/A	N/A	Yes	Water surface elevation is lower than the landside toe elevation; Seepage analysis performed for pore pressure input to slope stability; No reported deficiencies have been identified.
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year	4.73				Yes	Short levee with flatter landside slope; No reported deficiencies have been identified.
200-year + 3 feet	3.80				Yes	Short levee with flatter landside slope; No reported deficiencies have been identified.
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
N/A

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

TABLE 5-30A: CHARACTERIZATION OF REACH 30
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
30	1813+33 [3979+50]	1902+00 [4068+00]	1.68	Total Number of Explorations = 18; Crown Explorations = 12 (Borings-10, CPT-2); Landside Toe Explorations = 4 (Borings-3, CPT-1) Waterside Toe Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width = 15 feet Landside Slope = 2.8H:1V Waterside Slope = 2.4H:1V	At 1871+91 [4037+06], in 1986, a boil appeared on the landslide slope of levee.	After high water receded, approximately 300 feet of levee at this location was excavated to surrounding grade and rebuilt; no evidence of the boil was found during excavation.	Old levee fill mapped meandering along current levee alignment. Ra waterside and landside, with Rcu along landside of old levee fill (which at some locations is just to waterside of and underneath current levee alignment).	High resistivity present, fair correspondence with logs.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee silty sand to silt. Silty sand and silt from native grade to about 20 to 25 feet bgs, underlain by clean gravel to about 40 to 60 feet bgs, underlain by clay, clayey sand, and/or clayey gravel >5 feet thick.	**200 yr WSE** Head = approximately 5.6 feet at analysis section	Predominantly agricultural on landside and on waterside where levee set back from river. From approximately sta 1896+00 [4060+20] to 4068+00 [1902+00] there are homes on the landside of the levee (observed from the aerial map).	1826+94 [3993+10]	WM0007_004S	Section selection based on location that appears most likely to have highest gradient (i.e. underseepage potential).	

TABLE 5-30B: ANALYSIS RESULTS FOR REACH 30
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 1826+94

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.39	NA	NA	0.6	Yes	
200-year	0.48	NA	NA	1.2	Yes	Thin waterside blanket (if extrapolate crown boring) removed for analysis. Toe gradient marginally passes; through-seepage marginal*.
200-year + 3 feet	0.78	NA	NA	2.2	No	Toe gradient clearly does not meet criterion. Through-seepage more clearly not meeting criterion (daylights on slope, erodible material)

Landside Stability — * Consistent with past performance, report of one "boil" on the landside slope during 1986 high water event.

WSE	FS	Performance	Meets Criteria?	Comments
100-year	1.61		Yes	
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 30 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 30 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 1813+33 to 1816+40 Cutoff Wall Tip Elevation 80 , 1816+40 to 1865+90 Cutoff Wall Tip Elevation 40 , 1865+90 to 1877+90 Cutoff Wall Tip Elevation 50, 1877+90 to 1902+00 Cutoff Wall Tip Elevation 30

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	N/A	No breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage. Fine-grained layer varies in depth
200-year + 4 feet	No exit of water	N/A	N/A	No breakout	Yes	over length of reach, so wall depth varies over length of reach, as indicated above

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.81	Yes	
200-year + 4 feet	1.78	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm

Dimensions of Primary Features: 1813+33 to 1831+00 seepage berm 300 feet wide, 6.5 feet thick at levee toe, 1831+00 to 1888+00 seepage berm 100 feet wide, 5 feet thick at levee toe, 1888+00 to 1895+00 seepage berm 300 feet wide, 6.5 feet thick at levee toe, 1895+00 to 1902+00 seepage berm 100 feet wide, 5 feet thick at levee toe, for each, thickness at seepage berm toe = 3 feet and stability berm height = 4 feet (on top of seepage berm)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No Exit of Water	0.86	NA	1.3	Meets criteria at levee toe. See comments on berm toe.	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
200-year + 4 feet	No Exit of Water	1.14	NA	Top of berm	Meets criteria at levee toe. See comments on berm toe.	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	4.72	Yes	Drained stability berm (for through-seepage) significantly increases stability FS.
200-year + 4 feet	4.15	Yes	

TABLE 5-31A: CHARACTERIZATION OF REACH 31
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
31	1902+00 [4068+00)	1958+00 [4125+00]	1.06	Total Number of Explorations = 11; Crown Explorations = 9 (Borings-8, CPT-1); Landside Toe Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width = 16 feet Landside Slope = 1.4H:1V Waterside Slope = 2.5H:1V	none documented	none documented	Old levee fill mapped along current levee alignment for much of length (where river adjacent). Ra landside, with Rcs and Rofc at southern end landside River waterside for much of length, with Hch along waterside where levee set back from current river alignment.	High resistivity present, fair correspondence with logs; gap in HEM at upstream end of reach.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee lean clay, with some SC and ML. Foundation profile partly mostly clay, partly 10 to 15 foot clay blanket over clean gravel, sand, and some silt to 40 to 50 feet below ground surface, underlain by >5 feet clay.	**200 yr WSE** Head = approximately 8 ft above base of canal (no head above levee toe)	Butte Main Canal runs along LS toe of levee. The landside and waterside (where the levee is setback from the river) is mainly agricultural. A canal is located approximately 25 feet away from the landside toe. The canal is about 55 feet wide and 7 feet deep.	1907+91 [4074+00]	WM0007_37S SM0007_003A SM0007_004A	If address canal, reach has potential to meet criteria otherwise, so section selection based on location that appears most likely to have highest gradient (after addressing canal). Note that depth of wall (for cost purposes) controlled by other location (036S, at d/s end of segment).	

TABLE 5-31B: ANALYSIS RESULTS FOR REACH 31
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 1907+91

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	NA	2.3	0.14	5.1	No	High gradient at canal due to thin blanket (canal bottom close to underlying sand). Breakout point measured from bottom of canal.
200-year + 3 feet						No documentation of performance problems occurring in canal during high water events; unknown if canal was empty or full at time

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 31 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. The potential seepage problems, however, are due to the presence of the canal; if the canal were not present, the potential seepage problems would not occur. So Alternative 2 for Reach 31 is filling of the canal (and re-locating the canal a large distance from the levee). Canal fill material type is silt, to be permeability-compatible with underlying material (may use more permeable fill than silt).

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 1902+00 to 1916+90 Cutoff Wall Tip Elevation 30, 1916+90 to 1933+90 Cutoff Wall Tip Elevation 75, 1933+90 to 1958+00 Cutoff Wall Tip Elevation 40

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No Exit of Water	0.18	NA	No Breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage. Fine-grained layer varies in depth
200-year + 4 feet	No Exit of Water	0.24	NA	No Breakout	Yes	over length of reach, so wall depth varies over length of reach, as indicated above

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.62		Yes	
200-year + 4 feet	2.58		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Filled Canal

Dimensions of Primary Features: Canal filled up to adjacent grade; 1.4 % slope on top of fill for drainage. The filled canal and its existing embankments effectively become a landside berm, about 100 feet wide.

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No Exit of Water	0.24	NA	No Breakout	Yes	Filled canal and embankments considered a berm, so gradient criterion used at embankment toe is that for berms.
200-year + 4 feet	No Exit of Water	0.51	NA	No Breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	9.61		Yes	Berm condition, with fill up against short landside levee slope, significantly increases stability FS.
200-year + 4 feet	8.10		Yes	

TABLE 5-32A: CHARACTERIZATION OF REACH 32
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
32	1958+00 [4125+00]	1989+00 [4155+00]	0.59	Total Number of Explorations = 7; Crown Explorations = 5 (Borings-4, CPT-1); Landside Toe Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width = 14 feet Landside Slope = 2.1H:1V Waterside Slope = 2.1H:1V	none documented	none documented	H_{ch} (Holocene Channel deposits) R_a (Recent Alluvium) R_{cu} (Recent Cutoff Channel) Rob (Recent Overbank)	Approximately 10ft thick, continuous, High to Moderate Resistive Soil layers observed immediately below the embankment.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: SM, CL, ML, SC **Foundation**: Near Surface layers include SM, CL, ML. Thick (~ 20ft) pervious zones present at about 30ft below the embankment (GW).	**200 yr WSE** Head = approximately 12.9 feet at the analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river). Scattered houses and sheds were observed from the aerial map.	1965+80 [4132+00]	WM0007_042B WM0007_042S SM0007_002B	Section likely to control gradient, berm design (wall depth ~constant).	

TABLE 5-32B: ANALYSIS RESULTS FOR REACH 32
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 1965+80

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.83	NA	NA	4.6	No	High gradient at toe, due to thin blanket over permeable layers, clearly does not meet criteria. Through-seepage a concern (erodible soils).
200-year + 3 feet						No documented problems during floods. Gradient not FS<1, and analyzed WSE higher than floods; analysis and performance consistent

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 32 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and under seepage potential. Alternative 2 for Reach 32 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type is modeled as silty sand, which is similar to there more permeable of the shallow near surface layers (some silty sands on the finer blanket layer materials).

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 1958+00 to 1965+80 Cutoff Wall Tip Elevation 40, 1965+80 to 1986+80 Cutoff Wall Tip Elevation 58
1986+80 to 1989+00 Cutoff Wall Tip Elevation 10

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.27	NA	NA	No Breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage.
200-year + 4 feet	0.29	NA	NA	No Breakout	Yes	Fine-grained layer varies in depth over length of reach, so wall depth varies over length of reach, as indicated above

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.65		Yes	
200-year + 4 feet	1.65		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (SM) with stability berm

Dimensions of Primary Features: 1958+00 to 1982+00 seepage berm 120 feet wide, 6 feet thick at levee toe, with stability berm height = 6 feet (on top of seepage berm)
1982+00 to 1989+00 seepage berm 50 feet wide, 5 feet thick at levee toe, with stability berm height = 4 feet (on top of seepage berm)
for each, thickness at seepage berm toe = 3 feet

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.20	0.76	NA	No Breakout	Yes	
200-year + 4 feet	0.30	0.92	NA	No Breakout	Meets criteria at levee toe. See comments on berm toe.	No criteria of exit gradient at berm toe greater than 100 feet in width. Seepage condition should be monitored during flood. If needed, a relief well or drainage system may be needed at the toe of the berm.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.25		Yes	
200-year + 4 feet	2.16		Yes	

TABLE 5-33A: CHARACTERIZATION OF REACH 33
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
33	1989+00 [4155+00]	2122+00 [4288+00]	2.52	Total Number of Explorations = 22; Crown Explorations = 17 (Borings-14, CPT-3); Landside Toe Explorations = 5 (Borings-2, CPT-3)	At analysis section: Crown width = 16 feet Landside Slope = 2H:1V Waterside Slope = 3.3H:1V	none documented	none documented	Ra (Recent Alluvium) Rcu (Recent Cutoff Channel) DT (Dredge Tailings)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment. Low resistivity observed occasionally. Gap in HEM data intermittently.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: SM, ML **Foundation**: Near Surface layers include ML, SM, SP-SM. Thick (~ 40ft) pervious zones present at about 30ft below the embankment (GP, GW).	**200yr WSE** Head = approximately 4.9 feet at the analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river). Scattered houses and sheds were observed from the aerial map.	2076+90 [4243+00]	WM0007_009S (Crown) WM0007_002C (LS Toe) SM0007_005A (Crown)	Section likely to control gradient, berm design, and wall depth. Previous analyses at this location showed marginal/close to criteria.

TABLE 5-33B: ANALYSIS RESULTS FOR REACH 33
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2076+90

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.55	NA	NA	1.6	No	Gradient at toe does not meet. Dredge tailings (DT) modeled as GM-GP, about 60ft deep. DT has relatively little effect on gradients here.
200-year + 3 feet						No documented performance problems; gradient not much over criterion, though; consistent. Reach has ≤90-degree bends (3D effect).

Landside Stability

WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 33 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 33 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 1989+00 to 2000+80 Cutoff Wall Tip Elevation 10, 2000+80 to 2026+80 Cutoff Wall Tip Elevation 90
2026+80 to 2036+90 Cutoff Wall Tip Elevation 20, 2036+90 to 2086+90 Cutoff Wall Tip Elevation 35
2086+90 to 2122+00 Cutoff Wall Tip Elevation 90

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	NA	NA	No Breakout	Yes	Relatively deep wall needed to tie in to fine-grained layer, mitigate through-seepage and underseepage.
200-year + 4 feet	<0.1	NA	NA	No Breakout	Yes	Fine-grained layer varies in depth over length of reach, so wall depth varies over length of reach, as indicated above.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.82		Yes	
200-year + 4 feet	1.81		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm, optionally with relief wells

Dimensions of Primary Features: 1989+00 to 2020+00 seepage berm 50 feet wide, 5 feet thick at levee toe , 2020+00 to 2028+00 seepage berm 100 feet wide, 5 feet thick at levee toe ,
2028+00 to 2037+00 seepage berm 50 feet wide, 5 feet thick at levee toe , 2037+00 to 2050+00 seepage berm 100 feet wide, 6 feet thick at levee toe,
2050+00 to 2065+00 connect berm toe as straight line across bend, 2065+00 to 2087+00 seepage berm 100 feet wide, 6 feet thick at levee toe,
2087+00 to 2102+00 seepage berm 50 feet wide, 5 feet thick at levee toe, 2102+00 to 2106+00 connect berm toe as straight line across bend,
2106+00 to 2122+00 seepage berm 60 feet wide, 5 feet thick at levee toe, for each, thickness at seepage berm toe = 3 feet, stability berm height = 4 feet (on top of seepage berm)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.02	0.72	NA	Top of Berm	Yes	
200-year + 4 feet	0.22	1.05	NA	Top of Berm	Meets criteria at levee toe. See comments on	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.96		Yes	Drained stability berm (for through-seepage) significantly increases stability FS.
200-year + 4 feet	2.73		Yes	

TABLE 5-34A: CHARACTERIZATION OF FOR REACH 34
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
34	2122+00 [4288+00]	2182+00 [4348+00]	1.14	Total Number of Explorations = 9; Crown Explorations = 8 (Borings-7, CPT-1); Landside Toe Explorations = 1 (Borings-0, CPT-1)	At analysis section: Crown width = 20 feet Landside Slope = 1.6H:1V Waterside Slope = 3.0H:1V	none documented	none documented	Ra (Recent Alluvium) Rcu (Recent Cutoff Channel) DT (Dredge Tailings)	Continuous, High Resistive Soil layers observed immediately below the embankment. Gap in HEM data intermittently.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: SM, ML **Foundation**: Near Surface layers include ML, CL, SM, SP, SW-SM. Thick (~ 20ft) pervious zones present at about 30ft below the embankment (GP, GW).	**200 yr WSE** Head = approximately 1.4 feet at the analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river).	2138+99 [4305+20] (hinged section)	WM0007_055S (crown)	High ground along this reach, but steep levee LS slopes along parts, so section targeted at characterizing levee LS slope stability.	

TABLE 5-34B: ANALYSIS RESULTS FOR REACH 34
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2138+99

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.06	NA	NA	No Breakout	Yes*	Very low WSEs, result is low gradients. Dredge tailings (DT) modeled as GM-GP, about 60ft deep; DT has little effect on results here.
200-year + 3 feet	0.19	NA	NA	1.0	Yes*	* See note below in rationale for selection

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	1.62		Yes	
200-year + 3 feet	1.45		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Most of reach does not require rehabilitation. However, downstream end of reach needs rehabilitation for seepage. Rehabilitation measures for reach 33 should extend 1600 feet into reach 34, as described below. See reach 33 for rationale of rehabilitation measures and analysis results. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relie wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 2122+00 to 2138+00 Cutoff Wall Tip Elevation 90
2138+00 to 2182+00 no wall (no rehabilitation required)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	**					** See Reach 33 for representative analysis results.
200-year + 4 feet	**					

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Drained Stability Berm on Top

Dimensions of Primary Features: 2122+00 to 2138+00 seepage berm 60 feet wide, 5 feet thick at levee toe, with stability berm height = 4 feet (on top of seepage berm)
2138+00 to 2182+00 no berm (no rehabilitation required)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	**					** See Reach 33 for representative analysis results. Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
200-year + 4 feet	**					

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-35A: CHARACTERIZATION OF REACH 35
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
35	2182+00 [4348+00]	2224+00 [4390+00]	0.8	Total Number of Explorations = 11; Crown Explorations = 8 (Borings-7, CPT-1); Landside Toe Explorations = 1 (Borings-1, CPT-0) Field Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width = 16 feet Landside Slope = 2.1H:1V Waterside Slope = 3H:1V	Boil 1986 - "The foundation soils are susceptible to seepage and piping".(1986)	Site 1: Levee raise LM 9.89 to LM 10.39. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001. Note: Document 314, which included as-constructed improvement measures did not include this levee raise in the "Sutter County, California Past Problem Sites Map." "Rebuilt 300' levee section" Note: No detail of this rebuilt work was available during preparation of this SGDR. NOTE: AS-BUILT DOCUMENT NOT AVAILABLE TO HDR TEAM.	Ra (Recent Alluvium) Rcu (Recent Cutoff Channel) DT (Dredge Tailings)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment. Gap in HEM data intermittently.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: SM, ML, CL **Foundation**: Near Surface layers include ML, SM, SP-SM. Thick (~ 15ft) pervious zones present at about 30ft below the embankment (GP, GP-GM).	**200 yr WSE** Head = approximately 8.2 feet at analysis section	Predominantly agricultural on the landside. A warehouse is located on the landside of the levee at approximately station 2185+00 [4351+25]	2211+30 [4377+50]	WM0007_062B (Crown) WM0007_062S (Crown) SM0007_004B (Toe)	Section likely to control gradient, berm design, and wall depth. Previous analyses at this location showed marginal/close to criteria.	

TABLE 5-35B: ANALYSIS RESULTS FOR REACH 35
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2211+30

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.36	NA	0.57	1.8	Yes	Dredge tailings (DT) modeled as GM-GP, about 40ft deep. Underseepage gradients meet criteria, through-seepage marginal.
200-year + 3 feet	0.50	NA	0.72	3.6	No	Underseepage does not meet the field criterion, nor through-seepage (daylights on slope, erodible materials). Reach has 90-deg bends. A boil reported in 1986 (different location on same reach); consistent with analysis results showing not meeting criteria.

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 35 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 35 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silty sand, which is similar to shallow near surface layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2182+00 to 2224+00 Cutoff Wall Tip Elevation 55

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	NA	0.12	No Breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage.
200-year + 4 feet	<0.1	NA	0.14	No Breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.79		Yes	
200-year + 4 feet	1.79		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with and without Drained Stability Berm on Top

Dimensions of Primary Features:
2182+00 to 2199+00 seepage berm 65 feet wide, 5 feet thick at levee toe (no drained stability berm on top)
2199+00 to 2203+00 connect berm toe as straight line across bend (no drained stability berm on top)
2203+00 to 2224+00 seepage berm 65 feet wide, 5 feet thick at levee toe, with drained stability berm height = 5 feet (on top of seepage berm)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.08	0.62	NA	Top of Berm	Yes	Gradients at berm toe same values as in field for ex. conditions, but farther from levee; berm width extended to point where meet criteria.
200-year + 4 feet	0.19	0.78	NA	Top of Berm	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.44		Yes	
200-year + 4 feet	2.15		Yes	

TABLE 5-36A: CHARACTERIZATION OF REACH 36
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
36	2224+00 [4390+00]	2259+00 [4425+00]	0.66	Total Number of Explorations = 7; Crown Explorations = 5 (Borings-4, CPT-1); Landside Toe Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width = 8 feet Landside Slope = 3.2H:1V Waterside Slope = 2.9H:1V	none documented	none documented	Generally runs along boundary between DT and Ra, crossing onto and overlying each along part, with Rcu crossing under at several locations. H_{ms} (Holocene meander Scrolls)	Moderate resistivity, gap in HEM in d/s part of reach.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Silt levee. Silty sand, silt, and clay from native grade to about 15 to 20 feet bgs, underlain by clean sand and gravel to about 35 feet bgs, underlain by clay and/or clayey gravel >5 feet thick.	**200 yr WSE** Head = approximately 7.5 ft at analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river). Scattered houses and sheds on the landside and waterside were observed from the aerial map.	2250+78 [4417+00]	SM0007_005B (TOE)	Section likely to control gradient, berm design, and wall depth.	

TABLE 5-36B: ANALYSIS RESULTS FOR REACH 36
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2250+78

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.94	N/A	N/A	3.4	No	Gradient at toe does not meet. Dredge tailings (DT) modeled as GM-GP, about 40ft deep, about ≥300 feet to waterside of levee.
200-year + 3 feet						No documented performance problems; gradient not much over criterion, though; consistent. Reach has 90-degree bends (3D effect).

Landside Stability

WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 36 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 36 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as clayey sand, which is similar to shallow near surface layers. Clayey sand may be of higher value for other uses on the project; a more permeable material may be used as berm material. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2224+00 to 2259+00 Cutoff Wall Tip Elevation 75

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage.
200-year + 4 feet	<0.1	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.03		Yes	
200-year + 4 feet	2.00		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (SC) with stability berm

Dimensions of Primary Features:
2224+00 to 2227+00 seepage berm 65 feet wide, 5 feet thick at levee toe, with stability berm height = 5 feet (on top of seepage berm)
2227+00 to 2233+00 connect berm toe as straight line across bend, with stability berm height = 5 feet (on top of seepage berm)
2233+00 to 2259+00 seepage berm 300 feet wide, 7.5 feet thick at levee toe, with drained stability berm height = 4 feet (on top of seepage berm)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	0.95	N/A	Top of berm	Meets criteria at levee toe. See comments on berm toe.	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
200-year + 4 feet	0.15	1.27	N/A	Top of berm	Meets criteria at levee toe. See comments on berm toe.	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	3.19		Yes	Drained stability berm (for through-seepage) significantly increases stability FS.
200-year + 4 feet	2.86		Yes	

TABLE 5-37A: CHARACTERIZATION OF REACH 37
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
37	2259+00 [4425+00]	2290+00 [4456+00]	0.59	Total Number of Explorations = 7; Crown Explorations = 5 (Borings-5, CPT-0); Landside Toe Explorations = 2 (Borings-1, CPT-1)	At analysis section: Crown width = 20 feet Landside Slope = 2.1H:1V Waterside Slope = 3.1H:1V	none documented	none documented	Rcu (Recent Cutoff Channel) DT (Dredge Tailings) H_{ms} (Holocene meander Scrolls)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: ML, CL, CL-ML **Foundation**: Near Surface layers include ML, SM, CL-ML. Thick (~ 15ft) pervious zones present at about 20 to 30ft below the embankment (GP, GP).	**200 yr WSE** Head = approximately 6.1 feet at the analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river). Scattered houses were observed from the aerial map.	2276+76 [4443+00]	WM0007_013S SM0007_006A SM0007_006B	Section selected for location where gradient most likely to control fix dimensions for berm or other non-wall fix. Note that depth of wall (for cost purposes) controlled by other location (068S, at u/s end of segment).	

TABLE 5-37B: ANALYSIS RESULTS FOR REACH 37
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2276+76

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.49	N/A	N/A	3.6	No	Through-seepage daylights, erodible soil. Underseepage marginal. Dredge tailings modeled on waterside, instead of projecting silt blanket
200-year + 3 feet	0.72	N/A	N/A	4.3	No	At this WSE, underseepage also does not meet criteria. No documented performance problems; consistent with gradients for WSEs

Landside Stability

WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 37 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 37 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2259+00 to 2290+00 Cutoff Wall Tip Elevation 45

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.11	N/A	N/A	No breakout	Yes	Relatively deep wall needed to tie in to layer with fine-grained material, mitigate through-seepage and underseepage.
200-year + 4 feet	0.14	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.83		Yes	
200-year + 4 feet	1.8		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm

Dimensions of Primary Features: 2259+00 to 2290+00 seepage berm 65 feet wide, 5.5 feet thick at levee toe, with stability berm height = 6 feet (on top of seepage berm)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.1	0.53	N/A	Top of berm	Yes	
200-year + 4 feet	0.27	0.75	N/A	Top of berm	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.54		Yes	Drained stability berm (for through-seepage) significantly increases stability FS.
200-year + 4 feet	2.33		Yes	

TABLE 5-38A: CHARACTERIZATION OF REACH 38
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
38	2290+00 [4456+00]	2303+00 [4469+00]	0.25	Total Number of Explorations = 1; Crown Explorations = 1 (Borings-1, CPT-0)	At analysis section: Crown width = 29 feet Landside Slope = 2H:1V Waterside Slope = 2.6H:1V	None documented on levee reach. Adjacent "old" levee breached in 1955 event. "Old" levee extends southward, along river, from east end of Reach 38 levee (which runs west-east along Vance Ave). Adjacent levee that extends north from east end of Reach 38 levee is Reach 39 levee, which nearly breached in 1955, with multiple boils and sinkholes and significant flood-fighting to save levee.	none documented	DT (Dredge Tailings) H_{ms} (Holocene meander Scrolls)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment. Gap in HEM data towards the downstream end of the Reach.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]**	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
						SBFCA STATION [DWR ULE STATION]			
			Levee Embankment: ML **Foundation**: Thick (~ 30ft) pervious zones present below the embankment (GM, GC, GP, GP-GM), thought to be dredge tailings.	**200 yr WSE** Head = approximately 13.1 feet above berm toe at analysis section	Scattered trees on the landside and waterside of the levee.	2299+69 [4466+00] (hinged section)	WM0007_069B WM0007_069S (CREST)	Section selected to flag anticipated critical gradient, controlling berm dimensions. Note that depth of wall (for cost purposes) controlled by other locations (068S and 070S, at either end of segment).	

TABLE 5-38B: ANALYSIS RESULTS FOR REACH 38
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2299+69

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.17	N/A	N/A	0.7	No	Gradients meet. Through-seepage marginal. Does not meet based on past performance. At east end, adjacent levee to south breached
200-year + 3 feet	0.23	N/A	N/A	1.3	No	adjacent levee to north nearly breached, and those levee/foundation conditions still present at Reach 38 (silt levee built on dredge tailings)

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	2.68		Yes	
200-year + 3 feet	2.56		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Mechanisms of potential failure thought to be present for the Reach 38 levee are associated with the incompatibility of the silty levee material with the gravelly (dredge tailings) foundation soils. Under high head conditions, seepage through the silt and into the gravels, or along the silt/gravel interface, can lead to internal erosion and piping of the silt as the silt particles are carried into/through the gravel. Alternative 1 for Reach 38 is a soil-bentonite cutoff wall, to decrease the internal gradient at the silt/gravel interface and to inhibit the flow of water through the foundation along the silt/gravel interface. Alternative 2 for Reach 38 is a full de-grade and reconstruction of the levee, and a seepage berm with the newly reconstructed levee.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2290+00 to 2303+00 Cutoff Wall Tip Elevation 45

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						Existing gradients already meet criteria (exit gradients not salient for this reach); no need to analyze gradients for improved condition.
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Reconstructed Levee, with Seepage Berm

Dimensions of Primary Features: 2290+00 to 2302+00 De-grade entire levee and reconstruct, with zoned filter at base, and regrade landside to create 300 feet-wide drained seepage berm, 5 feet thick at levee toe, with filter carried out through berm. (2302 to 2303 occupied by berm of Reach 39)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						Existing gradients already meet criteria (exit gradients not salient for this reach); no need to analyze gradients for improved condition.
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-39A: CHARACTERIZATION OF REACH 39
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
39	2303+00 [4469+00]	2319+00 [4486+00]	0.3	Total Number of Explorations = 3; Crown Explorations = 3 (Borings-2, CPT-1)	At analysis section: Crown width = 60 feet Landside Slope = Varies, typically nominally 4H:1V Waterside Slope = Varies (as steep as 1H:1V in some places)	Levee nearly breached in 1955. During flood event, numerous boils and sinkholes, with multiple flood-fight crews and dozers pushing gravel into sinkholes.	Levee raising, setback, and reconstruction. **NOTE: AS-BUILT DOCUMENT NOT AVAILABLE TO HDR TEAM.**	DT (Dredge Tailings) H_{ch} (Holocene Channel deposits)	Continuous, Moderate Resistive Soil layers observed immediately below the embankment. Gap in HEM data towards the upstream end of the Reach.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: GP, GM **Foundation**: GM, GC, GP, GP-GM (~ 50ft thick below the embankment). Silt and silty sands layers (ML,SM) observed below the Gravel layer.	**200 yr WSE** Head = approximately 21.5 feet at analysis section	Scattered trees on the landside and waterside of the levee.	2314+91 [4481+00]	WM0007_071B (Crown) WM0007_071S (Crown)	Generally flows through, but projection of GW-GC layer (if acts GC-like) in 071S relative to ground surface profile anticipated to control gradient relationship.	

TABLE 5-39B: ANALYSIS RESULTS FOR REACH 39
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2314+91

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	No Exit of Water	N/A	0.27 (Local Y-grad)	No Breakout	Yes	Gradients meet. This reach nearly breached in 1955, with numerous boils and sinkholes, with multiple flood-fight crews and
200-year + 3 feet	No Exit of Water	N/A	0.3 (Local Y-grad)	No Breakout	Yes	dozers pushing gravel into sinkholes. Levee built on dredge tailings. No documentation of rehabilitation. Levee appears to have been rehabilitated after poor performance event.
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year	3.06				Yes	
200-year + 3 feet	2.62				Yes	
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

TABLE 5-40A: CHARACTERIZATION OF REACH 40
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
40	2319+00 [4486+00]	2359+00 [Old Butte Canal Structure]	0.76	Total Number of Explorations = 6; Crown Explorations = 4 (Borings-4, CPT-0); Landside Toe Explorations = 1 (Borings-1, CPT-0) Waterside Toe Explorations = 1 (Borings-0, CPT-1)	At analysis section: Crown width = 63 feet Landside Slope = 2.1H:1V Waterside Slope = 2.8H:1V	Numerous boils in 1955 event, with significant flood-fighting.	Levee raising, setback, and reconstruction. **NOTE: AS-BUILT DOCUMENT NOT AVAILABLE TO HDR TEAM.**	DT (Dredge Tailings) H_{ch} (Holocene Channel deposits)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: GP, GM, GP-GM, GW-GC **Foundation**: GM, GC, GW, GP, GP-GM intermixed thin layers (~2 to 3ft) of ML, SM.	**200 yr WSE** Head = approximately 10 feet at analysis section	Scattered trees on the landside and waterside of the levee. Some agricultural on the landside of the levee.	2332+91 [4499+00]	WM0007_072S WM0007_014S (CREST) SM0007_008B (FIELD)	Projection of clay layer in 072S relative to ground surface profile at 4499 anticipated to control gradient relationship, dimensions of berm. Depth of wall (for cost purposes) controlled by other location (073S, at u/s end of segment).	

TABLE 5-40B: ANALYSIS RESULTS FOR REACH 40
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2332+91

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.64	N/A	N/A	5.3	No	Does not meet gradient at toe. Past performance: boils/flood-fights. Dredge tailings (DT) modeled as GM-GP, about 40ft deep, waterside
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 40 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 40 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2319+00 to 2336+90 Cutoff Wall Tip Elevation 50
2336+90 to 2359+00 Cutoff Wall Tip Elevation 20

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	N/A	No breakout	Yes	Deep wall needed to tie in to layer with fine-grained material, mitigate through-seepage and underseepage.
200-year + 4 feet	No exit of water	N/A	N/A	No breakout	Yes	Fine-grained layer varies in depth over length of reach, so wall depth varies over length of reach, as indicated above

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.23		Yes	
200-year + 4 feet	2.18		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm and landside depressions (pits) filled.

Dimensions of Primary Features: Fill the large landside pit at 2321+00 to 2332+00 up to el 120,
2321+00 to 2329+00 seepage berm 65 feet wide, 5 feet thick at levee toe, with drained stability berm height = 7 feet (on top of seepage berm)
Fill the large landside pits at 2333+00 to 2343+00
2331+00 to 2346+00 seepage berm 120 feet wide, 5 feet thick at levee toe, with drained stability berm height = 10 feet (on top of seepage berm)
2346+00 to 2359+00 seepage berm 300 feet wide, 5 feet thick at levee toe, with drained stability berm height = 4 feet (on top of seepage berm

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.07	0.78	N/A	Top of berm	Yes	
200-year + 4 feet	0.2	0.82	N/A	Top of berm	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.96		Yes	
200-year + 4 feet	2.68		Yes	

TABLE 5-41A: CHARACTERIZATION OF REACH 41
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
41	2359+00 [Old Butte Canal Structure]	2368+00 [Thermalito]	0.17	Total Number of Explorations = 1; Crown Explorations = 1 (Borings-1, CPT-0)	At analysis section: Crown width = 21 feet Landside Slope = 2.6H:1V Waterside Slope = 2H:1V	none documented	none documented	DT (Dredge Tailings) H_{ch} (Holocene Channel deposits)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: GP, GM, GP-GM, GW-GC **Foundation**: GM, GC, GW, GP, GP-GM intermixed thin layers (~2 to 3ft) of ML, SM.	**200 yr WSE** Head = approximately 9.2 feet at analysis section	Scattered trees on the landside and waterside of the levee. Some agricultural on the landside of the levee.	2362+70 [None]	SM0007_010B (CREST)	WSE, geometry fairly consistent, so section at only boring location. Note that depth of wall (for cost purposes) expected to deepen d/s of boring (based on d/s reach characterization).	

TABLE 5-41B: ANALYSIS RESULTS FOR REACH 41
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2362+70

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.81	N/A	N/A	4	No	Does not meet gradient at toe. Dredge tailings (DT) modeled as GM-GP, about 60ft deep, waterside of levee, instead of extending blanket
200-year + 3 feet						No documented problems. Gradient not FS<1, analyzed WSE higher than this levee experienced; analysis and performance consistent

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 41 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 41 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: Cutoff Wall Tip Elevation 20 at 2359+00, constant decrease in depth up to Cutoff Wall Tip Elevation 70 at 2368+00

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	N/A	No breakout	Yes	Deep wall needed to tie in to layer with fine-grained material, mitigate underseepage.
200-year + 4 feet	No exit of water	N/A	N/A	No breakout	Yes	Fine-grained layer varies in depth over length of reach, so wall depth varies over length of reach, as indicated above

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.92		Yes	
200-year + 4 feet	1.91		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm and drainage relief trench at toe.

Dimensions of Primary Features: 2359+00 to 2368+00 seepage berm 70 feet wide, 5 feet thick at levee toe, with drainage relief trench along berm toe that is 50 feet wide at grade, extending down 12 feet deep, with 1.5:1 backcut and frontcut, filled with drain gravel, with filter zones adjacent in-situ soils

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.12	0.76	N/A	Top of berm	Yes	
200-year + 4 feet	0.27	0.98	N/A	Top of berm	Meets criteria at levee toe. See comments on berm toe.	Berm toe exit gradient marginally exceed the criteria. Seepage condition should be monitored during flood. If needed, a relief well or drainage system may be needed at the toe of the berm.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.38		Yes	
200-year + 4 feet	2.13		Yes	

Table 5-42: Summary of Geotechnical Analysis for 100 Year WSE

Reach	Design WSE (year)	Rehabilitation Needed for DWSE and or HTOL?	Reach analyzed for 100-year WSE?	Meets geotechnical criteria for 100-year WSE?
1	100	Yes	Yes	No
2	100	Yes	Yes	No
3	100	Yes	Yes	No
4	100	Yes	Yes	No
5	200	Yes	No	No
6	200	No	No	Yes
7	200	Yes	No	No
8	200	Yes	Yes	No
9	200	Yes	Yes	No
10	200	Yes	No	No
11	200	Yes	No	No
12	200	No*	No	Yes*
13	200	Yes	No	No
14	200	No*	No	Yes*
15	200	No*	No	Yes*
16	200	No	No	Yes
17	200	Yes	No	No
18	200	Yes	Yes	No
19	200	Yes	Yes	No
20	200	Yes	Yes	No
21	200	Yes	Yes	No
22	200	Yes	Yes	No
23	200	Yes	Yes	Yes
24	200	Yes	Yes	No
25	200	No	Yes	Yes
26	200	Yes	Yes	No
27	200	Yes	Yes	No
28	200	Yes	Yes	No
29	200	No	Yes	Yes
30	200	Yes	Yes	Yes
31	200	Yes	No	No
32	200	Yes	No	No
33	200	Yes	Yes	No
34	200	Yes	No	No
35	200	Yes	Yes	No
36	200	Yes	No	No
37	200	Yes	Yes	No
38	200	Yes	No	No
39	200	No*	No	Yes*
40	200	Yes	Yes	No
41	200	Yes	Yes	No

NOTE: * = Based on confirmation by receipt of as-constructed drawings or adequate confirmatory investigation.

TABLE 7-1. SUMMARY OF GEOTECHNICAL ANALYSES RESULTS FOR PRE-DESIGN FORMULATION
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

Evaluation Reach ID	Reach Limits		Existing Conditions Meet Analytical Criteria?	Existing Conditions Meet Performance Criteria?	Levee Rehabilitation Needed?	Rehabilitation Alternative	Approximate Dimensions of Primary Features	Comments
	Start Station	End Station						
1	10+00	129+66	No	No	Yes	Cutoff Wall	10+00 to 58+80 Cutoff Wall Tip Elevation 20 58+80 to 83+00 Cutoff Wall Tip Elevation 18 83+00 to 114+00 Cutoff Wall Tip Elevation 24 114+00 to 129+66 Cutoff Wall Tip Elevation 27	
						Undrained Seepage Berm with Drained Stability Berm	Drained Stability Berm: 8 feet tall Undrained Seepage Berm : 88 feet wide and 5 feet thick at levee toe.	Assume 25% of reach will have a seepage berm width extending to 100ft due to taller levee at some locations.
2	129+66	218+66	No	No	Yes	Cutoff Wall	129+66 to 181+00 Cutoff Wall Tip Elevation 20 181+00 to 191+00 Cutoff Wall Tip Elevation -10 191+00 to 218+66 Cutoff Wall Tip Elevation -73 with Full Levee Degrade.	191+00 to 220+00 Full Levee Degrade.
						Undrained Seepage Berm with Drained Stability Berm and Cutoff Wall with Seepage Berm	129+66 to 181+00: 8 feet tall Drained Stability Berm on Seepage Berm; Seepage Berm 100 feet wide and 5 feet thick at levee toe 181+00 to 218+66: Cutoff Wall Tip Elevation 30 feet with 100 feet wide Undrained Seepage Berm. Seepage Berm 5 feet thick at berm toe	
3	218+66	300+66	No	No	Yes	Cutoff Wall	218+66 to 220+00 Cutoff Wall Tip Elevation -73 220+00 to 230+00 Cutoff Wall Tip Elevation 20 230+00 to 250+00 Cutoff Wall Tip Elevation -35 250+00 to 289+00 Cutoff Wall Tip Elevation -20 289+00 to 300+66 Cutoff Wall Tip Elevation 15	
						Undrained Seepage Berm with Drained Stability Berm	8 feet tall Drained Stability Berm on 300 feet wide Undrained Seepage Berm with monitoring for seepage at the toe of the berm	Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
4	300+66	410+67	No	No	Yes	Cutoff Wall	300+66 to 349+00 Cutoff Wall Tip Elevation 15 349+00 to 368+00 Cutoff Wall Tip Elevation 10 368+00 to 410+67 Cutoff Wall Tip Elevation 20	
						Undrained Seepage Berm with Drained Stability Berm	8 feet tall Drained Stability Berm on 100 feet wide Undrained Seepage Berm; Seepage berm 5 feet thick at berm toe.	
5	410+67	478+68	No	No	Yes	Cutoff Wall and Cutoff Wall with Seepage Berm	410+67 to 417+00 Cutoff Wall Tip Elevation 20 417+00 to 425+00 Cutoff Wall Tip Elevation 10 425+00 to 456+00 Cutoff Wall Tip Elevation 15 456+00 to 478+68 Cutoff Wall Tip Elevation 15 with 200 feet wide Undrained Seepage Berm.	
						Undrained Seepage Berm	410+67 to 478+68: 300 feet wide Seepage Berm	Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

ENCLOSURE K

SBFCA WITH-PROJECT SEEPAGE/STABILITY RESULTS

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 7													
Station 539+30	Cutoff Wall Tip Elev. -5'	69.8	48	21.8	Physical Top of Levee (PTOL)	69.8	<0.10 [Toe, blanket = 7.8'] 0.54 [50' from toe, blanket=5.2']	0.0	Existing relief well did not perform adequately during previous flood event. Accordingly, they are not included in the model. Exit gradients are calculated at the toe and 50 feet from the toe. Blanket includes Layer 2 (CL).	1.54 (shallow) 2.36 (deep)		-	
					200yr + 1'	67.4	<0.10 [Toe, blanket = 7.8'] 0.50 [50' from toe, blanket=5.2']	0.0		1.65 (shallow) 2.42 (deep)		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 541+00	Cutoff Wall Tip Elev. -5'	69.8	47.1	22.7	Physical Top of Levee (PTOL)	69.7	Sensitivity Analysis Only Responding DWR review comment ID # 48, a set of sensitivity analyses were performed with adjusted stratigraphy. Steady State Seepage and Stability Analyses Results are as below; (Exit gradients are calculated at approximately 40 feet from toe through both thin and thick blankets) <u>PTOL</u> i=0.24 [Near toe, thin blanket=7'] i=0.19 [Near toe, thick blanket=12.6'] Breakout above toe =1.2' FS = 2.00 (Slope stability) <u>200yr+1'</u> i=0.23 [Near toe, thin blanket=7'] i=0.18 [Near toe, thick blanket=12.6'] Breakout above toe =1.2' FS = 2.02 (Slope stability) <u>Sensitivity analysis</u> performed with sand to elev. -8' results in; <u>PTOL</u> i=0.24 [Near toe, thin blanket=7'] i=0.20 [Near toe, thick blanket=12.6'] Breakout above toe =1.2' FS = 1.99 (Slope stability) <u>200yr+1'</u> i=0.24 [Near toe, thin blanket=7'] i=0.18 [Near toe, thick blanket=12.6'] Breakout above toe =1.2' FS = 2.02 (Slope stability) <u>Sensitivity analysis</u> performed with aquiclude truncated on landside results in; <u>PTOL</u> i=0.39 [Near toe, thin blanket=7'] i=0.33 [Near toe, thick blanket=12.6'] Breakout above toe =2' FS = 1.86 (Slope stability) <u>200yr+1'</u> i=0.37 [Near toe, thin blanket=7'] i=0.30 [Near toe, thick blanket=12.6'] Breakout above toe =2' FS = 1.90 (Slope stability)		RDD Analysis Only		-	This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.
					200yr + 1'	67.4						1.30	Waterside Levee Slope: 2.7H to flatter than 3.0H:1V Levee Slope Height = 22 feet Bench Width to Bank Slope = 15 feet Bank Slope: 1.4H to 1.7H:1V Bank Slope Height = 36 feet

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 545+50	Cutoff Wall Tip Elev. -5' Relief Wells: 50 feet deep, spaced 60 feet apart.	70.3	44.9	25.4	Physical Top of Levee (PTOL)	70.3	Sensitivity Analysis Only Responding to USACE review comment ID #1, sensitivity analysis was performed with and without the aquiclude to see if only cutoff wall option for this subreach could work or not. The following sensitivity results showed that the only cutoff wall option would work with the presence of aquiclude.			RDD Analysis Only		-	This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.
					200yr + 1'	67.5	<u>Sensitivity analysis</u> with hanging wall (tip elev. -54.5') without the aquiclude (SP instead of CL for Layer 6 results in; 200yr+4' :i=0.85 200yr+1': i=0.76 <u>Sensitivity analysis</u> with shallow cutoff wall (tip elev. -0.7') with the aquiclude (5.2' thick Elev. -0.7' to 4.5') results in; 200yr+4' :i=0.30 200yr+1': i=0.27					1.29	Waterside Levee Slope: 2.1H to flatter than 3.0H:1V Levee Slope Height = 22 feet Bench Width to Bank Slope = 30 feet Bank Slope: 1.0H to 1.2H:1V Bank Slope Height = 20 feet
Station 565+50	Cutoff Wall Tip Elev. -5' Relief Wells: 50 feet deep, spaced 60 feet apart.	70.8	47.1	23.7	200yr + 4'	70.7	0.58 [Toe, blanket=20.6'] 0.83 [50' from toe, blanket=18.7']	2.4	Relief wells modeled with fixed total head boundary condition at the bottom of the blanket. Fixed total head values chosen to represent conditions Mid-way between wells (i=0.3 for 200yr+1' at the toe due to thinning blanket conditions away from the toe; i=0.6 for 200yr+4' at the toe) Exit gradients are calculated at the toe and 50 feet from the toe. Blanket includes Layer 3 (ML).	1.52		-	Levee Slope: 2.1H to flatter than 3.0H:1V Levee Slope Height = 24 feet Bench Width to Bank Slope = 8 feet Bank Slope: 2.1H:1V Bank Slope Height = 20 feet Past performance records state instability associated with rapid drawdown was experienced between stations 563+00 and 568+74 when the east bank of the levee was breached during the 1997 flood event.
					200yr + 1'	67.7	0.30 [Toe, blanket=20.6'] 0.58 [50' from toe, blanket=18.7']	2.2		1.80		1.27	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 585+00	Cutoff Wall Tip Elev. -10'	70.6	46.5	24.1	Physical Top of Levee (PTOL)	70.6	<0.10 [Toe, blanket=9.1']	11.4	Exit gradient is calculated at the toe. Blanket includes Layer 2 (CL). Responding to DWR Review Comments ID #54, sensitivity analysis was performed with truncated waterside blanket to validate the design. The results are as below; PTOL i<0.10 [Toe, blanket=7.9'] Breakout above toe = 11' FS = 1.73 (slope stability) 200yr+1' i<0.10 [Toe, blanket=7.9'] Breakout above toe =0' FS = 1.76 (slope stability) Responding to DWR Review Comments ID #55, sensitivity analysis was performed with truncated landside aquiclude to validate the design. The results are as below; PTOL i=0.37 [Toe, blanket=7.9'] i=0.20 [Toe, blanket=25.4'] Breakout above toe = 3.1' FS = 1.58 (slope stability) 200yr+1' i=0.32 [Toe, blanket=7.9'] i=0.17 [Toe, blanket=25.4'] Breakout above toe =1.8' FS = 1.62 (slope stability) Responding to DWR Review Comments ID #55, sensitivity analysis was performed with truncated landside aquiclude and blanket thinned to elev +40 to validate the design. The results are as below; PTOL i=0.38 [Toe, blanket=7.9'] Breakout above toe = 11' FS = 1.59 (slope stability) 200yr+1' i=0.35 [Toe, blanket=7.9'] Breakout above toe =1.8' FS = 1.61 (slope stability)	1.73		-	
					200yr + 1'	67.8	<0.10 [Toe, blanket=9.1']	0.0		1.74		1.28	Waterside Levee Slope: 4.8H:1V Levee Slope Height = 13 feet Bench Width to Bank Slope = 25 feet Bank Slope: 1.1H:XV Bank Slope Height = 17 feet

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 8													
Station 601+00	Cutoff Wall Tip Elev. +15'	72.1	48	24.1	200yr + 1'	68.0	RDD Analysis Only			RDD Analysis Only		1.98	Waterside Levee Slope: 2.7H to flatter than 3.0H:1V Levee Slope Height = 23 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.2H to 1.4H:1V Bank Slope Height = 31 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 623+86	Cutoff Wall Tip Elev. +15'	72.1	48	24.1	200yr + 4'	71.3	<0.10 [Toe, thin blanket=10.6'] 0.57 [Toe, thick blanket =35.1'] 0.10 [20' from toe, thin blanket =9.7'] 0.59 [20' from toe, thick blanket =33.9']	0.0	Exit gradients are calculated at the toe and 20 feet from the toe. Thin blanket includes Layer 3 (CL); thick blanket includes Layer 3 (CL), Layer 4 (SP-SM) and Layer 5 (CL). Responding to DWR Review Comments ID #113, a <u>sensitivity analysis</u> was performed with SC instead of SP for Layer 2 and truncated waterside blanket. The results are as below;	1.89		-	
					200yr + 1'	68.3	<0.10 [Toe, thin blanket =10.6'] 0.50 [Toe, thick blanket =35.1'] <0.10 [20' from toe, thin blanket =9.7'] 0.52 [20' from toe, thick blanket=33.9']	0.0	<u>200yr+4'</u> i=0.12 [Toe, thin blanket=10.6'] i=0.56 [Toe, thick blanket=35.1'] <u>200yr+1'</u> i<0.1 [Toe, thin blanket=10.6'] i=0.48 [Toe, thick blanket=35.1'] Responding to DWR Review Comments ID #61, a <u>sensitivity analysis</u> was performed with truncated waterside blanket. The results are as below; <u>200yr+4'</u> i=0.08 [Toe, thin blanket=10.6'] i=0.57 [Toe, thick blanket=35.1'] i=0.10 [20' from toe, thin blanket=9.7'] i=0.59 [20' from toe, thick blanket=33.9'] Breakout above toe = 0' FS = 1.89 (Slope stability) <u>200yr+1'</u> i=0.08 [Toe, thin blanket=10.6'] i=0.50 [Toe, thick blanket=35.1'] i=0.09 [20' from toe, thin blanket=9.7'] i=0.52 [20' from toe, thick blanket=33.9'] Breakout above toe = 0' FS = 1.90 (Slope stability) The above sensitivity results are identical to those of the primary model presented. Accordingly, truncated WS has no effect on the results.	1.90		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 636+00	Cutoff Wall Tip Elev. +15'	72.5	48.2	24.3	200yr + 4'	71.4	0.21 [Toe, thin blanket=9.6'] 0.60 [Toe, thick blanket=32.2']	0.0	Exit gradient is calculated at the toe. Thin blanket includes Layer 2 (CL); thick blanket includes Layer 2 (CL), Layer 3 (SP), and Layer 4 (CL). <u>Sensitivity analysis</u> was performed with boundary condition changed from the fixed total head to no flow along the water side of model (at the middle of river). The results are as below; <u>200yr+4'</u> i=0.13 [Toe, thin blanket] i=0.28 [Toe, thick blanket] <u>200yr+1'</u> i<0.10 [Toe, thin blanket] i<0.10 [Toe, thick blanket] Responding to DWR Review Comments ID # 63, the following explanation is added. The average exit gradient is 0.52 across a 32 feet thick blanket at 200yr + 1 ft WSE. The lower CL layer and thin blanket are separated by a permeable sand layer (SP), which will likely release some pore water pressure across SP layer and 3-dimensional directions in reality, thereby reducing the exit gradient. Furthermore, the gradient criteria (i=0.5 equivalent to FS=0.8/0.5=1.6) is based on an assumed saturated unit weight of 112.5 pcf for the blanket materials. The average estimated saturated unit weight for the 32 ft thick combined blanket layer is nearer 125 pcf. The critical exit gradient, i_{cr} and FS computations are as follows; i_{cr}=(125-62.4)/(62.4)=1.0 and FS =i_{cr}/i = 1.0/0.52=1.9 > 1.6 Given the above it is considered that the section meets criteria.	1.68		-	
					200yr + 1'	68.4	0.19 [Toe, thin blanket=9.6'] 0.52 [Toe, thick blanket=32.2']	0.0		1.69		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 9													
Station 656+00	Cutoff Wall Tip Elev. +15'	74.2	50.8	23.4	200yr + 1'	68.7	Sensitivity Analysis Only Responding to DWR Review Comment ID #64, sensitivity analysis was performed with SM instead of CL for Layer 2 to validate the design. The results are as below; 200yr+4' i=0.33 [Toe, blanket=24.6'] Breakout above toe = 0.3' FS = 2.21 (Slope stability) 200yr+1' i=0.28 [Toe, blanket=24.6'] Breakout above toe = 0.3' FS = 2.31 (Slope stability)			RDD Analysis Only		0.84 1.00 (deep slip surface crossing the levee prism)	Waterside Levee Slope: 2.7H to flatter than 3.0H:1V Levee Slope Height = 23 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.2H to 1.4H:1V Bank Slope Height = 31 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. Possible rapid drawdown stability remediation extent may be between station 654+00 and 667+00 Rapid drawdown (RDD) analysis show that slip surfaces with a factor of safety less than or equal to 1 occur within the steep channel slopes and that some of these encroach into the theoretical levee prism. However, slip surfaces that encroach into the existing levee profile and that could impact the global stability of the levee have a factor of safety greater than 1. Therefore, the levee is considered to have an adequate FOS to meet RDD criteria. Wide levee crown and/or waterside bench in this area. Slope maintenance to address sloughing of steep channel bank slopes may be required in the future..

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 683+00	Cutoff Wall Tip Elev. +20'	75.8	49.9	25.9	200yr + 4'	72.4	0.29 [Toe, thin blanket =12.4'] 0.48 [Toe, thick blanket =31.7']]	0.0	Exit gradient is calculated at the toe. Thin blanket includes Layer 2 (SP-SM) and Layer 3 (ML); thick blanket includes Layer 2 (SP-SM), Layer 3 (ML) and Layer 5 (ML). <u>Sensitivity analysis</u> was performed with ML instead of SP-SM for Layer 2. The results are as below; <u>200yr+4'</u> i=0.46 (Toe, thin blanket) i=0.49 (Toe, thick blanket) <u>200yr+1'</u> i=0.40 (Toe, thin blanket) i=0.43 (Toe, thick blanket) Responding to DWR review comment ID#66, <u>Sensitivity analysis</u> with adjusted layer 6 (SP) referring to CPT SL0001_007C results in; <u>200yr+4'</u> i=0.38 (Toe, thin blanket) i=0.55 (Toe, thick blanket) FS=2.18 (Slope stability) <u>200yr+1'</u> i=0.32 (Toe, thin blanket) i=0.48 (Toe, thick blanket) FS=2.21 (Slope stability)	2.22		-	
					200yr + 1'	69.4	0.24 [Toe, thin blanket =12.4'] 0.41 [Toe, thick blanket =31.7']]	0.0		2.24		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 705+84	Cutoff Wall Tip Elev.-10'	76.6	50.9	25.7	200yr + 4'	72.9	0.30 [Toe, thin blanket =11.3'] 0.52 [Toe, thick blanket =28.6']	0.0	Exit gradient is calculated at the toe. Thin blanket includes Layer 3 (SM) and Layer 4 (CL); thick blanket includes Layer 3 through Layer 6 (CL). <u>Sensitivity Analysis</u> With cutoff wall tip elev. +20' results in; <u>200yr+4'</u> i=0.30 (Toe, thin blanket) i=0.63 (Toe, thick blanket) <u>200yr+1'</u> i=0.26 (Toe, thin blanket) i=0.54 (Toe, thick blanket) Accordingly, results do not meet criteria. <u>Sensitivity Analysis</u> With the kh=1.0E-05 cm/s instead of kh=1.0E-6 cm/s for Layer 6 (CL) results in; <u>200yr+4'</u> i=0.58 (Toe, thin blanket) i=0.33 (Toe, thick blanket) <u>200yr+1'</u> i=0.50 (Toe, thin blanket) i=0.28 (Toe, thick blanket) <u>Sensitivity Analysis</u> With the anisotropic ratio (kh/kv=10) for Layer 7 (SP-SM) results in the same as the primary analysis. Anisotropic ratio change does not affect the results.	2.40		-	
					200yr + 1'	69.9	0.20 [Toe, thin blanket =11.3'] 0.45 [Toe, thick blanket =28.6']	0.0		2.42		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 10													
Station 721+00	Cutoff Wall Tip Elev. -10'	76.6	49	27.6	200yr + 4'	73.3	0.25 [Toe, blanket =24.3']	8.2	Exit gradient is calculated at toe. Blanket includes Layer 3 (CL) and Layer 4 (CL). Sensitivity analysis with cutoff wall tip elev.+25' results in; 200yr+4' :i=0.87 [Toe] 200yr+1' : i=0.77 [Toe] Responding to DWR Review Comments ID #70, through seepage flux Q on landside slope are calculated as follows; 200yr+4'; Q=0.00131 gpm/ft of levee 200yr+1'; Q=0.00098 gpm/ft of levee Due to the presence of the clay core in the embankment and very small amount of seepage flux estimated, through seepage is considered as "meeting criteria".	1.85		-	
					200yr + 1'	70.3	0.22 [Toe, blanket =24.3']	8.2		1.87		-	
Station 733+84	Cutoff Wall Tip Elev. -5'	77.7	51.7	26.0	200yr + 4'	73.6	<0.10 [Toe, thin blanket =13.5'] 0.34 [Toe, thick blanket =64.2'] 0.15 [21' from toe, thin blanket =11.7'] 0.37 [21' from toe, thick blanket =63.5']	1.2	Exit gradients are calculated at the toe and 21 feet from toe. Thin blanket includes Layer 3 (CL); thick blanket includes Layer 3 (CL), Layer 4 (SP-SM), and Layer 5 (CL). Responding to DWR Review Comments ID #71, through seepage flux Q on landside slope are calculated as follows; 200ry+4'; Q=0.00047 gpm/ft of levee 200yr+1'; Q=0.00041 gpm/ft of levee Due to the presence of the clay core in the embankment and very small amount of seepage flux estimated, through seepage is considered as "meeting criteria".	1.92		-	
					200yr + 1'	70.6	<0.10 [Toe, thin blanket =13.5'] 0.29 [Toe, thick blanket =64.2'] 0.13 [21' from toe, thin blanket =11.7'] 0.32 [21' from toe, thick blanket =63.5']	0.8		1.95		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 11													
Station 808+85	Cutoff Wall Tip Elev. -5'	78.7	56.5	22.2	200yr + 4'	75.6	<0.10 [Toe, blanket=8.8']	0.0	Exit gradients are calculated at the toe. Blanket includes Layer2 (ML) and Layer 3 (CL).	1.61		-	
					200yr + 1'	72.6	<0.10 [Toe, blanket=8.8']	0.0		1.61		-	
Station 810+00	Cutoff Wall Tip Elev. -5'	78.7	55.6	23.1	200yr + 1'	72.6	Sensitivity Analysis Only Responding to USACE review comment ID # 3, sensitivity analysis was performed with refined aquiclude layer 5 (ML) underlain by gravel layer. The cutoff wall embedded into the aquiclude with both kh=1.0E-4 cm/s and kh=1.0E-5 cm/s produced the following results: <u>Sensitivity analysis</u> with thin aquiclude (7' thick) i = 0.42 for 200yr+1 (kh=1.0E-5 cm/s) i = 0.91 for 200yr+1 (kh=1.0E-4 cm/s) It is considered overly conservative to assume a thin aquiclude layer in combination with higher hydraulic conductivity of 1.0E-04 cm/s, As such, URS conclude from the sensitivity analysis that the proposed rehabilitation option is acceptable.			RDD Analysis Only		1.69	Waterside Levee Slope: Flatter than 3.0H:1V Levee Slope Height = 23 feet Bench Width to Bank Slope = 0 feet Bank Slope: 2.7H to flatter than 3.0H:1V Bank Slope Height = 35 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.
Reach 13													
Station 861+33	Cutoff Wall Tip Elev. -30.5' Rehabilitation of existing relief wells (if needed)	81.2	55	26.2	200yr + 4'	78.2	0.42 [Toe, blanket=12.2'] 0.72 [Ditch 12' from toe, blanket=9.4']	0.0 Seepage flux Q within 100 feet from toe across 100 feet distance of levee (existing relief well spacing) = 0.78 gpm	Existing relief wells are not modeled. Exit gradient is calculated at toe. Design Tech Memo for Reach 13 (July 2012) presents alternatives 1, 2, 3A, and 3B. Alternative 3A is selected for the primary analysis and alternative 2 and 3B results are presented as sensitivity analyses in GDRR. Responding DWR Review Comments #77, #78, and #83, the following sensitivity analyses were performed. <u>Sensitivity analysis</u> (alternative 2) with fully penetrating cutoff wall with full or partial levee degraded results in;	1.56		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
					200yr + 1'	75.2	0.33 [Toe, blanket=12.2'] 0.60 [Ditch 12' from toe, blanket=9.4']	0.0 Seepage flux Q within 100 feet from toe across 100 feet distance of levee (existing relief well spacing) = 0.65 gpm	<u>200yr+4'</u> i<0.10 [Toe, blanket=12.2'] Seepage flux Q within 100 feet from toe across 100 feet distance of levee (existing relief well spacing) = 0.03 gpm FS =1.87 (Slope stability) <u>200yr+1'</u> i<0.10 [Toe, blanket=12.2'] Seepage flux Q within 100 feet from toe across 100 feet distance of levee (existing relief well spacing) = 0.0 gpm FS =1.87 (Slope stability) <u>Sensitivity analysis</u> (alternative 3B) with full levee degrade and approximately 22 feet gap between cutoff wall tip and aquiclude results in; <u>200yr+4'</u> i=0.61 [Toe, blanket=12.2'] i=0.96 [Ditch 12' from Levee Toe, blanket= 9.4'] Seepage flux Q within 100 feet from toe across 100 feet distance of levee (existing relief well spacing) = 1.01 gpm FS =1.38 (Slope stability) <u>200yr+1'</u> i=0.50 [Toe, blanket=12.2'] i=0.81 [Ditch 12' from Levee Toe, blanket=9.4'] Seepage flux Q within 100 feet from toe across 100 feet distance of levee (existing relief well spacing) = 0.85 gpm FS =1.49 (Slope stability)	1.63		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 15													
Station 966+00	No proposed rehabilitation measure as cutoff wall is present	81.5	57.3	24.2	200yr + 1'	77.8	RDD Analysis Only			RDD Analysis Only Responding to DWR Review Comments ID #86, sensitivity analysis was performed with shear strength OCR<2 of CL for Layer 4. The result does not change. No effect on strength change for relatively deep material.		1.52	Representative of LD1 reported that an existing cutoff wall exists at this location, however as-built documents not available. For RDD analyses, dimensions and properties of this existing cutoff wall were assumed. As-builts are needed to confirm. Waterside Levee Slope: 1.2H to 1.4H:1V Levee Slope Height = 24 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA Sensitivity Analysis with shear strength OCR<2 for Layer 4 results in (DWR review comment ID #86) FS=1.51 (same) This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 16													
Station 993+80	None	82.8	61.3	21.5	200yr + 1'	78.7	RDD Analysis Only			RDD Analysis Only Responding to DWR Review Comments ID # 88, sensitivity analysis was performed with using SP-SM by thickening Layer 4 to elevation 30-56 feet on landside. This had no effect on the results due to same phreatic surfaces conditions as in primary analysis .		0.85	Waterside Levee Slope: 1.2H to 1.4H:1V Levee Slope Height = 24 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. Critical slip surface occurs in steep levee slope. Possible extent of remediation may be between station 992+00 and 1001+00. Rapid drawdown (RDD) analysis show that slip surfaces with a factor of safety less than or equal to 1 occur within the steep channel slopes and that some of these encroach into the theoretical levee prism. However, slip surfaces that encroach into the existing levee profile and that could impact the global stability of the levee have a factor of safety greater than 1. Therefore, the levee is considered to have an adequate FOS to meet RDD criteria. Wide levee crown in this area. Slope maintenance to address sloughing of steep channel bank slopes may be required in the future.

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 997+00	Monitoring for waterside slope distress during and after high water events	82.9	61.3	21.6	200yr + 1'	78.7	RDD Analysis Only			RDD Analysis Only		0.94	Waterside Levee Slope: 2.7H to flatter than 3.0H:1V Levee Slope Height = 21 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.2H to 1.4H:1V Bank Slope Height = 33 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. Rapid drawdown (RDD) analysis show that slip surfaces with a factor of safety less than or equal to 1 occur within the steep channel slopes and that some of these encroach into the theoretical levee prism. Slip surfaces that encroach into the existing levee profile and that could impact the global stability of the levee have a factor of safety greater than 1. Therefore, the levee is considered to have an adequate FOS to meet RDD criteria. However, the theoretical levee prism daylights out of the lower channel slope and monitoring for signs of slope distress should be performed. Slope maintenance to address sloughing of steep channel bank slopes may be required in the future

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1005+00	None.	83.2	61.9	21.3	200yr + 1'	78.7	RDD Analysis Only			RDD Analysis Only		1.16	Waterside Levee Slope: 1.7H to flatter than 3.0H:1V Levee Slope Height = 21 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.7H:1V Bank Slope Height = 30 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.
Station 1006+20	Closure of gap in cutoff wall at 5th Street Bridge crossing: cutoff wall tip elev. +40 '	84.8	70.1	14.7	200yr + 4'	81.7	<0.10 [Toe, thin blanket =13.7'] 0.15 [Toe, thick blanket =50.2'] 0.29 [50 feet from toe, thin blanket =8.6'] 0.26 [50 feet from toe, thick blanket =46.7']	0.0	Exit gradients are calculated at levee toe and 50 feet from toe. Thin blanket includes Layer 3 (ML); Thick blanket includes Layer 3 (ML), Layer 4 (SC), Layer 5 (SP-SM), and Layer 6 (ML). Responding to DWR Review Comments ID # 93, sensitivity analysis was performed with SM (30-49% fines, anisotropic ratio kh/kv=10) instead of ML for Layer 6 results in: 200yr+4' i<0.10 [Toe, thin blanket=13.7'] i=0.13 [Toe, thick blanket=50.2'] i=0.50 [50 feet from toe, thin blanket=8.6'] i=0.23 [50 feet from toe, thick blanket=46.8'] FS=1.44 (Slope stability) 200yr+1' i<0.10 [Toe, thin blanket=13.7'] i<0.10 [Toe, thick blanket=50.2'] i=0.40 [50 feet from toe, thin blanket=8.6'] i=0.19 [50 feet from toe, thick blanket=46.8'] FS=1.44 (Slope stability)	1.44		-	
					200yr + 1'	78.7	<0.10 [Toe, thin blanket =13.7'] 0.10 [Toe, thick blanket =50.2'] 0.22 [50 feet from toe, thin blanket =8.6'] 0.21 [50 feet from toe, thick blanket =46.7']	0.0		1.44		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1026+50	Closure of 10th Street Bridge crossing: Existing Conditions	91.8	60	31.8	200yr + 3'	81.3	0.42 [Existing landside toe, blanket =39.8']	10.4	Exit gradients are calculated at the toe of the existing levee. Blanket includes Layer 3 (ML), Layer 4 (ML), and Layer 5 (CL). Sensitivity analysis was performed with SM 13 to 29 % fines for Layer 2 in embankment. The results are as below; 200yr+3' i=0.42 [Levee toe], breakout=3.3 feet FS=1.17 (Slope Stability) 200yr i=0.36 [Levee toe], breakout=3.3 feet FS=1.22 (Slope Stability)	1.09			
					200yr	78.3	0.36 [Existing landside toe, blanket=39.8']	6.9		1.18			
	Closure of 10th Street Bridge crossing: Stability Berm 23 feet wide and approximately 7 feet thick at the levee toe.	91.8	60	31.8	200yr + 4'	82.3	0.26 [Levee Toe, blanket =45.7'] 0.49 [Toe of Stability Berm blanket =38.4']	1.0 above toe of berm	Proposed berm modeled assuming 3 to 7 percent of fines (Kh=4.0E-03 cm/s). Exit gradients are calculated at levee toe and at toe of stability berm. Blanket includes Layer 3 (ML), Layer 4 (ML) and Layer 5 (CL). Responding to DWR comment ID EXT/Reach16-001, the filter compatibility check has been performed (see appendix C). Sensitivity analysis was performed with proposed berm with 0 to 2 percent of fines (kh=1.5E-2 cm/s). The results are as below; 200yr+4' i=0.26 [Levee toe] i=0.49 [Toe of stability berm] breakout =0.0' above toe of berm FS=1.55 (Slope stability) 200yr+1' i=0.20 [Levee toe] i=0.42 [Toe of stability berm] breakout=0.0' above toe of berm FS=1.55 (Slope Stability)	1.46 (1.89) localized shallow failure surface at top of the stability berm)		-	
					200yr + 1'	79.3	0.20 [Levee Toe, blanket =45.7'] 0.42 [Toe of Stability Berm blanket =38.4']	0.8 above toe of berm		1.55 (1.94) localized shallow failure surface at top of the stability berm)		-	
Station 1031+00	None	84.6	62.2	22.4	200yr + 1'	79.3	RDD Analysis Only			RDD Analysis Only		1.25	Waterside Levee Slope: 2.1H to flatter than 3.0H:1V Levee Slope Height = 25 feet Bench Width to Bank Slope = 15 feet to 20 feet Bank Slope: 1.7H:1V Bank Slope Height = 17 feet

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 17													
Station 1108+86	Cutoff Wall Tip Elev. +35' with landside depression backfilled.	86.4	64.5	21.9	200yr + 4'	83.1	0.53 [Toe, blanket =7.0'] 0.64 [65' from toe, blanket=4.9']	3.0	Exit gradients are calculated at toe and approximately 65 feet from toe. Blanket includes Layer 2 (CL). Through seepage flux Q on landside slope across 100 feet of Levee 200yr+4'; Q=0.00027 gpm/ft of levee 200yr+1'; Q=0.00022 gpm/ft of levee	1.36		-	
					200yr + 1'	80.1	0.46 [Toe, blanket =7.0'] 0.58 [65' from toe, blanket=4.9']	1.8		1.42		-	
Station 1116+00	Cutoff Wall Tip Elev. +35' with landside depression backfilled.	86.0	64.8	21.2	200yr + 1'	80.3	RDD Analysis Only			RDD Analysis Only		1.06	Waterside Levee Slope: 2.1H to flatter than 3.0H:1V Levee Slope Height = 22 feet Bench Width to Bank Slope = 0 feet Bank Slope: Flatter than 3.0H:1V Bank Slope Height = 10 feet Existing embankment has been modeled as a normally consolidated silt with c'=0 and a ϕ'=30°. Sensitivity analysis assuming c'=50 psf and a ϕ'=31° generates a min FS=1.27.

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1125+00	Cutoff Wall Tip Elev. +35' with landside depression backfilled.	86.0	65.6	20.4	200yr + 4'	83.5	0.19 [Toe, thin blanket =8.3'] 0.19 [Toe, thick blanket=37'] 0.56 [55' from toe, blanket =5.6']	0.0	Exit gradients are calculated at toe and 55 feet from the toe. Thin blanket includes Layer 2 (CL-ML) thick blanket includes Layers 2 through 6. This location is a transition from shallow to deeper cutoff wall. Analysis represents shallow cutoff wall.	1.71		-	
					200yr + 1'	80.5	0.13 [Toe, thin blanket =8.3'] 0.15 [Toe, thick blanket=37'] 0.50 [55' from toe, blanket =5.6']	0.0	Responding IPE review comments ID # 55, sensitivity analysis was performed with CL instead of ML for Layer 6 to evaluate effects of this layer on seepage conditions. Results are as below; <u>200yr+4'</u> i<0.10 [Toe, thin blanket=8.4'] i=0.26 [55' from toe, thin blanket=5.6'] i=0.32 [55' from toe, thick blanket=33.1'] Breakout=0' FS=1.86 (Slope Stability) <u>200yr+1'</u> i<0.10 [Toe, thin blanket=8.4'] i=0.23 [55' from toe, thin blanket=5.6'] i=0.25 [55' from toe, thick blanket=33.1'] Breakout=0' FS=1.92 (Slope Stability)	1.80		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 18													
Station 1138+86	Cutoff Wall Tip Elev. +0'	86.8	66.6	20.2	200yr + 4'	83.6	<0.10 [Toe, blanket =8.8']	0.0	Blanket includes Layer 2 (CL).	1.82		-	
					200yr + 1'	80.6	<0.10 [Toe, blanket =8.8']	0.0		1.84		-	
Station 1163+75	Cutoff Wall Tip Elev. +25'	86.8	66.7	20.1	200yr + 4'	84.1	0.39 [Toe, blanket =5.7'] 0.23 [Toe, blanket =9.8'] 0.20 [Toe, blanket =42.2']	1.2	The first blanket includes Layer 2 (CL). The second blanket includes Layer 2 (CL) and Layer 3 (SM). The third blanket includes Layer 2 (CL) through Layer 5 (ML). Due to the presence of the clay core in the embankment and the cutoff wall, through seepage is considered as "meeting criteria" Responding to DWR review comment #100, exit gradient was calculated through blanket including Layer 2 through Layer 5 (=42.2').	1.60		-	
					200yr + 1'	81.1	0.30 [Toe, blanket =5.7'] 0.18 [Toe, blanket =9.8'] 0.17 [Toe, blanket =42.2']	0.9		1.69		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 19													
Station 1224+00	Cutoff Wall Tip Elev. +5'	87.2	68.1	19.1	200yr + 4'	84.9	0.43 [Toe, blanket =4.9']	1.4	Blanket includes Layer 2(CL).	1.61		-	
					200yr + 1'	81.9	0.33 [Toe, blanket =4.9']	0.7	Sensitivity analysis with cutoff wall tip elev. +25' results in; 200yr+4' :i=0.73 [Toe] 200yr+1' :i=0.59 [Toe]	1.65		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1244+00	Cutoff Wall Tip Elev. -42'	88.3	68.9	19.4	200yr + 4'	85.0	<0.10 [Toe, blanket =5.5']	0.0	Blanket includes Layer 2 (CL).	1.69		-	
					200yr + 1'	82.0	<0.10 [Toe, blanket =5.5']	0.0	Sensitivity Analysis with the cutoff wall tip elev. -35' results in: 200yr+4': i=0.18 [Toe] 200yr+1': i=0.15 [Toe] Responding to DWR Review Comment ID # 103, the following sensitivity analyses were performed. Sensitivity analysis with truncated landside CL aquiclude and added aquifer below results in; 200yr+4' i=0.31 [Toe, blanket=5.5'] Breakout above toe = 1.7' FS = 1.58 (Slope stability) 200yr+1' i=0.24 [Toe, blanket=5.5'] Breakout above toe =1.3' FS = 1.61 (Slope stability) Sensitivity analysis with truncated landside aquicludes (CL and SM) and add aquifer below results in; 200yr+4' i=0.33 [Toe, blanket=5.5'] Breakout above toe = 1.8' FS = 1.57 (Slope stability) 200yr+1' i=0.25 [Toe, blanket=5.5'] Breakout above toe =1.4' FS = 1.61 (Slope stability)	1.69		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1293+00	Cutoff Wall Tip Elev. +35'	89.0	70.5	18.5	200yr + 4'	85.4	<0.10 [Toe, thin blanket =8.7'] 0.24 [Toe, thick blanket=40.0']	0.0	Exit gradient is calculated at toe. Thin blanket includes Layer 2 (CL). Thick blanket includes Layers 2, 3, 4, and 5.	1.79		-	
					200yr + 1'	82.4	<0.10 [Toe, thin blanket =8.7'] 0.19 [Toe, thick blanket=40.0']	0.0		1.79		-	
Reach 20													
Station 1338+83	Cutoff Wall Tip Elev. +50'	89.1	73.8	15.3	200yr + 4'	86.0	<0.10 [Toe, thin blanket =10'] 0.20 [Toe, thick blanket =37']	0.0	Exit gradient is calculated at the toe. Thin blanket includes Layer 2 (SC-SM). Thick blanket includes Layer 2 (SC-SM), Layer 3 (SP-SM), and Layer 4 (CL).	1.59		-	Waterside Levee Slope: 2.7H to flatter than 3.0H:1V Levee Slope Height = 16 feet Bench Width to Bank Slope = 15 feet to 20 feet Bank Slope: 2.1H to 2.7H:1V Bank Slope Height = 13 feet
					200yr + 1'	83.0	<0.10 [Toe, thin blanket =10'] 0.15 [Toe, thick blanket =37']	0.0		1.59		1.95	
Reach 21													
Station 1378+83	Cutoff Wall Tip Elev. +32'	89.3	78.4	10.9	200yr + 4'	87.1	<0.10 [Toe, blanket =8.8'] 0.58 [bottom of ditch 40' from toe, blanket=2.4']	0.0	Exit gradients are calculated at the toe and at the bottom of ditch 40 feet from the toe). Blanket at the bottom of ditch includes Layer 2 (CL). <u>Sensitivity analysis</u> with Layer 5 (ML) replaced with SP results in: <u>200yr+4'</u> i<0.10 [Toe] i=0.58 [bottom of ditch] <u>200yr+1'</u> i<0.10 [Toe] i=0.58 [bottom of ditch]	1.89		-	
					200yr + 1'	84.1	<0.10 [Toe, blanket = 8.8'] 0.58 [bottom of ditch 40' from toe, blanket=2.4']	0.0		1.89		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1400+00	Cutoff Wall Tip Elev. +55	89.9	78.7	11.2	200yr + 4'	87.4	Sensitivity Analysis Only			2.37			
					200yr + 1'	84.4	Responding to IPE Review Comment ID #45, analysis was performed at station 1400+00. The results are as below; 200yr+4' i<0.10 [toe, thin blanket =12.5'] i=0.24 [toe, thick blanket =22.3'] i=0.49 [bottom of ditch 50' from toe, thin blanket =6.5'] i=0.51 [bottom of ditch 50' from toe, thick blanket =16.3'] 200yr+1' i<0.10 [toe, thin blanket =12.5'] i=0.19 [toe, thick blanket =22.3'] i=0.44 [bottom of ditch 50' from toe, thin blanket =6.5'] i=0.42 [bottom of ditch 50' from toe, thick blanket =16.3']			2.37			
Station 1427+00	Cutoff Wall Tip Elev. +40'	91.4	80.3	11.1	200yr + 4'	87.6	<0.10 [Toe, blanket =10.2'] 0.37 [bottom of ditch 52' from levee toe, blanket=5.6']	0.0	Blanket at the bottom of ditch includes Layer 3 (SM).	1.69		-	
					200yr + 1'	84.6	<0.10 [Toe, blanket =10.2'] 0.29 [bottom of ditch 52' from toe, blanket=5.6']	0.0		1.70		-	
Station 1430+00	Cutoff Wall Tip Elev. +40'	91.0	74.6	16.4	200yr + 4'	87.6	0.34 [Toe at the bottom of canal, blanket=5.0']	0.0	Exit gradient is calculated at the bottom of canal adjacent to levee. Blanket includes Layer 3 (SM).	1.43		-	
					200yr + 1'	84.6	0.24 [Toe at the bottom of canal, blanket=5.0']	0.0	Total head boundary condition as an elevation head at far field is used for the upper pervious Layer 3 (SP-SM) on right side of model. It prevents unrealistic seepage flow back from landside.	1.48		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 22													
Station 1458+00	Cutoff Wall Tip Elev. +50' Full levee degrade and reconstruction due to severe animal burrowing (not modeled see note in figure C-R22-1A)	90.7	77	13.7	200yr + 4'	88.2	<0.10 [Toe, blanket =5.8'] <0.10 [Ditch 170' from toe, blanket =2.0']	0.0	Exit gradients are calculated at toe and at bottom of ditch 170 feet from toe. Breakout is beyond landside toe	1.90		-	
					200yr + 1'	85.2	<0.10 [Toe, blanket =5.8'] <0.10 [Ditch 170' from toe, blanket =2.0']	0.0		1.90		-	
Station 1468+83	Cutoff Wall Tip Elev. +55'	91.4	79.1	12.3	200yr + 4'	88.4	<0.10 [Toe, blanket =3.0'] <0.10 [at the bottom of ditch 85' from toe, blanket =5.0']	0.0	Exit gradients are calculated at toe and at the bottom of ditch 85 feet from toe. Breakout is beyond landside toe <u>Sensitivity Analysis</u> For Layer 3 (SC-SM) replaced with SP-SM results in; <u>200yr+4'</u> i<0.10 [Toe] i<0.10 [bottom of ditch] <u>200yr+1'</u> i<0.10 [Toe] i<0.10 [bottom of ditch] <u>Sensitivity Analysis</u> For the Layer 2 (CL) with kv=1.0E-5cm/s results in; <u>200yr+4'</u> i<0.10 [Toe] i<0.10 [bottom of ditch] <u>200yr+1'</u> i<0.10 [Toe] i<0.10 [bottom of ditch]	2.03		-	
					200yr + 1'	85.4	<0.10 [Toe, blanket =3.0'] <0.10 [at the bottom of ditch 85' from toe, blanket=5.0']	0.0		2.03		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1470+00	Cutoff Wall Tip Elev. +55'	91.8	81.5	10.3	200yr + 1'	85.4	RDD Analysis Only			RDD Analysis Only		1.51	Waterside Levee Slope: 1.4H to 2.7H:1V Waterside Levee Slope Height = 10 feet Bench Width to Bank Slope = 0 feet Bank Slope: 2.7H:1V Bank Slope Height = 8 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1499+00	Cutoff Wall Tip Elev. +55'	90.6	79.5	11.1	200yr + 4'	89.2	<0.10 [Toe, thin blanket=9.2'] 0.17 [Toe, thick blanket=26.3'] <0.10 [170' from toe, thin blanket=4.8'] 0.38 [170' from toe, thick blanket=21.9']	0.0	Exit gradients are calculated at the toe and at bottom of ditch 170 feet from the toe. Breakout is beyond toe. Thin blanket includes Layer 2 (CL). Thick blanket includes Layers 2, 3, and 4. Total head boundary condition as an elevation head at far field is used for the upper pervious Layer 3 (SP) on right side of model. It prevents unrealistic seepage flow back (limitation of 2D model) through Layer 3 SP from landside. Responding to DWR Review Comment ID # 111, <u>sensitivity analysis</u> was performed with truncated landside aquiclude with no flow boundary condition at landside to validate the design. The results are as below; <u>200yr+4'</u> i=0.35 [Toe, blanket=9.2'] i=1.54 [170' from toe, blanket=4.8'] Breakout 1.1' FS=1.19 (Slope stability) <u>200yr+1'</u> i=0.26 [Toe, blanket=9.2'] i=1.38 [170' from toe, blanket= 4.8'] Breakout 0.7' FS=1.27 (Slope stability) During meeting with DWR on Aug. 14 2012, URS agrees to an additional exploration in this area.	1.62		-	
					200yr + 1'	86.2	<0.10 [Toe, thin blanket=9.2'] <0.10 [Toe, thick blanket=26.3'] <0.10 [170' from toe, thin blanket=4.8'] 0.29 [170' from toe, thick blanket=21.9']	0.0		1.62		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 23													
Station 1508+33	Cutoff Wall Tip Elev. +55'	91.3	81	10.3	200yr + 4'	89.5	0.0 [Toe, phreatic surface below blanket]	0.0	Breakout is beyond toe. Landside ditch is connected to Layer 4 (SP) at 250 feet from toe. Blanket includes Layer 3 (CL-ML). Responding to DWR Review Comments ID #112, the following sensitivity analyses were performed to validate the design. <u>Sensitivity analysis</u> with truncated landside aquiclude and added aquifer at elev. +50' to +60' results in; <u>200ry+4'</u> i<0.10 [Toe, blanket=5.0'] No breakout above toe FS = 1.84 (Slope stability) <u>200ry+1'</u> i<0.10 [Toe, blanket=5.0'] No breakout above toe FS = 1.84 (Slope stability) <u>Sensitivity analysis</u> with truncated landside aquiclude, added aquifer at elev. +50'-+60' and filled ditch with blanket material results in; <u>200ry+4'</u> i=0.34 [Toe, blanket=5.0'] Breakout above toe = 1.2' FS = 1.72 (Slope stability) <u>200ry+1'</u> i=0.22 [Toe, blanket=5.0'] Breakout above toe = 0.6' FS = 1.77 (Slope stability) <u>Sensitivity analysis</u> with truncated landside aquiclude, at elev. +50'-+60', and filled ditch with water results in; <u>200ry+4'</u> i=0.20 [Toe, blanket=5.0'] Breakout above toe = 0.6' <u>FS = 1.77 (Slope stability)</u> <u>200ry+1'</u> i=0.14 [Toe, blanket=5.0'] Breakout above toe = 0' FS = 1.80 (Slope stability) During meeting with DWR on Aug. 14 2012, URS agrees to an additional exploration in this area.	1.84		-	
					200yr + 1'	86.5	0.0 [Toe, phreatic surface below blanket]	0.0		1.84		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1536+00	Cutoff Wall Tip Elev. +55'	92.1	85.1	7.0	200yr + 1'	87.4	RDD Analysis Only			RDD Analysis Only		1.32	Waterside Levee Slope: 2.7H:1V Levee Slope Height = 8 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.4H to 2.1H:1V Bank Slope Height = 10 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.
Reach 24													
Station 1610+00	Cutoff Wall Tip Elev.+28'	94.4	81.3	13.1	200yr + 1'	89.3	RDD Analysis Only			RDD Analysis Only		- 1.38	Waterside Levee Slope: 1.7H:1V to flatter than 3.0H:1V Levee Slope Height = 8 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. Responding to DWR Review Comments ID #115, sensitivity analysis was performed with OCR<2 strength for Layer 1 CL-ML. FS=1.22

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1615+62	Cutoff Wall Tip Elev.+28'	94.4	81.3	13.1	200yr + 4'	92.3	0.50 [Bottom of ditch, blanket=3.4']	0.0	Exit gradient is calculated at the bottom of ditch. Blanket includes Layer 2 (CL-ML). Sensitivity analysis with cutoff wall tip elev. +60' results in; 200yr+4' i=2.02 [Bottom of the ditch] 200yr+1' i=1.57 [Bottom of the ditch] Responding to DWR Review Comment ID #117, sensitivity analysis was performed with truncated landside aquiclude and added aquifer below. The results are as below; 200yr+4' i=1.43 [Bottom of ditch 22' from toe, blanket=3.5'] Breakout above toe = 2.8' FS = 1.41 (Slope stability) 200yr+1' i=1.29 [Bottom of ditch 22' from toe, blanket=3.5'] Breakout above toe = 2.6' FS = 1.49 (Slope stability) During meeting with DWR on Aug. 14 2012, URS agrees to an additional exploration in this area.	2.03	Responding to the DWR Review Comment ID # 118, sensitivity analysis was performed with OCR<2 strength for layer 1 (c'=0 phi'=30). 200+4' FS=1.97 200+1' FS=2.02	-	
					200yr + 1'	89.3	0.38 [Bottom of ditch, blanket=3.4']	0.0		2.09		-	
Reach 27													
Station 1710+00	Cutoff Wall Tip Elev. +65' and Landside slope reconstruction	96.9	85.4	11.5	200yr + 1'	91.0	RDD Analysis Only			RDD Analysis Only		1.81	Waterside Levee Slope: 1.7H:1V to flatter than 3.0H:1V Levee Slope Height = 8 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 28													
Station 1764+00	Cutoff Wall Tip Elev. +45' and Landside slope reconstruction	99.4	86.7	12.7	200yr + 1'	93.1	RDD Analysis Only			RDD Analysis Only		2.00	Waterside Levee Slope: 1.0H:1V to 2.7H:1V Levee Slope Height = 12 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.
Reach 30													
Station 1820+80	Cutoff Wall Tip Elev.+30'	102.2	88.7	13.5	200yr + 4'	98.4	<0.10 [Toe, blanket=3.6']	0.0	Exit gradient is calculated at the toe. Blanket includes Layer 2 (ML) Responding to DWR Review Comment ID #123, sensitivity analysis was performed with the following adjustment. Layer 5 (CL) is bottom of model so added 10' thick aquifer (SP) below Layer 5 to make it possible to calculate a gradient across Layer 5. Results are as below; 200yr+4' i=0.17 [Toe, thin blanket=3.6' (Layer 2)] i=0.18 [Toe, thick blanket=49.3' (Layers 2-5)] 200yr+1' i=0.11 [Toe, thin blanket=3.6' (Layer 2)] i=0.15 [Toe, thick blanket=49.3' (Layers 2-5)]	1.80		-	
					200yr + 1'	95.4	<0.10 [Toe, blanket=3.6']	0.0		1.80		-	
Station 1826+94	Cutoff Wall Tip Elev.+30'	102.2	88.7	13.5	200yr + 4'	98.5	0.57 [Toe, blanket=2.3']	0.6	Exit gradient is calculated at the toe. Blanket includes Layer 1 (ML)	1.56		-	
					200yr + 1'	95.5	0.35 [Toe, blanket=2.3']	0.6		1.66		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1892+00	Cutoff Wall Tip Elev. +27'	102.2	88.7	13.5	200yr + 4'	103.3	<0.10 [Toe, blanket=11.3'] <0.10 [180' from the toe, blanket=10.5']	0.0	Exit gradients are calculated at the toe and adjacent landward levee toe. Breakout is beyond toe. <u>Sensitivity Analysis</u> With cutoff wall elev. +75' results in: <u>200yr+4'</u> i=0.69 [Toe] i=0.87 [180 feet from the levee toe] <u>200yr+1'</u> i=0.45 [Toe] i=0.65 [180 feet from the levee toe] <u>Sensitivity Analysis</u> With cutoff wall elev. +75 and SM material filled landside ground surface results in: <u>200yr + 4'</u> i=0.39 [Toe] i=0.87 [180 feet from the levee toe] <u>200yr+1'</u> i=0.20 [Toe] i=0.65 [180 feet from the levee toe]	2.07		-	
					200yr + 1'	100.3	<0.10 [Toe, blanket=11.3'] <0.10 [180' from the toe, blanket=10.5']	0.0		2.07		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1902+00	Cutoff Wall Tip Elev. +27' *Monitoring for waterside slope distress during and after high water events*	111.1	98	13.1	200yr + 1'	100.9	RDD Analysis Only			RDD Analysis Only		1.01	Waterside Levee Slope: 2.7H:1V Levee Slope Height = 15 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.2H to 2.1H:1V Bank Slope Height = 30 feet Critical slip surface occurs at transition between steep bank slopes and flatter levee slope. Section is considered critical due to steep bank slopes and lack of bench. Possible extent of remediation may extend between station 1899+00 and 1911+00. This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. *Rapid drawdown (RDD) analysis show that slip surfaces with a factor of safety less than or equal to 1 occur within the steep channel slopes. However, slip surfaces that encroach into the existing levee profile and that could impact the global stability of the levee have a factor of safety greater than 1. Therefore, the levee is considered to have an adequate FOS to meet RDD criteria.* *Wide levee crown and/or waterside bench in this area.* *Slope maintenance to address sloughing of steep channel bank slopes may be required in the future.* Responding to DWR Review Comments ID#129, sensitivity analysis with 16 feet drop was performed. FS=1.00

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 31													
Station 1907+91	Cutoff Wall Tip Elev. +44' *Slope flattening or other appropriate measures.*	107.7	102.4	5.3	200yr + 4'	104.3	0.41 [bottom of ditch, blanket =3.2']	0.0	Exit gradient is calculated at bottom of ditch adjacent to levee. Blanket includes Layer 1 (CL). Responding to DWR Review Comment ID#130, sensitivity analysis was performed with truncated landside aquiclude and added aquifer below. The results are as below; 200yr+4' i=2.53 [Bottom of ditch approx. 55' from toe, blanket=3.2'] Breakout above bottom of ditch = 5.2' FS = 1.30 (Slope stability) 200yr+1' i=2.09 [Bottom of ditch approx.. 55' from toe, blanket=3.2'] Breakout above bottom of ditch = 4.4' FS = 1.49 (Slope stability) During meeting with DWR on Aug. 14 2012, URS agrees to an additional exploration in this area.	2.59		-	Waterside Levee Slope: Flatter than 3.0H:1V Levee Slope Height = 7 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.2H to 1.4H:1V Bank Slope Height = 30 feet Critical slip surface occurs at transition between steep bank slopes and flatter levee slope. Section is considered critical due to steep bank slopes and lack of bench. Possible extent of remediation may extend between station 1899+00 and 1911+00. *Rapid drawdown (RDD) analysis show that slip surfaces with a marginal factor of safety occur within the steep channel slopes and that these encroach into the theoretical levee prism and could compromise the integrity of the levee.* *The theoretical levee prism daylights out of the lower channel slope.* *Slope flattening or other appropriate measures should be undertaken in this area.*
					200yr + 1'	101.3	0.31 [bottom of ditch, blanket =3.2']	0.0		2.64		1.02	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1909+00	Cutoff Wall Tip Elev. +44' *Slope flattening or other appropriate measures.*	107.7	98.1	9.9	200yr+1'	101.5	RDD Analysis Only			RDD Analysis Only NOTE: i). sensitivity analysis performed with higher friction angle for gravel layers results in FS<1.0 *ii). analysis results are controlled by oversteepened channel slope, where the theoretical levee prism daylights out of the slope.*		0.93	Waterside Levee Slope: Flatter than 3.0H:1V Levee Slope Height = 10 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.2H to 1.4H:1V Bank Slope Height = 45 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. Critical slip surface occurs at transition between steep bank slopes and flatter levee slope. Section is considered critical due to steep bank slopes and lack of bench. Possible extent of remediation may extend between station 1899+00 and 1911+00. *Rapid drawdown (RDD) analysis show that slip surfaces with a factor of safety less than or equal to 1 occur within the steep channel slopes and that these encroach into the theoretical levee prism and could compromise the integrity of the levee.* *The theoretical levee prism daylights out of the lower channel slope.* *Slope flattening or other appropriate measures should be undertaken in this area.*

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1924+00	Cutoff Wall Tip Elev. +75'	108.5	101.7	6.8	200yr + 1'	103.0	Sensitivity Analysis Only Responding to DWR Review Comment ID #132, seepage and stability analyses were performed. The results are as below; <u>200yr+4'</u> i=0.42 [Bottom of ditch, blanket=12.1'] Breakout above toe = 0' FS = 2.09 (Slope stability) <u>200yr+1'</u> i=0.34 [Bottom of ditch, blanket=12.1'] Breakout above toe = 0' FS = 2.26 (Slope stability)			RDD Analysis Only		1.22	Waterside Levee Slope: 2.7H:1V to flatter than 3.0H:1V Levee Slope Height = 8 feet Bench Width to Bank Slope = 15 feet Bank Slope: 1.4H to 2.1H:1V Bank Slope Height = 28 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. Responding to DWR Review Comments ID # 133, sensitivity analysis with drained strength c'=0 psf and phi'=28 degree and undrained strength c=100 psf and phi=15 results in FS=1.10

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1933+00	Cutoff Wall Tip Elev. +50'	109.1	102.8	6.3	200yr + 4'	106.2	<0.10 [Toe, blanket=10.2'] 0.50 [bottom of ditch 70' from toe, blanket =0.6']	0.0	Total head boundary condition as an elevation head at far field is used for the upper pervious Layer 3 (SP-SM) on right side of model. It prevents unrealistic seepage flow back from landside. Exit gradients are calculated at the toe and bottom of ditch 70 feet from the toe. Blanket includes Layer 2 (CL). <u>Sensitivity analysis</u> with no flow boundary condition at landside far field and tip elev. +75 results in; <u>200yr+1'</u> i > 2.0 [bottom of ditch, blanket=0.6'] <u>Sensitivity analysis</u> with no flow boundary condition at landside far field and tip elev. +40 results in; <u>200yr+1'</u> i=0.67 [bottom of ditch, blanket=0.6'] Responding to DWR Review Comment ID #134, <u>sensitivity analysis</u> with no flow boundary condition at landside far field and tip elev. +80 results in; <u>200yr+4'</u> i >2.0 [bottom of ditch, blanket=0.6'] FS=3.83 (Slope stability) <u>200yr+1'</u> i >2.0 [bottom of ditch, blanket=0.6'] FS=3.00 (Slope stability) Responding to DWR Review Comments ID #135, exit gradient for thick blanket are calculated as below; <u>200yr+4'</u> i<0.10 [Toe, thick blanket=18.6' through Layers 2 to 5] <u>200yr+1'</u> i<0.10 [Toe, thick blanket=18.6' through Layers 2 to 5]	3.14		-	
					200yr + 1'	103.2	<0.10 [Toe, blanket=10.2'] 0.33 [bottom of ditch 70' from toe, blanket =0.6']	0.0		3.17		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 32													
Station 1965+80	Cutoff Wall Tip Elev. +40'	110.6	89	21.6	200yr + 4'	106.6	0.30 [Toe, blanket=6.3']	0.0	Blanket includes Layer 1 (SC-SM) and Layer 2 (CL).	1.55	Sensitivity Analysis with OCR<2 for layer 2 (CL) results in; 200yr+4 FS=1.38 200yr+1 FS=1.39	-	
					200yr + 1'	103.6	0.25 [Toe, blanket=6.3']	0.0		1.56		-	
Station 1980+00	Cutoff Wall Tip Elev. +48'	110.4	98	12.4	200yr + 4'	106.8	RDD Analysis Only			RDD Analysis Only		-	Waterside Levee Slope: 1.4H to 2.7H:1V Waterside Levee Slope Height = 13 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. Critical slip failure surface is located within the steeper portion of the levee slope where the existing silt embankment has been modeled as normally consolidated silt with c'=0 and a ϕ'=30°. Sensitivity analysis assuming c'=50 psf and a ϕ'=31° generates a min FS=1.21.
					200yr + 1'	103.8						0.93	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1981+50	Cutoff Wall Tip Elev. +48'	111.2	99.1	12.1	200yr + 4'	106.9	<0.10 [Toe, blanket =12.7']	0.0	Breakout is beyond toe. Responding to DWR Review Comment ID #139, sensitivity analysis was performed with shallow cutoff tip elev. +86.2'. The results are as below; 200yr+4' i<0.10 [Toe, blanket=12.7'] i=0.88 [Depression 270' from toe, blanket=4.3'] Breakout above toe = 0.7' FS = 1.56 (Slope stability) 200yr+1' i<0.10 [Toe, blanket=12.7'] i=0.78 [Depression 270' from toe, blanket=4.3'] Breakout above toe = 0' FS = 1.67 (Slope stability)	1.67		-	
					200yr + 1'	103.9	<0.10 [Toe, blanket =12.7']	0.0		1.67		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 33													
Station 2008+00	Cutoff Wall Tip Elev. +90'	113.0	101.7	11.3	200yr + 4'	108.3	<0.10 [Toe, blanket=7.8']	0.0	Sensitivity Analysis Only Responding to IPE Review Comment ID #11, analysis was performed at station 2008+00 to verify the design. 200yr+4' i=0.15 [toe, thin blanket =18.4'] i=0.10 [toe, thick blanket=25.8'] breakout=0.7'above toe 200yr+1' i<0.10 [toe, thin blanket =18.4'] i<0.10 [toe, thick blanket=25.8'] breakout at toe	1.49		-	
					200yr + 1'	108.3	<0.10 [Toe, blanket=7.8']	0.0		1.61		-	
Station 2076+90	Cutoff Wall Tip Elev. +33'	118.4	103.8	14.6	200yr + 4'	113.6	<0.10 [Toe, blanket=7.8']	0.0	Blanket includes Layer 2 (ML). Responding to DWR Review Comment ID#140, sensitivity analysis was performed with cutoff wall tip elev. +60'. The results are as below; 200yr+4' i=0.81 [Toe, blanket=7.8'] Breakout above toe = 3.6' FS = 1.20 (Slope stability) 200yr+1' i=0.56 [Toe, blanket=7.8'] Breakout above toe = 2.4' FS = 1.24 (Slope stability)	1.56		-	
					200yr + 1'	110.6	<0.10 [Toe, blanket=7.8']	0.0		1.56			
Station 2114+00	Cutoff Wall Tip Elev. +90'	121.8	107.0	14.8	200yr + 4'	115.5	=0.57 [Toe, blanket=11.3']	3.1	Exit gradient is calculated at the toe. Blanket includes Layer 2 (ML). During meeting with DWR on Aug. 14 2012, URS agrees to an additional exploration in this area.	1.42		-	
					200yr + 1'	112.5	=0.36 [Toe, blanket=11.3']	1.5		1.56		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 34													
Station 2141+00	Cutoff Wall Tip Elev. +20'	123.5	109.9	13.6	200yr + 4'	117.3	<0.1 [Toe, blanket=9.6']	0.0	Exit gradient is calculated at levee toe. Blanket includes Layer 2 (ML). <u>Sensitivity Analysis</u> With cutoff wall tip elev.+90' results in; <u>200yr+4'</u>: i=0.71 (Toe) <u>200yr+1'</u>: i=0.43 (Toe) Responding to DWR Review Comment ID#145, <u>sensitivity analysis</u> was performed with a thicker blanket, connecting the crown and landside boring, and cutoff wall toe elev. +90'. The results are as below; <u>200yr+4'</u> i=0.39 [Levee toe, blanket=17.8'] i=0.69 [70 feet from toe, blanket=9.6'] Breakout=1.7' FS=1.47 (Slope Stability) <u>200yr+1'</u> i=0.23 [Levee toe, blanket=17.8'] i=0.41 [70 feet from toe, blanket=9.6'] Breakout=0.5' FS=1.60 (Slope Stability) During meeting with DWR on Aug. 14 2012, URS agrees to an additional exploration in this area (responding to DWR comment #145).	1.65	Responding to DWR Review Comment ID#144, <u>sensitivity analysis</u> was performed with shear strength of c'=0 psf and p'=30 deg. (OCR<2) for Layer 2. The results are as below; FS=1.44 for 200yr+4 FS=1.45 for 200yr+1	-	
					200yr + 1'	114.3	<0.1 [Toe, blanket=9.6']	0.0		1.65		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 2171+00	Cutoff Wall Tip Elev. +50'	123.9	110.3	13.6	200yr + 4'	119.4	<0.10 [Toe, thin blanket=5.5'] <0.10 [Toe, thick blanket=14.4']	0.0	Exit gradient is calculated at the toe. Thin blanket includes Layer 2 (SM). Thick blanket includes Layer 2 (SM), Layer 3 (SP) and Layer 4 (SM).	1.78		-	
					200yr + 1'	116.4	<0.10 [Toe, thin blanket=5.5'] <0.10 [Toe, thick blanket=14.4']	0.0	Responding to DWR Review Comment ID#146, sensitivity analysis was performed with tip elevation +97.2'. The results are as below; 200yr+4' i = 0.25 [Toe, thin blanket=5.5'] i = 0.39 [Toe, thick blanket=14.4'] Breakout above LS Toe = 1.2 feet FS = 1.56 (Slope stability) 200yr+1' i = 0.18 [Toe, thin blanket=5.5'] i = 0.26 [Toe, thick blanket=14.4'] Breakout above LS Toe = 0.7 feet FS = 1.66 (Slope stability) Responding to DWR Review Comment ID#146, sensitivity analysis was performed with tip elevation +97.2' and with assumed ML for Layer 2 (SM) and Layer (SP). The results are as below; 200yr+4' i = 0.85 [Toe, blanket=8.4'] Breakout above LS Toe = 4.4 feet FS = 1.32 (Slope stability) 200yr+1' i = 0.57 [Toe, blanket=8.4'] Breakout above LS Toe = 3.0 feet FS = 1.59 (Slope stability)	1.80		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 2177+00	Cutoff Wall Tip Elev. +50'	123.9	110.3	13.6	200yr + 4'	119.7	0.25 [Toe, blanket=13.1']	0.5	Exit gradient is calculated at the toe. Blanket includes Layer 2 (ML). Sensitivity Analysis With the cutoff wall tip elev.+90' results in; 200yr+4': i=0.60 [Toe] 200yr+1': i=0.41 [Toe] NOTE: 2D analysis result did not meet the criteria for 200yr+4. Location is at 90 degree bend of levee; 3D effect expected to increase gradient to higher than allowable.	1.44	Sensitivity Analysis With the cutoff wall tip elev.+90' results in; 200yr+4' FS=1.04 200yr+1' FS=1.27	-	
					200yr + 1'	116.7	0.17 [Toe, blanket=13.1']	0.5		1.53			

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 35													
Station 2211+30	Cutoff Wall Tip Elev. +45'	126.2	110.3	15.9	200yr + 4'	124.7	<0.10 [Toe, blanket=15.1'] <0.10 [60 ' from toe blanket=13.3']	0.0	Exit gradients are calculated at the toe and 60 feet from the toe. Blanket includes Layer 2 (ML). Sensitivity Analysis With the thin blanket (=7.0 feet) determined based on WM0007_007B results in; 200yr+4': i<0.10 [Toe] 200yr+1': i<0.10 [Toe]	1.81		-	Waterside Levee Slope: 2.7H:1V to flatter than 3.0H:1V Levee Slope Height = 17 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA
					200yr + 1'	121.7	<0.10 [Toe, blanket=15.1'] <0.10 [60' from toe, blanket=13.3']	0.0		1.81		1.40	
Reach 36													
Station 2250+78	Cutoff Wall Tip Elev. +70'	130	113.2	16.8	200yr + 4'	126.6	<0.10 [Toe, blanket=6.5'] =0.16 [Toe, blanket=38.5']	0.0	Exit gradient is calculated at levee toe. Blanket includes Layer 2 (SC). A set of sensitivity analyses were performed by raising the cutoff wall tip elevation to +70 feet and incorporating a 3 feet thick aquiclude from elevation 75 to 78 feet. Both GC and CL materials were considered for the aquiclude. Responding to DWR Review Comment ID#152, sensitivity analysis was performed with aquiclude modeled as GC (kh=4.0E-04 cm/s) material. The results are as below; 200yr+4' i=0.65 [Levee toe (6.5 feet blanket – SC(2))] i=0.13 [Levee toe (38.5 feet blanket-SC, GW, and GC)] Breakout above LS Toe = 3.0 feet FS = 1.55 (Slope stability) 200yr+1' i=0.49 [Levee toe (6.5 feet blanket – SC(2))] i=0.10 [Levee toe (38.5 feet blanket-SC, GW, and GC)] Breakout above LS Toe = 2.3 feet FS = 1.68 (Slope stability)	2.05		-	
					200yr + 1'	123.6	<0.10 [Toe, blanket=6.5'] =0.12 [Toe, blanket = 38.5']	0.0		2.06		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 37													
Station 2276+76	Cutoff Wall Tip Elev. +42'	132.4	117.2	15.2	200yr + 4'	127.8	0.28 [10' from Toe, blanket=9.7']	0.0	Exit gradient is calculated at the toe. Blanket includes Layer 2 (ML). Responding to DWR Review Comment ID#153 a set of sensitivity analyses were performed with revised Layer 3 (SP) layering, a cutoff wall tip elevation of +70 feet, and hydraulic conductivity of Kh = 1.2E-03 cm/s for the aquiclude (Layer 5), based on WM007_067S. The results are as below: 200yr+4' i = 0.93 [10' from toe (9.7' blanket –ML(2)] Breakout above LS Toe = 3.5 feet FS = 1.14 (Slope stability) 200yr+1' i = 0.69 [10' from toe (9.7' blanket –ML(2)] Breakout above LS Toe = 2.2 feet FS = 1.43 (Slope stability) Responding to DWR review comment #25, sensitivity analysis was performed with Layer 4 Kh increased by factor 10 to 5.0E-01 cm/s. The results are as below; 200yr+4' i=0.24 [10' from toe (x=54.5), blanket=9.7'] Breakout above toe = 0' FS = 1.80 (Slope stability) 200yr+1' i=0.19 [10' from toe (x=54.5), blanket=9.7'] Breakout above toe = 0' FS = 1.82 (Slope stability) Above gradients are slightly lower than the original analysis. Results for analysis with Layer 4 Kh increased by factor of 100 are the same as those above.	1.75		-	
					200yr + 1'	124.8	0.22 [10' from Toe, blanket=9.7']	0.0		1.81		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 2280+00	Cutoff Wall Tip Elev. +45'	132.1	116.3	15.8	200yr + 1'	124.9	RDD Analysis Only			RDD Analysis Only		1.53 (slip surface on WS bank) 1.58 (deep slip surface)	Waterside Levee Slope: 2.7H:1V to flatter than 3.0H:1V Levee Slope Height = 15 feet Bench Width to Bank Slope = 15 feet Bank Slope: 1.2H to 2.7H:1V Bank Slope Height = 12 feet
Reach 38													
Station 2291+75 (WITHOUT ML BLANKET LAYER)	Seepage berm 11' high extending horizontally at elev. 200yr + 4' for a distance of 50' from the landside levee slope before tapering to a height of 3' at a distance of 170' from levee centerline	132.9	117.6	15.3	200yr + 4'	128.5	No blanket condition	No breakout above seepage berm	Considering the presence of the pond north of this reach, total head boundary condition equal to ground surface elevation was used. The ground surface head boundary condition was assigned along the vertical face of landside in model at 1,000 feet away from the levee. Poorly graded Gravel (GP-GM, 5% fines) was assumed for seepage berm. The cutoff wall from Reach 37 extends about 200 feet into Reach 38 (from station 2290+00 to station 2292+00). This cutoff wall was not modeled in the analysis.	4.09		-	
					200yr + 1'	125.5	No blanket condition	No breakout above seepage berm		4.44		-	
Station 2291+75 (WITH ML BLANKET LAYER)	Seepage berm 11' high extending horizontally at elev. 200yr + 4' for a distance of 50' from the landside levee slope before tapering to a height of 3' at a distance of 170' from levee centerline	132.9	117.6	15.3	200yr + 4'	128.5	0.77 [toe of berm, blanket=10.6']	1.5	Considering the presence of the pond north of this reach, total head boundary condition equal to ground surface elevation was used. The ground surface head boundary condition was assigned along the vertical face of landside in model at 1,000 feet away from the levee. Poorly graded Gravel (GP-GM, 5% fines) was assumed for seepage berm. Responding to DWR comment ID EXT/Reach38-002 and IPE comment ID EXT/Reach38-001, the filter compatibility check has been performed (see appendix C).	2.68		-	
					200yr + 1'	125.5	0.57 [toe of berm, blanket=10.6']	1.5		3.25		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 40													
Station 2328+58	No rehabilitation measure	137.0	119.0	18.0	200yr + 4'	133.0	No blanket condition	Elev. 119.7' (Pond WSE 119.0') Elev. 108.0' (Pond WSE 106.5')	The pond was evaluated with a lower water level equal to that recorded during the LiDAR survey (Elevation 106.5 feet) and a higher water level equal to the landside ground surface elevation (Elevation 119.0 feet). A no flow boundary condition at a distance of 2,000 feet from the levee centerline was assumed for the landside vertical face of the model. A continuous bathymetry survey is not available for these landside ponds. However, the HDR design team has performed a line survey at Station 2328+00. The cross section for Station 2328+58 was developed using the DWR ULE LiDAR data and extended in the pond using the FRWL survey data. Responding to DWR review comment ID EXT/Reach40-002 for Design Tech Memo, the rate of seepage flow into the landside pond is calculated as below: <u>Pond WSE 119.0'</u> 200yr+4': Total Q = 0.42 gpm/ft Q above El. 119.0' = 0.08 gpm/ft 200yr+1': Total Q = 0.30 gpm/ft Q above El. 119.0' = 0.06 gpm/ft <u>Pond WSE 106.5'</u> 200yr+4': Total Q = 0.63 gpm/ft Q above El. 106.5' = 0.26 gpm/ft 200yr+1': Total Q = 0.52 gpm/ft Q above El. 106.5' = 0.19 gpm/ft	1.47 (Pond WSE 119.0') 1.57 (Pond WSE 106.5')			
					200yr + 1'	130.0	No blanket condition	Elev. 119.0' (Pond WSE 119.0') Elev. 108.0' (Pond WSE 106.5')		1.52 (Pond WSE 119.0') 1.65 (Pond WSE 106.5')			

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 2332+91	Seepage berm 120' feet wide, 9' thick at levee toe and 3' thick at berm toe	137.6	120.2 (Top of seepage berm: 129.2)	17.4 (Top of levee to top of seepage berm: 8.4)	200yr + 4'	134.1	<0.10 [Toe of levee, blanket=14.6'] <0.10 [Toe of seepage berm, blanket=5.2']	No breakout above seepage berm	Exit gradients are calculated at the toe of levee and toe of seepage berm. Blanket at levee toe includes Layer 11 (GP-GM, seepage berm) and Layer 3 (CL). Blanket at seepage berm toe includes Layer 3 (CL). Responding to DWR comment ID EXT/Reach40-003, and IPE comment IDs EXT/Reach40-002 and EXT/Reach40-003, the filter compatibility check has been performed (see appendix C). Responding to DWR review comment ID EXT/Reach40-002 for Design Tech Memo, the rate of seepage flow from the berm toe extending 125 ft landside is calculated as below: 200yr+4': Total Q = 0.33 gpm/ft 200yr+1': Total Q = 0.29 gpm/ft	2.25		-	
					200yr + 1'	131.1	<0.10 [Toe of levee, blanket=14.6'] <0.10 [Toe of seepage berm, blanket=5.2']	No breakout above seepage berm		2.25		-	
Station 2349+00	Seepage berm 100' feet wide, 9' thick at levee toe and 3' thick at berm toe	139.0	120.0	19.0	200yr + 4'	135.4	<0.10 [Toe of levee, blanket=22.3'] 0.23 [Toe of seepage berm, blanket=13.4']	No breakout above seepage berm	Considering the presence of the Sutter Butte Canal in this area, a total head boundary condition used at the landside vertical face of the model at 1,800 feet away from the levee. Exit gradients are calculated at the toe of levee and toe of seepage berm. Blanket at levee toe includes Layer 8 (GP-GM, seepage berm), Layer 1 (GP-GM), and Layer 2 (SC). Blanket at seepage berm toe includes Layer 1 (GP-GM) and Layer 2 (SC). Responding to DWR comment ID EXT/Reach40-003, and IPE comment IDs EXT/Reach40-002 and EXT/Reach40-003, the filter compatibility check has been performed (see appendix C).	2.27		-	
					200yr + 1'	132.4	<0.10 [Toe of levee, blanket=22.3'] 0.13 [Toe of seepage berm, blanket=13.4']	No breakout above seepage berm		2.27		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 41													
Station 2362+70	Seepage berm 100' wide, 5' thick at levee toe (including 1' thick filter layer) and 3' thick at berm toe	139.2	123.2	16.0	200yr + 4'	135.8	0.35 [Toe of levee, blanket=16.1'] 0.92 [Toe of berm, blanket=10.6']	No breakout above seepage berm	Considering the presence of Thermalito Afterbay on north of this reach and a lateral canal on west of this reach, total head boundary condition equal to the ground surface elevation was used for analysis. The ground surface head boundary condition was assigned along the landside vertical face in the model at 1000 feet away from the levee. Gravel (GP-GM, 3-7% fines) was used for seepage berm material. ASTM C33 fine aggregate was used as filter drain. Geotextile separator was not modeled in the analysis. Exit gradients are calculated through the clay blanket at the toe of levee and toe of berm. Responding to DWR comment ID EXT/Reach41-002, and USACE comment ID #14, the filter compatibility check has been performed (see appendix C).	1.77		-	Waterside Levee Slope: 2.1H to 2.7H:1V Levee Slope Height = 16 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA
					200yr + 1'	132.8	0.19 [Toe of levee, blanket=16.1'] 0.70 [Toe of berm, blanket=10.6']	No breakout above seepage berm		1.77		1.65	

[1]Measured from the landside toe to the top of the levee.
[2]Assumed a 26-foot drop for Reaches 2 to 17 and a 15-foot drop for Reaches 18 to 41.

ENCLOSURE L

MEMORANDUM ON ULE AND SBFCA SEISMIC EVALUATIONS

REVIEW
of the ULE – Sutter Task Area: Feather River West (Right Bank) Levee
Seismic Vulnerability Issues

Reviewed Documents

The reviewed documents were:

- (1) Phase 1 Preliminary Geotechnical Evaluation Report (P1GER) – Sutter Study Area, prepared by URS for DWR, dated March 2008 (Chapter 5.4 and Appendix C-3)
- (2) Geotechnical Design Recommendations Report – Feather River West Levee Project Segment 7, prepared by Blackburn Consulting for SBFCA, dated October 2012 (Sections 2.6.5 and 8.4, Appendix A, Appendix B(-1), Appendix B-2, Appendix D
- (3) Geotechnical Design Recommendations Report – Feather River West Levee Project Segments 1 through 6, prepared by URS for SBFCA, dated October 2012 (Sections 6.5 and 8.3, Appendix A, Appendix B(-1), Appendix B-2, Appendix D

Additional data were obtained from the following documents:

- Phase 1 Geotechnical Data Report (P1GDR) – Sutter Study Area, prepared by URS for DWR, dated November 2008

Seismicity Assessment

Ground accelerations for 100-year, 200-year and 500-year return period earthquake events were estimated using information from the Guidance Document for Geotechnical Analyses version 5 (URS, 2007). The evaluations in document (1) considered all 3 return periods; documents (2) and (3) used the 200-year return period only. The computed peak ground acceleration values in document (1) are compared below with data from USGS Interactive Deaggregations (2008) recommended by USACE, for slightly different return periods:

Table 1 – Seismicity Assessment in Document (1)

Levee Segment	Return Period (years) URS / USGS*	Peak Ground Acceleration	
		Per URS	Per USGS
Sutter Bypass and Wadsworth Canal	100 / 108	0.11g	0.11g
	200 / 224	0.14g	0.15g
	500 / 475	0.18g	0.19g to 0.20g
Feather River South	100 / 108	0.10g to 0.11g	0.10g to 0.11g
	200 / 224	0.13g to 0.14g	0.14g to 0.15g
	500 / 475	0.16g to 0.18g	0.18g to 0.19g
Feather River North	100 / 108	0.10g	0.10g
	200 / 224	0.13g	0.13g to 0.14g
	500 / 475	0.16g	0.18g

Note: * USGS date are available for 50% probability of exceedance in 75 years, or 108-year average return period; 20% probability of exceedance in 50 years, or 224-year average return period; and 10% probability of exceedance in 50 years, or 475-year average return period.

It is evident that the URS evaluation and our independent one are in good agreement. Differences of up to 0.02g for the 500-year return period event are not significant.

It is noted that of major importance in PGA evaluation is the assumed amplification of the seismic motion, which depends mainly on the shear wave velocity of the upper 30 meters near the ground surface, Vs30. URS assumed in all cases Vs30 = 800 fps = 240 m/s. For verification of this assumption shear wave velocity measurements were not available, but 20 borings with SPT's to a depth of at least 100 feet were used to evaluate Vs30 through correlations with N_{60} available in literature, as shown in Figure 1 [Figures 23 for large data base of all types of soils and Figure 24 for granular soils, from USACE WES (1987)]. The 20 borings considered were along the Feather River South levee system (MA3), between Stations 2204+77 and 3211+79.

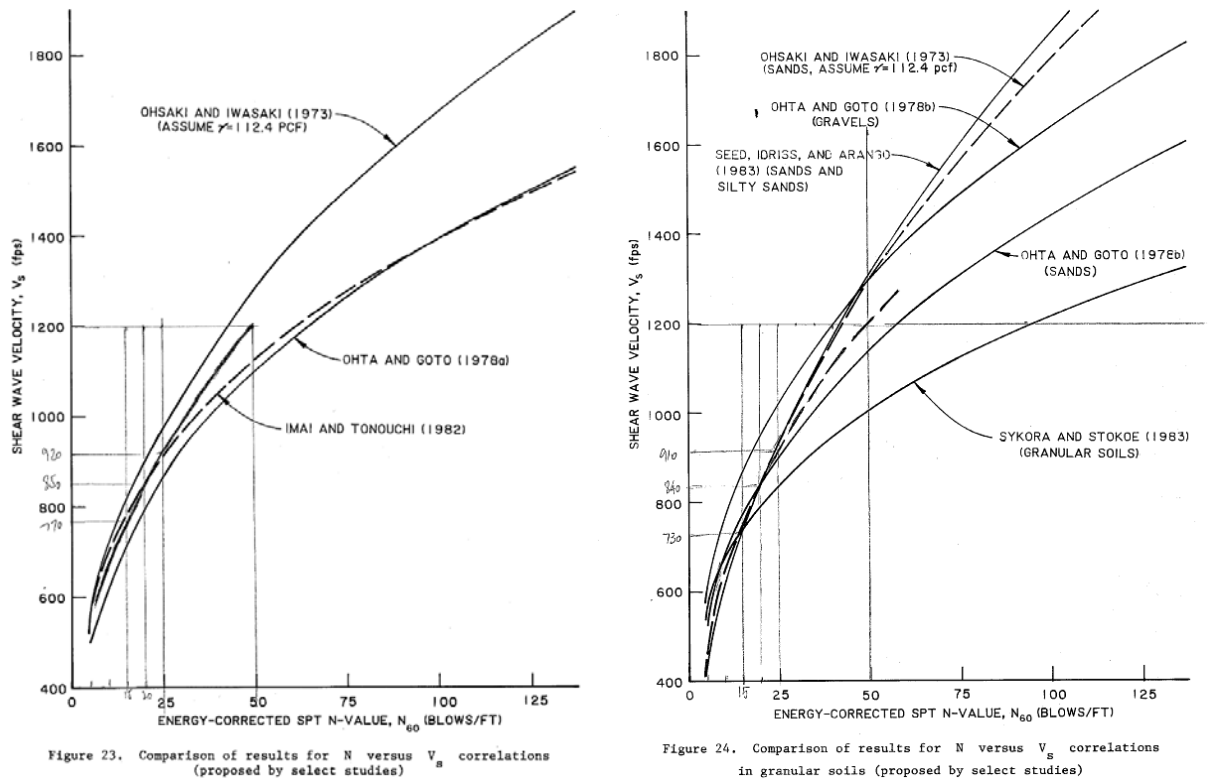

Figure 1. Excerpt of USACE WES (1987): Average curves were considered that pass through the point represented by N_{60} = 50 and Vs = 1200 fps, which is the boundary between stiff soil and soft rock in USGS classification.

The harmonic mean (which is the average value definition appropriate for velocity and, therefore, for N_{60} when it is used as a proxy for Vs) for each boring varied between 12.3 and 31.0, with an arithmetic mean of them of 19.6; the corresponding Vs value on the average curves

in Figure 1 is 844 fps and 834 fps, respectively. The selected value of 800 fps is considered appropriate, slightly conservative with respect to the average curves but close to the middle of the range corresponding to the various recommended criteria. It is mentioned that the same value of 800 fps (240 m/s) was used in conjunction with the evaluation of PGA per USGS, as presented in the last column of Table 1.

The expected earthquake magnitudes (Mw) associated with the three return period events listed in Table 1 are:
- Mw = 6.5 for 100-year return period event,
- Mw = 7.0 for 200-year return period event, and
- Mw=8.0 for 500-year return period event, per URS study.

The USGS reference confirmed these estimates, except for the 500-year return period event where Mw can be as high as 9.0 for Feather River North, probably due to relative proximity to the Cascadia Subduction zone.

In summary, the reviewer found the seismicity assessment in document (1) correct.

Documents (2) and (3) used for the seismicity assessment the ULE Hazard Map for a 200-year Return Period developed for Marysville, Sacramento, and Stockton regions. This map provides PGA assuming stiff soil condition (V_{s30} = 335 m/s); this is different from V_{s30} = 240 m/s used in document (1) and we found acceptable and corresponds to stiff soil outcropping motion. Consequently, there is a significant difference between URS estimates and the values recommended by USGS for a similar return period but a softer soil condition. See the comparison in the following table:

Table 2 – Seismicity Assessment in Documents (2) and (3)

Levee Segment	Return Period (years) URS / USGS*	Peak Ground Acceleration	
		Per URS	Per USGS
Feather River South Reaches 1 – 6	200 / 224	0.125g	0.14g
Feather River South Reaches 7 – 22	200 / 224	0.125g	0.13g to 0.14g
Feather River North Reaches 23 – 41	200 / 224	0.11g	0.13g

Based on the graph in Figure 1 we estimate V_{s30} = 335 m/s to correspond to N_{60} = 42.5. Our spot checks found, as shown before, an average N_{60} of about 20, with the range of 12 to 31 for the evaluated locations (20 borings along the Feather River South levee). It is emphasized that the representative average for an individual boring is the harmonic mean, as N_{60} is a proxy for shear wave velocity; consequently the low values occurring generally near the surface have a much higher weight than the high values at greater depth on the mean value.

The non-conservative assumption with regard to PGA selection may be compensated by a conservative triggering criterion, as shown below.

Liquefaction Triggering Analyses

As specified in Chapter 5.4 "Seismic Vulnerability Analyses" of the report (1), liquefaction analyses have been done for the following levee units:

In Northern Sutter Bypass (Tisdale Bypass to Wadsworth Canal) and Wadsworth Canal (ENGEO analysis sections), liquefaction triggering analyses for 500-year return period earthquake events were performed using the results of SPT borings and 2 year flood elevations. No seismic deformation analyses were performed in these sections. The liquefaction triggering analyses were not available and, therefore, not reviewed. However, it is believed the same methodology as for the unit listed below was used, so the comments below should apply to this unit also.

In Southern Sutter Bypass (Tisdale Bypass to Feather River Confluence) and Feather River South sections (URS analysis sections), liquefaction triggering analyses for 500-year, 200-year, and 100-year return period earthquake events were performed using the results of SPT borings and typical winter water levels (February Mean). The liquefaction analyses were performed to the bottom of the exploration depths. Based on the results of the liquefaction analyses, seismic deformation analyses were performed in eight sections using the results of liquefaction analyses for 500-year return period earthquake event. If the results of the analyses indicated "probably uncompromised" seismic vulnerability class, no further analyses were performed. If the results of the analyses indicated "Possibly Compromised," "Likely Compromised," or "Compromised" seismic vulnerability classes, further analyses were performed using liquefaction analyses results for 200-year and 100-year return period earthquake events. The evaluations by URS will be discussed in detail in what follows.

In Feather River North sections (GEI analysis sections), liquefaction triggering analyses for 500-year, 200-year, and 100-year return period earthquake events were performed using the results of SPT borings and typical winter (February Mean) or summer (August Mean) water levels, which one was higher. The liquefaction analyses were performed to a depth of 50 feet below the bottom of the levee base. Based on the results of the liquefaction analyses, seismic deformation analyses were performed in nine sections using the results of liquefaction analyses for 500-year return period earthquake event. Neither the results of the liquefaction triggering analysis nor those of seismic deformation analyses were available, but it is assumed the same procedures as URS did for Feather River South sections were used.

URS spreadsheet for liquefaction triggering analysis is based on the procedure recommended by Cetin et al. (2004), that is slightly more conservative than the procedure by Youd et al. (2001) recommended in USACE Guidelines (draft ETL 1110-2-580); however, both procedures are considered state-of-the-practice and can alternatively be used.

The analyses were performed on 20 borings with SPT drilled along the Feather River South, practically one representative boring for each reach, M through Z4 (Stations 2166+00 to 3295+59). The results for the first two analyzed borings are plotted in Figure 2.

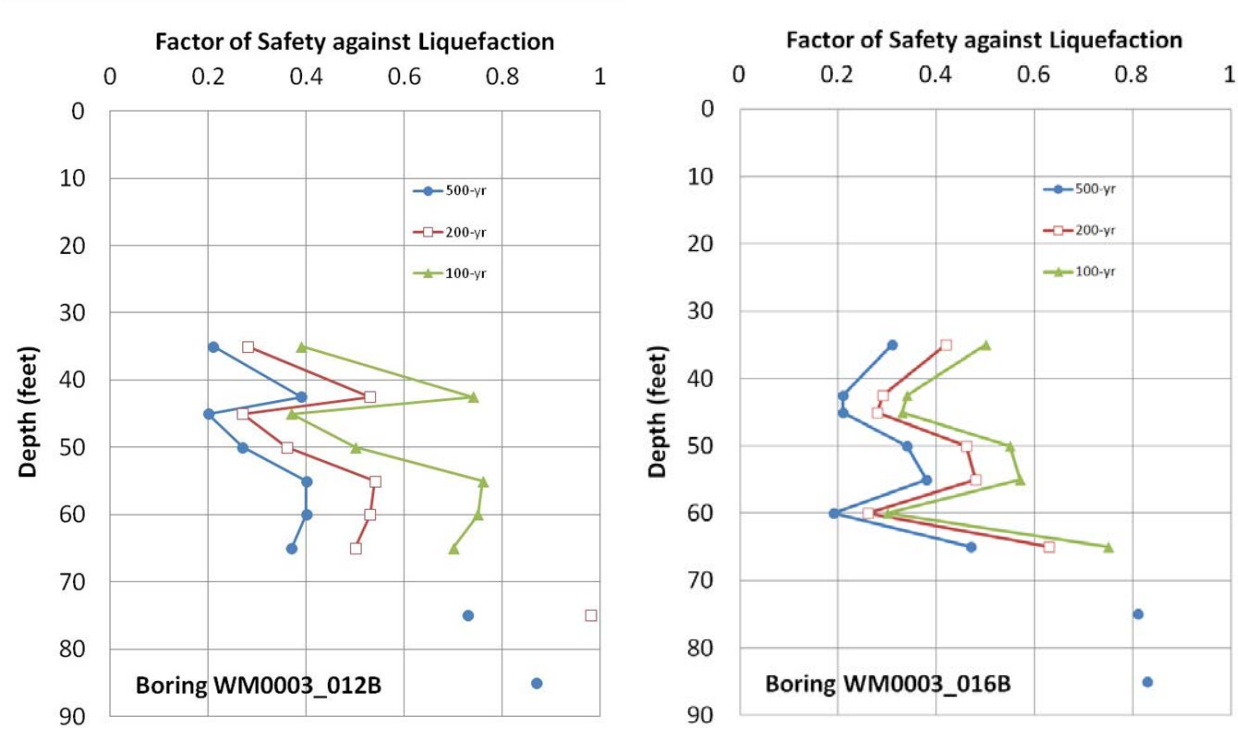

Figure 2. Variation with depth of the factor of safety against liquefaction for two locations in the southern part of the Feather River South levee system (Stations 2204+77 and 2282+82).

The plots in Figure 2 are representative for many other locations along the Feather River South. With the exception of some deep, isolated layers (at 75 feet and 85 feet), the easiest liquefiable layer (in these cases between depths of 35 feet and 65 feet) liquefies under the action of the 500-year return period event, but also under the 200-year and 100-year. It makes little difference if FS_{liq} is of the order of 0.2-0.4 or 0.3-0.5 or 0.4-0.7; in all cases the 30-foot layer is expected to fully liquefy. In all three cases the residual undrained strength is expected to mobilize, which theoretically depends on N (SPT) only and is independent on the FS_{liq}.

It is noted that in the cases presented in Figure 2 the liquefiability index ($N_{1,60\text{-}cs}$) was relatively low, with the 33-percentile average of the 30-foot liquefiable layer of 8.9 and 5.0, respectively. There is, however, little difference in other locations. Figure 3 presents the results obtained in two locations at the northern limit of the Feather River South levee system, where the liquefiability index ($N_{1,60\text{-}cs}$) was relatively higher, with the 33-percentile average of the 20-foot or 30-foot liquefiable layer of 11.6 and 11.0, respectively. It is evident that in this case also the liquefaction occurs with all three different return period considered.

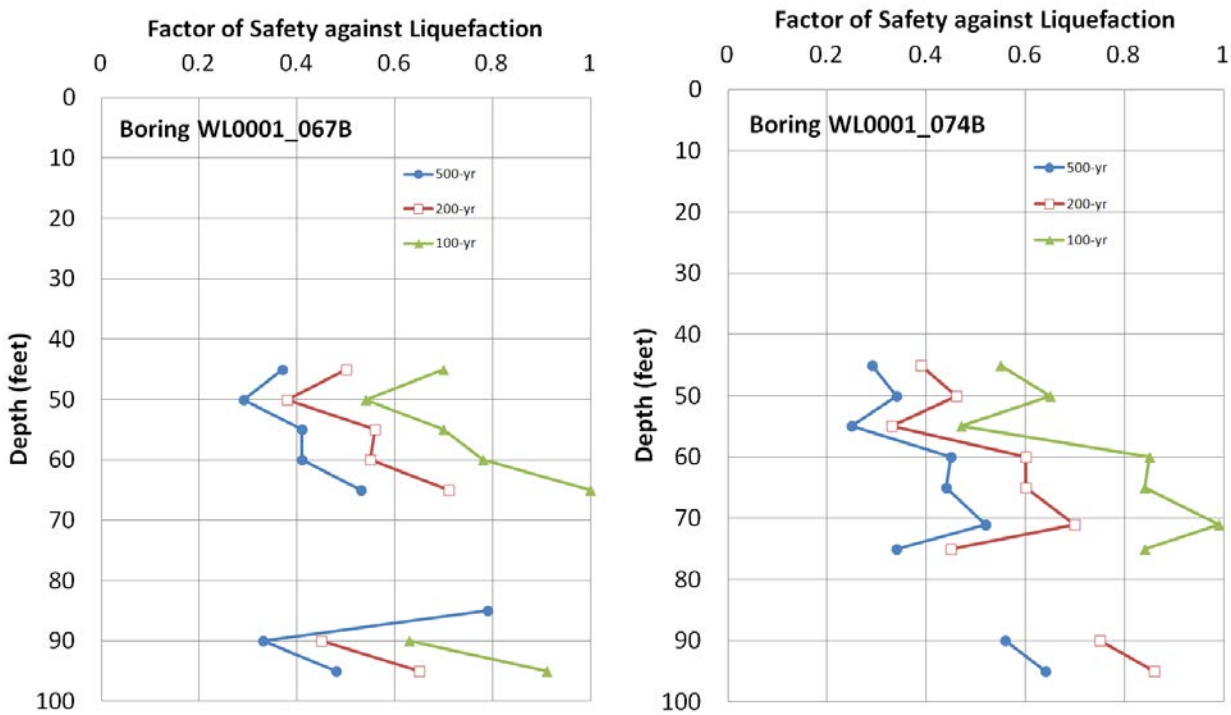

Figure 3. Variation with depth of the factor of safety against liquefaction for two locations in the northern part of the Feather River South levee system (Stations 3027+34 and 3073+29).

Documents (2) and (3) used similar procedure for triggering analysis, but for 200-year return period only. Not all details were available, but the DWR Guidance Document, Revision 10, developed by URS was used in both cases.

In general, the evaluation of the liquefaction susceptibility is satisfactory with all three documents.

Levee Stability Evaluation

Once significant liquefaction of the foundation soil was found probable, stability analysis is performed in steps:

- First, post-earthquake slope stability analyses were performed using limit equilibrium software. The computer program used is not specified in documents (2) and (3); with document (1) Utexas4 was apparently used. In accordance with USACE requirements, the DWR-ULE Guidance requires the Spencer approach be the basis for all stability analyses. We believe this requirement was met.

An important parameter in post-earthquake analyses is the residual strength of liquefiable materials. As with USACE (2013) draft guidelines the correlation proposed by Seed and Harder (1990) is recommended. Correctly, for estimating the undrained residual strength from the Seed & Harder plot, the lower 1/3 curve of the upper and lower range limits was used.

USACE (2013) recommends to alternatively use Seed and Harder (1990) and Olson and Stark (2002) procedures and to consider both results as possible occurrences. Although we would prefer both procedures to be considered in evaluation, the URS recommended approach is state-of-the-practice and acceptable.

Also in accordance with USACE concepts, if the calculated post-earthquake FS, for any calculated potential failure surface, is less or equal to 1.0, then the study-section should be considered unstable (i.e. "compromised") and no further evaluations are needed. In addition to this criterion, USACE (2013) Guidelines state that for intermittent-hydraulically loaded levees (like Feather River levees) further evaluation is not needed if FS > 1.2 and the levee should be considered stable and continuing to function after the design earthquake occurrence.

- Next step was to perform a pseudo-static stability analysis with a horizontal seismic coefficient not well defined; the suggested value (0.5 K_{max}, where K_{max} is the maximum seismic coefficient for a potential sliding mass) is not justified. It is noted that this evaluation is not mentioned in the Guidance Document (URS, 2012) or the USACE (2013) Guidelines. However, it was included in a Technical Memorandum prepared by URS in October 2012 for SBFCA and apparently accepted by technical reviewers (Les Harder, Jr., Lelio Mejia, John Hess, and Francke Walberg).

If the minimum calculated FS for this pseudo-acceleration level ($K = 0.5\ K_{max}$) was greater than 1.0, no additional evaluation was considered necessary and the study section was classified as probably uncompromised and further refinement for the vulnerability evaluation was considered unnecessary.

It is noted that the criterion FS > 1.0 for the pseudo-static stability analysis is in lieu of the USACE supported (USACE, 2013) criterion of FS > 1.2 for the post-earthquake stability analysis. More evaluations are necessary for deciding which criterion is the most appropriate.

Deformation Analysis

Deformation analysis should be done if the study section could not be classified through previous analyses as "Compromised" or "Probably Uncompromised". The goal of the seismic deformation analyses is to evaluate post-seismic vertical displacements at the levee crest, classification into the other two categories ("Likely Compromised" and "Possibly Compromised") be made possible. USACE (2013) Guidelines offer several alternate methods for estimation of displacements, including that based on the Newmark approach which is the only one recommended by URS Technical Memorandum and used in documents (2) and (3).

The recommended approach is based on the Makdisi and Seed, 1978 method, but replaces the original range of results with an average one. Figure 4 compares the range in the original Makdisi & Seed study (interpolated for M7 between the original ranges provided for M6.5 and M7.5) with the average curve recommended in URS Technical Memorandum. The obtained Newmark displacement should be multiplied by 0.7 to obtain an estimate of the freeboard loss (vertical displacement).

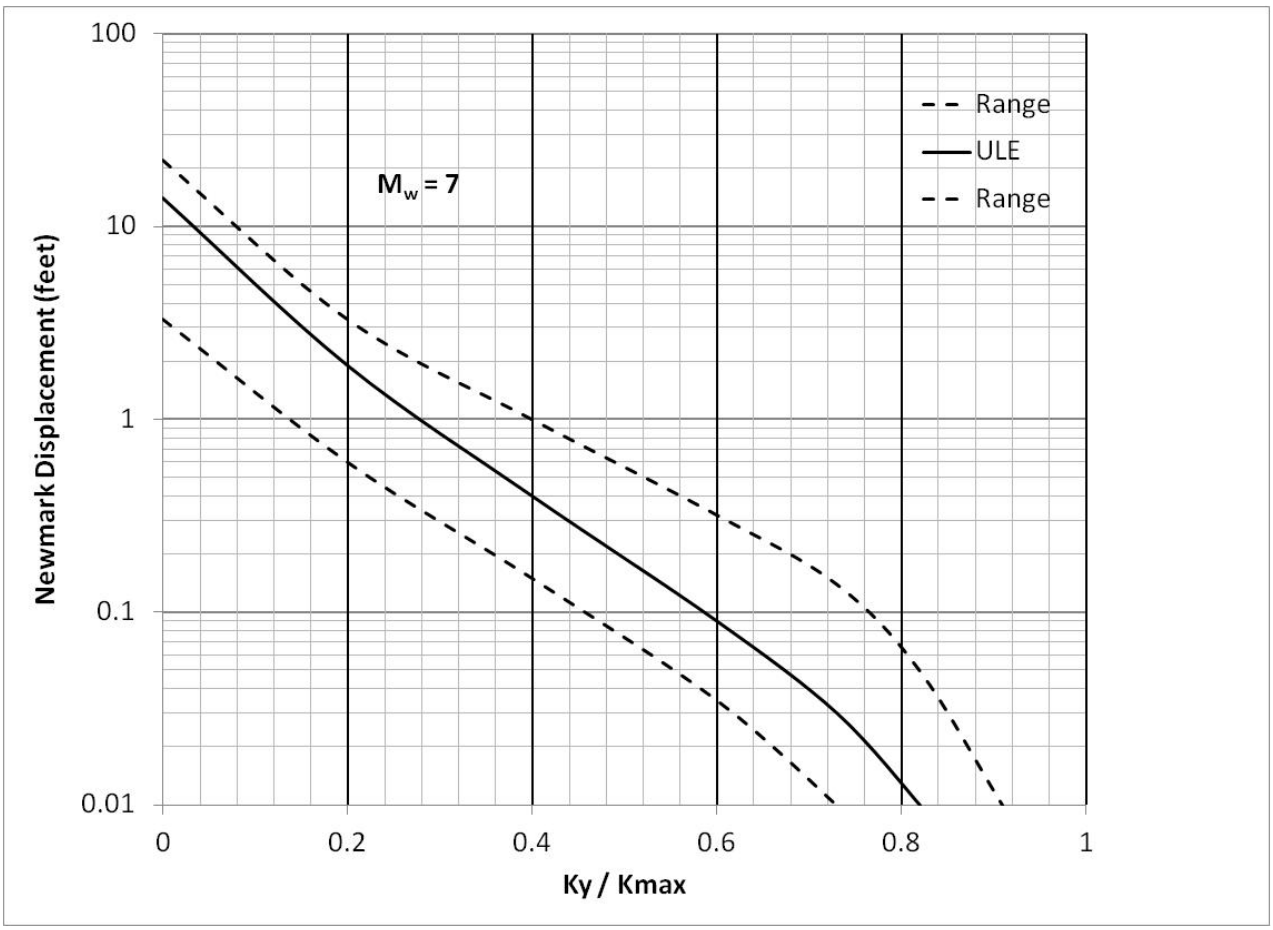

Figure 4. Comparison between the URS (2012) recommended correlation for ULE (solid line) and the range indicated by Makdisi and Seed (1978) (dashed lines).

It is evident that the actual scatter of the results, which is not mentioned in URS (2012) Guidelines, for a credible classification based on more or less than 1 foot remaining freeboard after the seismic deformation. For example, if the original freeboard was 3 feet, for a remaining 1 foot of freeboard the estimated Newmark deformation should be 2 feet/0.7 = 3 feet. From Figure 4, an estimate of 3 feet would correspond to K_y / K_{max} = 0.15, but the range corresponding to this ratio is 0.9 feet to 5 feet. Based on the average curve (solid line) the seismic vulnerability classification would be on the boundary between "Possibly Compromised" and "Likely Compromised" (remaining freeboard = 1 foot), but based on the possible range the study section can be classified either "Likely Compromised" (no remaining freeboard) or "Probably Uncompromised" (0.9 x 0.7 = 0.6 feet vertical deformation, which leaves a freeboard of 2.4 feet and represents less than 5% of landside levee height). It is considered that the procedure is not sensitive enough for a credible seismic vulnerability classification.

It is also noted that in the main text of the document (3), section 6.5, the main parameter used in seismic vulnerability classification is "the amount of deformation", but in the referenced Appendix B-2 "Technical Memorandum" the corresponding parameter is "the amount of vertical deformation". There is significant difference between the two parameters, because the amount

of deformation can be the Newmark deformation or the displacement in any direction, including horizontal.

Conclusions

All reviewed documents are satisfactory with reference to liquefaction assessment, evaluation of levee stability, and seismic vulnerability classification in class "compromised". There are not currently available trustable procedures for classification in the other classes. USACE (2013) Guidelines recommend using 2-3 procedures of several presented in appendices, including the procedure recommended and used by URS, but there is no indication if one is better than the others. More experience with using the proposed methods is necessary for an acceptable methodology of seismic vulnerability classification.

References

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Makdisi, F.I. and Seed, H.B. (1978). Simplified Procedure for Estimating Dam and Embankment Earthquake Induced Deformations, *Journal of the Geotechnical Engineering Division*, ASCE, Vol. 104, No. GT7, pp 848-867

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of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 127, No.10, October, pp 817-833.

ENCLOSURE M

REPORTS PREPARED BY OUTSIDE AGENCIES (PROVIDED AS SEPARATE FILES)

DWR ULE P1GER
DWR ULE P1GDR
DWR ULE SGDR
DWR NULE GAR
DWR NULE GAR Appendix C
DWR NULE GAR Appendix E
SBFCA Geotechnical Design Recommendations for the PFR
SBFCA Final GDR
SBFCA Final GDRR
Modified SBFCA 65% Plans

SUTTER BASIN FEASIBILITY STUDY
SUTTER AND BUTTE COUNTIES

CIVIL DESIGN APPENDIX

Prepared by

U.S. Army Corps of Engineers
Sacramento District, Civil Design Section A

March 2013

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- Enclosure 3, Design of New Levee Segments
- Enclosure 4, Encroachment Improvements & Estimates

RELATED STUDIES AND REPORTS

- Technical Memorandum 26 - Sutter Butte Main Canal Encroachment

REFERENCES

- USACE EM 1110-2-1913, “Design and Construction of Levees”, 30 April 2000
- CESPK-ED-G, SOP-EDG-03 “Geotechnical Levee Practice”, 11 April 2008

ACRONYMS

CCEL Cherokee Canal East Levee (Left Levee)
EIP Early Implementation Project (local sponsor’s Plan)
FRWL Feather River West Levee (Right Levee)
MEIP Modified EIP (COE’s modifications to the EIP)
O&M Operation and Maintenance
ROW Right of Way
SBEL Sutter Bypass East Levee (Left Levee)
SBLS Sutter Basin Levee System
WCEL Wadsworth Canal East Levee (Left Levee)

WCWL Wadsworth Canal West Levee (Right Levee)

CHAPTER 1 – INTRODUCTION

1.1 Project Description

The existing Sutter Basin Levee System (SBLS) consists of four mainline levees which are Feather River West Levee (FRWL or right levee), Sutter Bypass East Levee (SBEL or left levee), Wadsworth Canal East Levee (WCEL or left levee) and Wadsworth Canal West Levee (WCWL or right levee), and Cherokee Canal East Levee (CCEL or left levee) surrounding the communities of Yuba City, Live Oak, Gridley, Biggs and other smaller towns in Sutter and Butte Counties, California.

During Phase 1 of this Feasibility Study, many potential remediation measures were considered and combined to form a preliminary array of conceptual alternatives. Through plan formulation process, the preliminary array of conceptual alternatives was refined to a draft array that includes 8 potential alternatives:

- SB-1: No Action.
- SB-2: Minimal Fix-in-place the FRWL from Star Bend to Sunset Weir
- SB-3: Yuba City Ring Levee
- SB-4: Little “J” Levee
- SB-5: Fix-in-place the FRWL from Star Bend to Thermalito Afterbay
- SB-6: Fix-in-Place the FRWL, SBEL and WCEL
- SB-7: Fix-in-Place the FRWL from Laurel Avenue to Sunset Weir
- SB-8: Fix-in-Place the FRWL from Laurel Avenue to Thermalito Afterbay.

During Phase 2 of the study, the draft array of 8 potential alternatives was analyzed and refined to a final array that includes 2 final alternatives, SB7 and SB8. During Phase 3, the final alternatives were further evaluated to determine the Tentatively Selected Plan (TSP) for final recommendation.

1.2 Purpose and Scope

The purpose of this report is to provide a summary of Phase 2’s civil design considerations and evaluations for 8 potential alternatives, SB1 to SB8. Phase 2’s evaluation is a refinement of Phase 1’s evaluation. A summary of Phase 1’s evaluation is provided in enclosure 1, Evaluation of Preliminary Array of Conceptual Alternatives.

Phase 3’s civil design considerations and evaluations of final alternatives, SB7 and SB8, are discussed in paragraph 2.5 of the Engineering Appendix. Enclosure 2, EIP Review & Incorporation, of this report is an extension of paragraph 2.5 of the Engineering Appendix.

1.3 Coordination

Existing information and information from the local sponsor's Early Implementation Plan (EIP) were utilized for civil design considerations and evaluations. Close coordination with the local sponsor's design teams took place throughout the study.

CHAPTER 2 – DESIGN CONSIDERATIONS

2.1 General

The following paragraphs provide a summary of Phase 2's civil design considerations and evaluations for the draft array of 8 potential alternatives, SB1 to SB8. Design considerations include engineering guidance or methodology used and assumptions.

2.2 Alignment and Stationing

Three levees considered during Phase 2 of this study were the FRWL (right levee), SBEL (left levee) and WCEL (left levee).

The project levee alignments and stationing for the SBEL and the WCEL were developed based on the surveyed data from the National Levee Data Base. The stationing for the SBEL begins with station 0+00 at the confluence of the SBEL at the FRWL and increases in an upstream (North) direction. The stationing for the WCEL begins with station 0+00 at the confluence of the WCEL at the SBEL and increases in an upstream (North) direction.

The project levee alignment and stationing for the FRWL, adopted from the 65% EIP, follows the existing levee centerline of the FRWL except at Star Bend where the levee alignment follows the centerline of the setback levee. The stationing begins with station 10+00 at the confluence of the FRWL at the SBEL and increases in an upstream (North) direction. This levee stationing conforms to the existing levee centerline and accounts for recent changes in the alignment, such as the Star Bend Setback Levee (between station 478+68 and station 512+00). At locations where levee relocations (e.g. roughly between station 1432+70 and station 1754+30 etc.) are proposed, supplementary levee alignments stationing necessary for designs and analyses were established.

2.3 Reaches and Alternatives

2.3.1 Reaches

A total of 28 reaches were considered. 16 of these reaches are the existing levee segments (see table 2.1). The other 12 reaches are either proposed setback or new levee segments (see table 2.2). The reaches are shown in figure 1.

Table 2.1 – Existing Levee Segments

Reach	Alignment	Type	STA. (Beg.)	STA. (End.)
S5-A-Upper	FRWL	Existing Levee	1958+00	2372+17
S5-A-Lower	FRWL	Existing Levee	1825+00	1958+00
S5-B	FRWL	Existing Levee	1432+00	1825+00

S5-C	FRWL	Existing Levee	1129+00	1432+00
S5-D	FRWL	Existing Levee	816+00	1129+00
S7-D	FRWL	Existing Levee	603+00	816+00
S7-E-Upper	FRWL	Existing Levee	512+00	603+00
S7-E-Middle	FRWL	Existing Levee	479+00	512+00
S7-E-Lower	FRWL	Existing Levee	420+00	479+00
S7-F-Upper	FRWL	Existing Levee	200+00	420+00
S7-F-Middle	FRWL	Existing Levee	47+00	200+00
S7-F-Lower	FRWL	Existing Levee	10+00	47+00
S7-G	SBEL	Existing Levee	0+00	400+00
S7-H	SBEL	Existing Levee	400+00	493+00
S7-I	SBEL	Existing Levee	493+00	922+16
S7-J	WCEL	Existing Levee	0+00	244+00

Table 2.2 – New Levee Segments

Reach	Alignment	Type	STA. (Beg.)	STA. (End.)
S4-South	YCRL	New Ring Levee	0+00	280+00
S4-West	YCRL	New Ring Levee	280+00	490+00
S4-North	YCRL	New Ring Levee	490+00	750+00
S6-South	YCJL	New “J” Levee	0+00	280+00
S6-West-lower	YCJL	New “J” Levee	280+00	490+00
S6-West-upper	YCJL	New “J” Levee	490+00	550+00
S9-G	SBEL	Setback Levee	0+00	400+00
S9-H	SBEL	Setback Levee	400+00	493+00
S9-I	SBEL	Setback Levee	493+00	922+16
S10	FRWL	Setback Levee	1958+00	2372+17
S11	FRWL	Setback Levee	47+00	200+00
S12	FRWL	Setback Levee	479+00	512+00

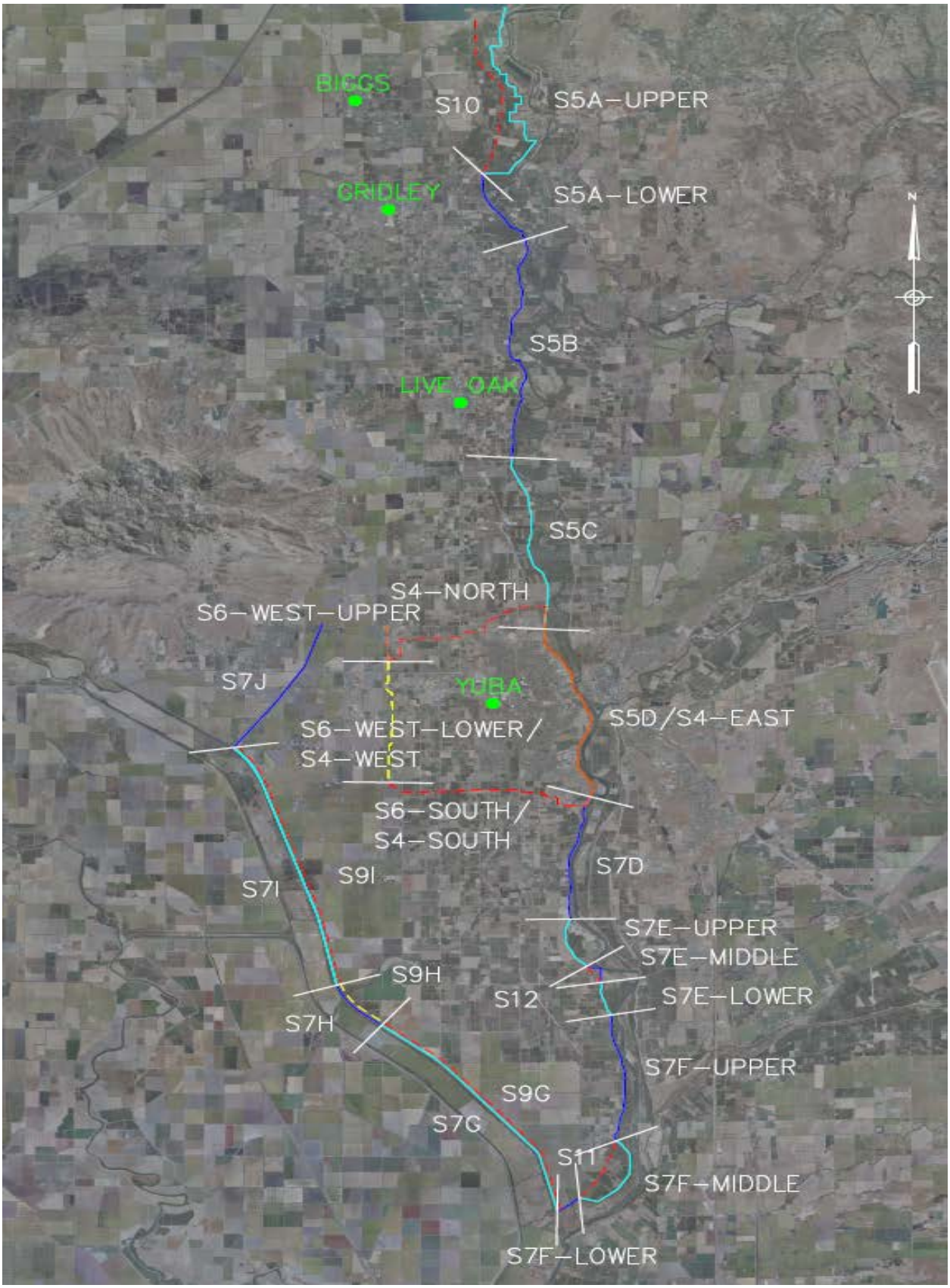


Figure 1 – Map of Reaches

2.3.2 Alternatives

Through plan formulation, from the preliminary array of conceptual alternatives, eight potential alternatives were retained for further evaluation during Phase 2 of the study, include:

- SB-1: No Action.
- SB-2: Minimal Fix-in-place the FRWL from Star Bend to Sunset Weir
- SB-3: Yuba City Ring Levee
- SB-4: Little “J” Levee
- SB-5: Fix-in-place the FRWL from Star Bend to Thermalito Afterbay
- SB-6: Fix-in-Place the FRWL, SBEL and WCEL
- SB-7: Fix-in-Place the FRWL from Laurel Avenue to Sunset Weir
- SB-8: Fix-in-Place the FRWL from Laurel Avenue to Thermalito Afterbay.

Table 2.3 summarizes the reaches included in each of the 8 potential alternatives.

Table 2.3 – Draft Array of Potential Alternatives

Reach	SB1	SB2	SB3	SB4	SB5	SB6	SB7	SB8
S5-A-Upper				X	X	X		X
S5-A-Lower				X	X	X		X
S5-B				X	X	X		X
S5-C		X		X	X	X	X	X
S5-D		X	X	X	X	X	X	X
S7-D		X			X	X	X	X
S7-E-Upper		X			X	X	X	X
S7-E-Middle		X			X	X	X	X
S7-E-Lower						X	X	X
S7-F-Upper						X	X	X
S7-F-Middle						X		
S7-F-Lower						X		
S7-G						X		
S7-H						X		
S7-I						X		
S7-J						X		
S4-South			X					
S4-West			X					
S4-North			X					
S6-South				X				
S6-West-lower				X				
S6-West-upper				X				
S9-G								
S9-H								
S9-I								
S10								
S11								
S12								

2.4 Existing Condition and Remediation Measures

2.4.1 Existing Condition

Based on the results of preliminary geotechnical investigations, the average geometry of the existing levees were defined and shown in table 2.4.

Table 2.4 – Average Geometry of Existing Levee Segments

Reach	Length (LF)	Height (LF)	Crest Width (LF)	LS Slope (H:V)	WS Slope (H:V)	Base Width (LF)
S5-A-Upper	41,417	17.5	20	2:1	3:1	107.5
S5-A-Lower	13,300	17.5	20	2:1	3:1	107.5
S5-B	39,300	12.5	20	2:1	3:1	82.5
S5-C	30,300	17.5	16	2:1	3:1	103.5
S5-D	31,300	25	15	2:1	3:1	140
S7-D	21,300	25	15	2:1	3:1	140
S7-E-Upper	9,100	22.5	17	2:1	3:1	127.5
S7-E-Middle	3,300	22.5	17	2:1	3:1	127.5
S7-E-Lower	5,900	22.5	17	2:1	3:1	127.5
S7-F-Upper	22,000	22.5	13	2:1	3:1	125.5
S7-F-Middle	15,300	22.5	13	2:1	3:1	125.5
S7-F-Lower	3,700	22.5	13	2:1	3:1	125.5
S7-G	40,000	22.5	22	2:1	3:1	134.5
S7-H	9,300	20	22	2:1	3:1	122
S7-I	42,916	20	22	2:1	3:1	122
S7-J	24,400	15	24	2:1	3:1	99

2.4.2 Proposed Levee Remediation Measures

Based on preliminary geotechnical design recommendations, 9 conceptual typical levee remediation measures were developed and shown in figure 2.1 through 2.9.

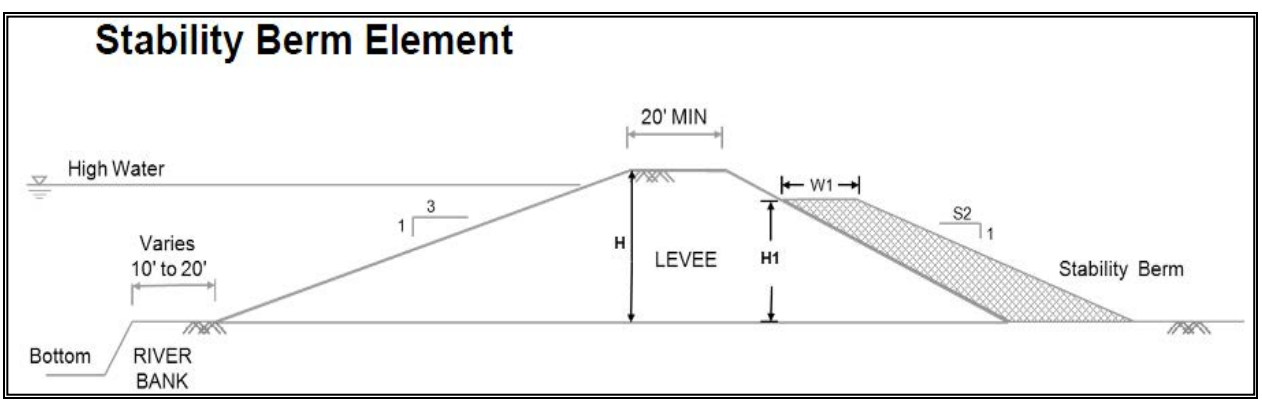


Figure 2.1 – Levee Improvement Type 1

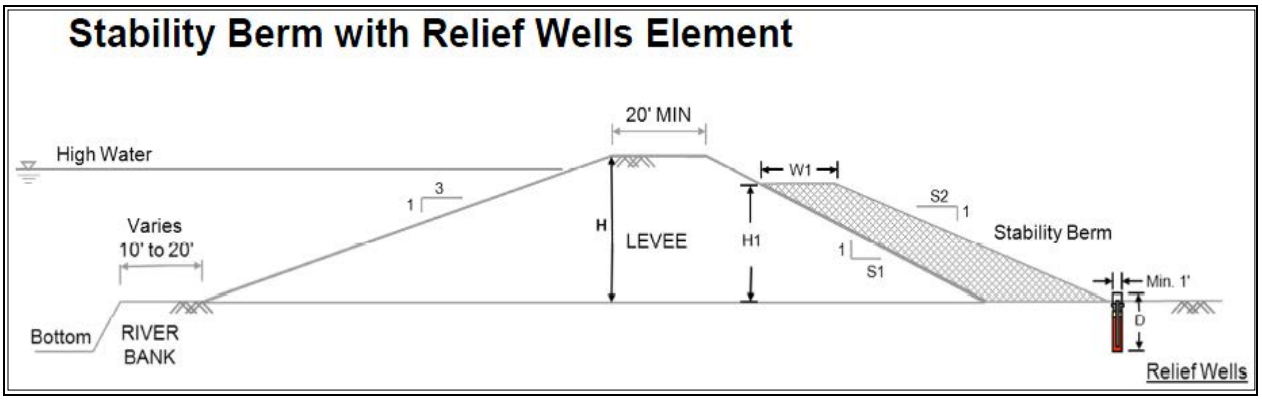


Figure 2.2 – Levee Improvement Type 2

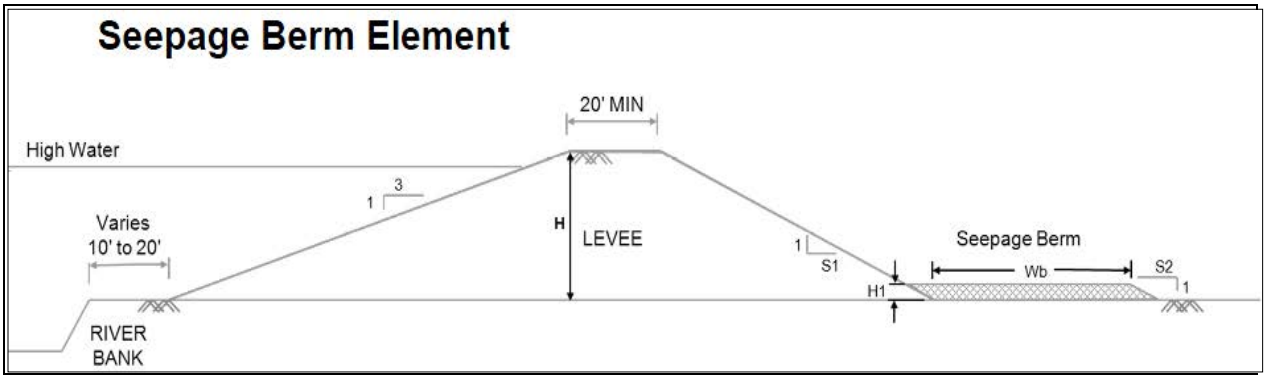


Figure 2.3 – Levee Improvement Type 3

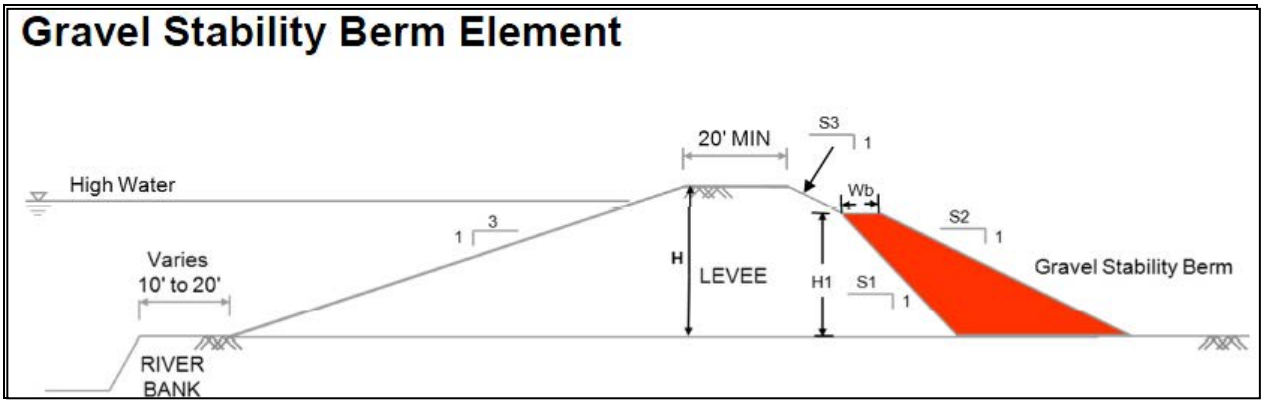


Figure 2.4 – Levee Improvement Type 4

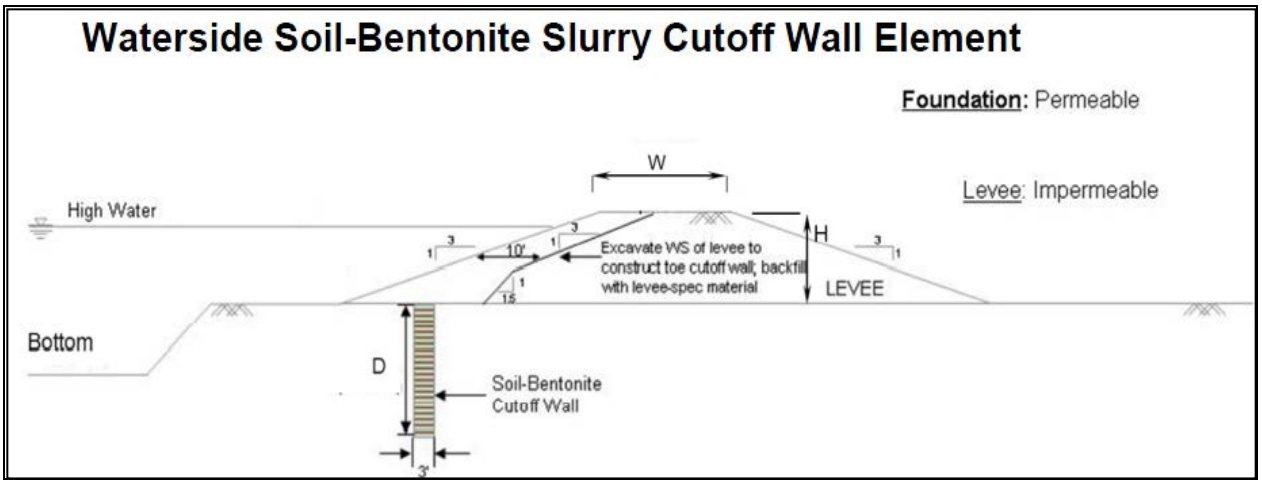


Figure 2.5 – Levee Improvement Type 5

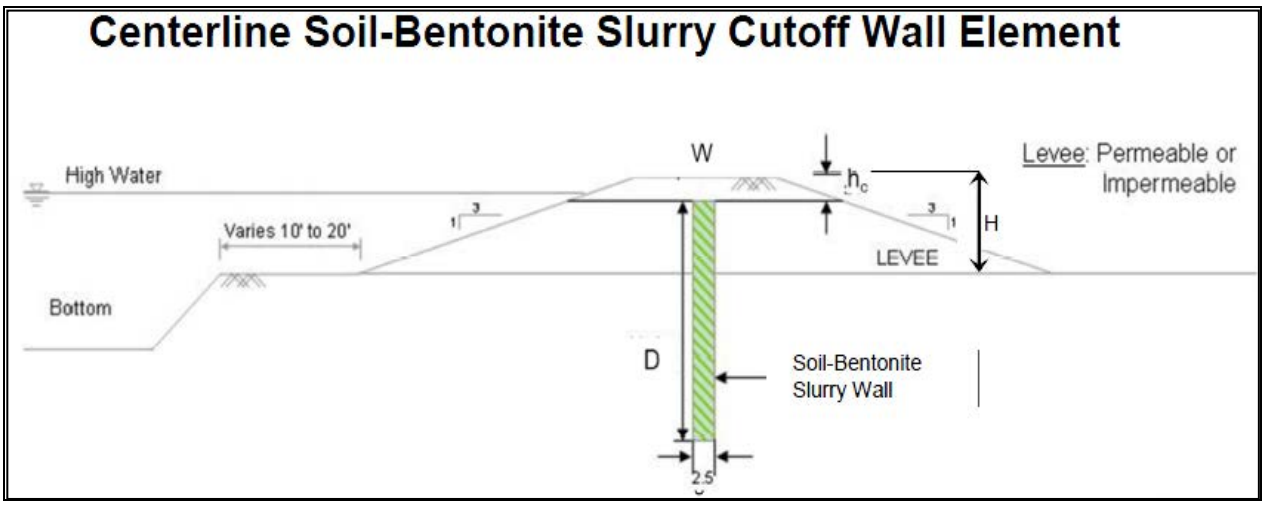


Figure 2.6 – Levee Improvement Type 6

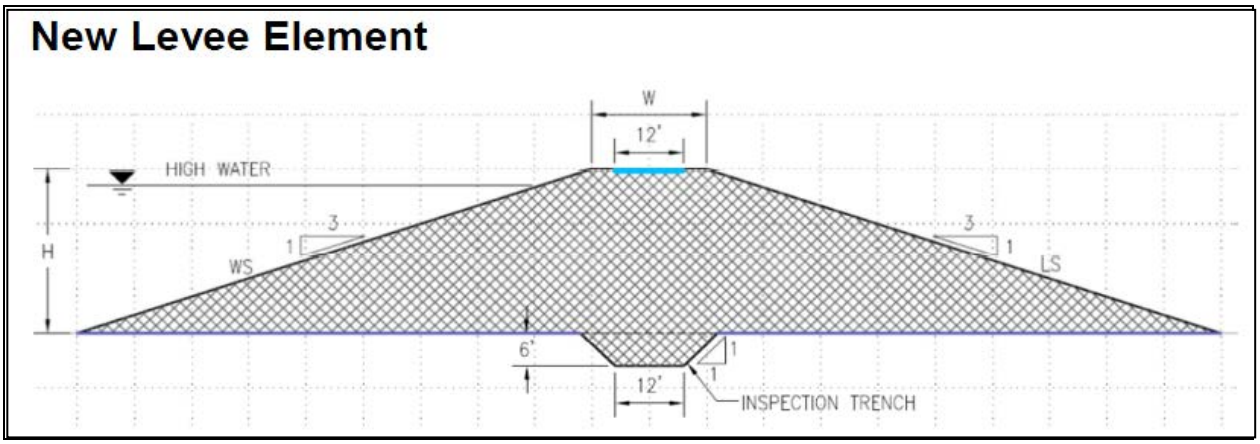


Figure 2.7 – Levee Improvement Type 7

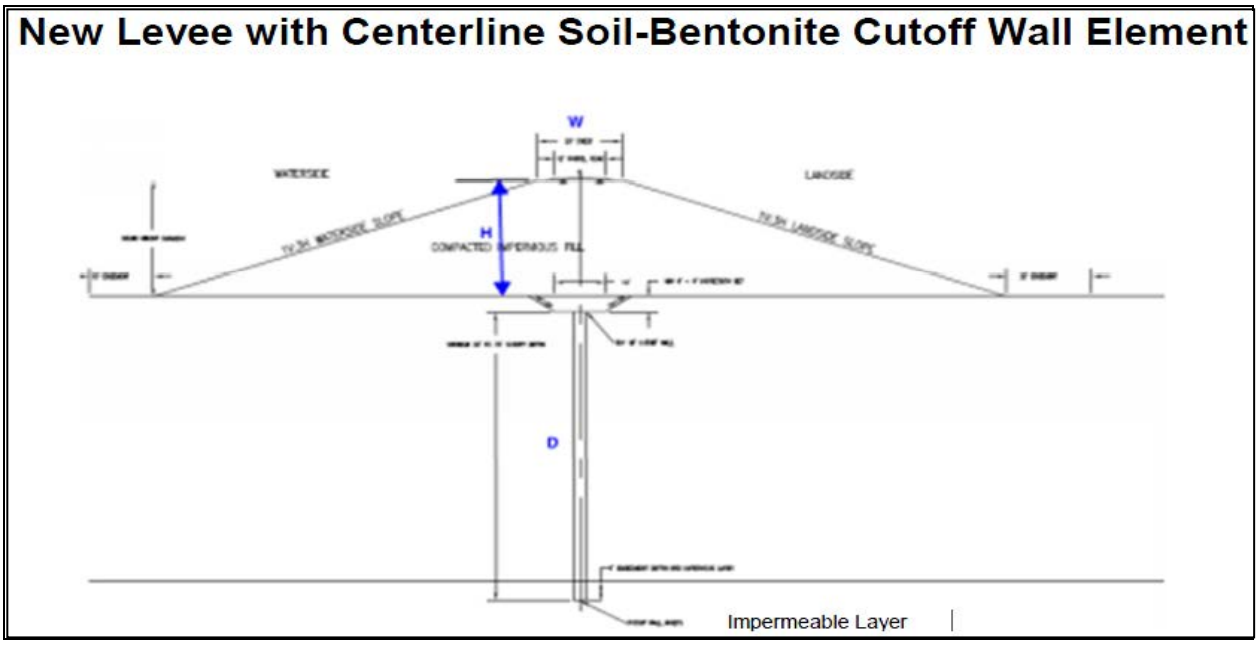


Figure 2.8 – Levee Improvement Type 8

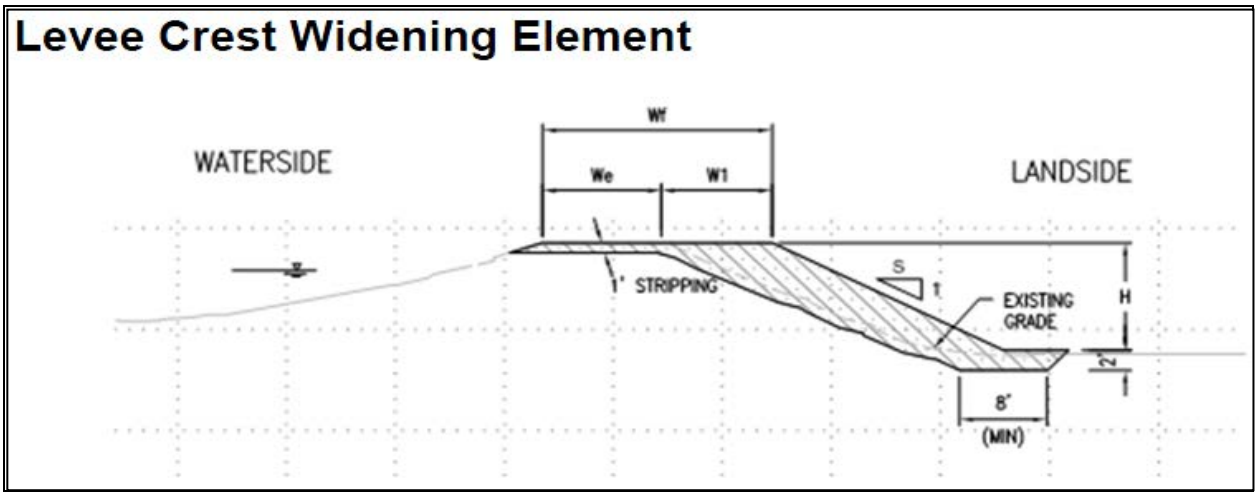


Figure 2.9 – Levee Improvement Type 9

The typical levee remediation measures (shown in figure 2.1 through 2.9) were assigned to each of the 28 reaches as shown in table 2.5A and 2.5B:

Table 2.5A – Levee Remediation Measures (by Percentage of Reach Length)

Reach	Length (LF)	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9
S5-A-Upper	41,417				25%		100%			
S5-A-Lower	13,300				25%		100%			
S5-B	39,300				75%		75%			
S5-C	30,300				25%		75%			100%
S5-D	31,300				10%		50%			100%
S7-D	21,300				10%		50%			100%
S7-E-Upper	9,100				10%		75%			100%

S7-E-Middle	3,300				10%		75%			100%
S7-E-Lower	5,900				10%		75%			100%
S7-F-Upper	22,000				10%		75%			100%
S7-F-Middle	15,300				10%		75%			100%
S7-F-Lower	3,700				10%		75%			100%
S7-G	40,000				10%		100%			
S7-H	9,300				10%		100%			
S7-I	42,916				10%		100%			
S7-J	24,400				10%		50%			
S4-South	28,000							50%	50%	
S4-West	21,000							75%	25%	
S4-North	26,000							50%	50%	
S6-South	28,000							50%	50%	
S6-West-lower	21,000							75%	25%	
S6-West-upper	6,000							75%	25%	
S9-G	40,000								100%	
S9-H	9,300								100%	
S9-I	42,916								100%	
S10	41,417								100%	
S11	15,300							50%	50%	
S12	3,300						25%		75%	

Table 2.5B – Levee Remediation Measures (by Length in Linear Feet)

Reach	Length (LF)	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9
S5-A-Upper	41,417				10,354		41,417			
S5-A-Lower	13,300				3,325		13,300			
S5-B	39,300				29,475		29,475			
S5-C	30,300				7,575		22,725			30,300
S5-D	31,300				3,130		15,650			31,300
S7-D	21,300				2,130		10,650			21,300
S7-E-Upper	9,100				910		6,825			9,100
S7-E-Middle	3,300				330		2,475			3,300
S7-E-Lower	5,900				590		4,425			5,900
S7-F-Upper	22,000				2,200		16,500			22,000
S7-F-Middle	15,300				1,530		11,475			15,300
S7-F-Lower	3,700				370		2,775			3,700
S7-G	40,000				4,000		40,000			
S7-H	9,300				930		9,300			
S7-I	42,916				4,292		42,916			
S7-J	24,400				2,440		12,200			
S4-South	28,000							14,000	14,000	
S4-West	21,000							15,750	5,250	
S4-North	26,000							13,000	13,000	
S6-South	28,000							14,000	14,000	
S6-West-lower	21,000							15,750	5,250	
S6-West-upper	6,000							4,500	1,500	
S9-G	40,000								40,000	

S9-H	9,300								9,300	
S9-I	42,916								42,916	
S10	41,417								41,417	
S11	15,300							7,650	7,650	
S12	3,300						825		2,475	

Assignment (dimension and extent) of the remediation measures (figure 2.1 to 2.9) for each reach are graphically presented in figure 2.10A through 2.29B. Also shown in these figure are the 20-foot landside and 15-foot waterside O&M corridors. The outer most limits of the O&M corridors define the project ROW. The heights of new levee segments (shown in figure 2.21A to 2.23B, Ring and J levee segments, see definition in table 2.2) were based on hydraulic design recommendations (enclosure 3, Design of New Levee Segments).

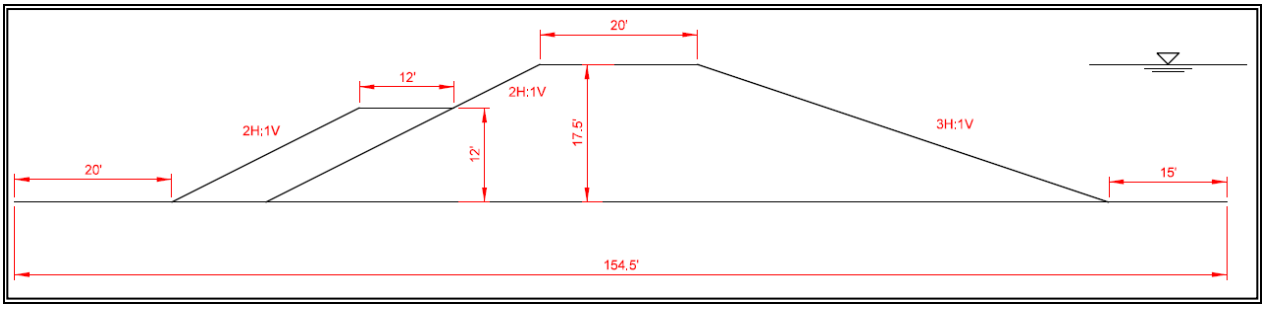


Figure 2.10A – Reach S5-A (Improvement Type 4 for 25% of Reach Length)

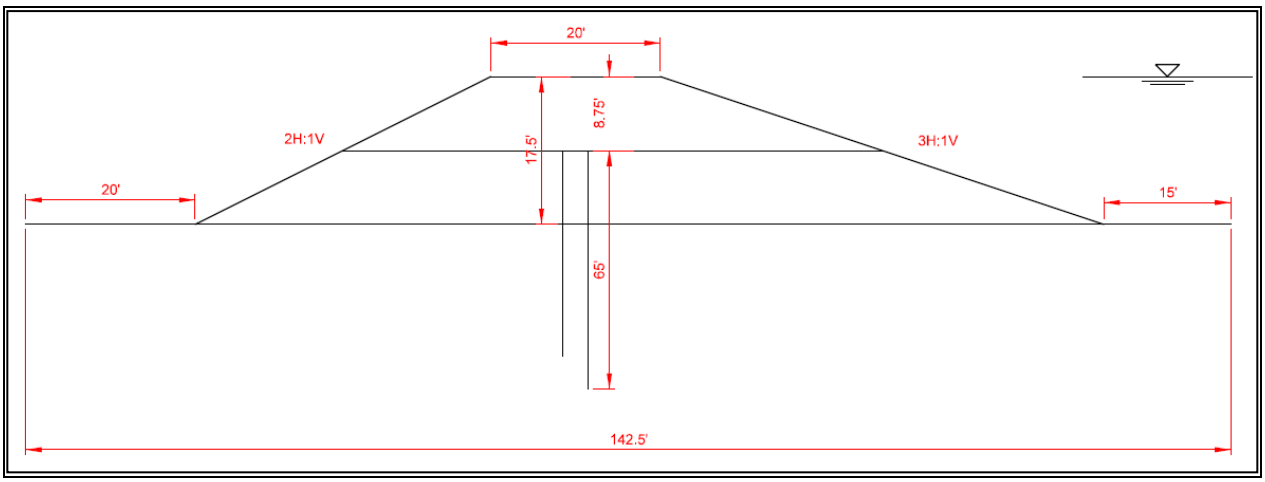


Figure 2.10B – Reach S5-A (Improvement Type 6 for 100% of Reach Length)

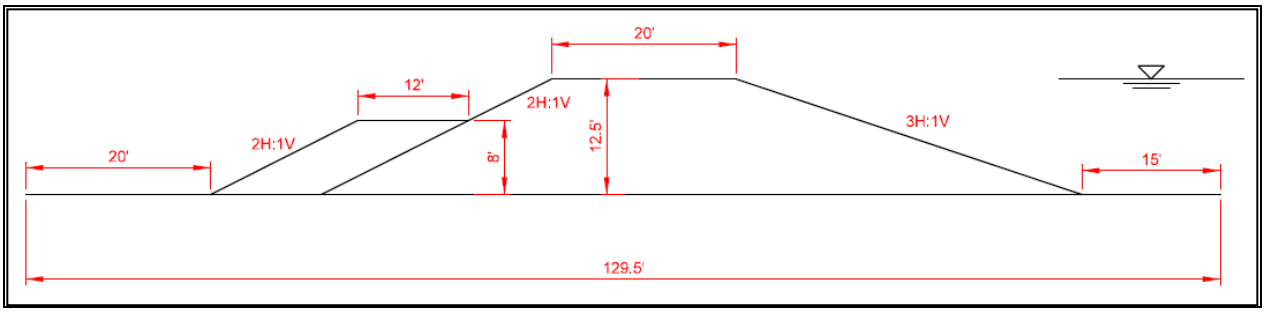


Figure 2.11A – Reach S5-B (Improvement Type 4 for 75% of Reach Length)

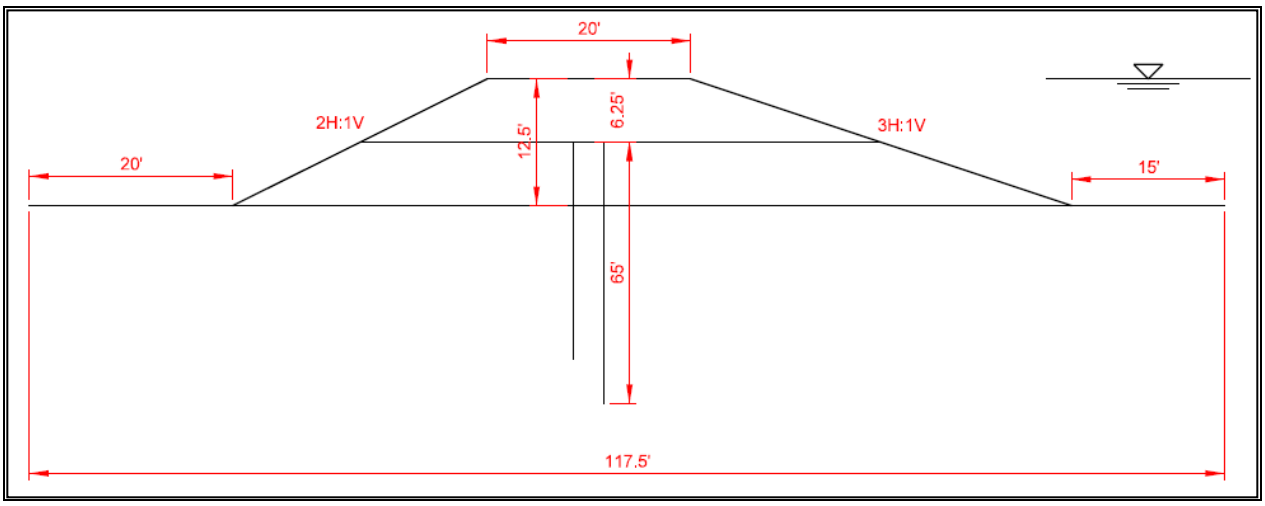


Figure 2.11B – Reach S5-B (Improvement Type 6 for 75% of Reach Length)

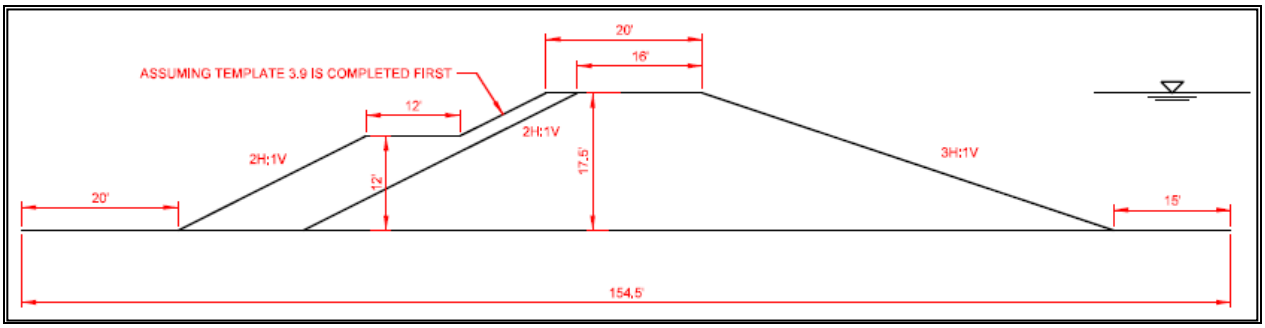


Figure 2.12A – Reach S5-C (Improvement Type 4 for 25% of Reach Length)

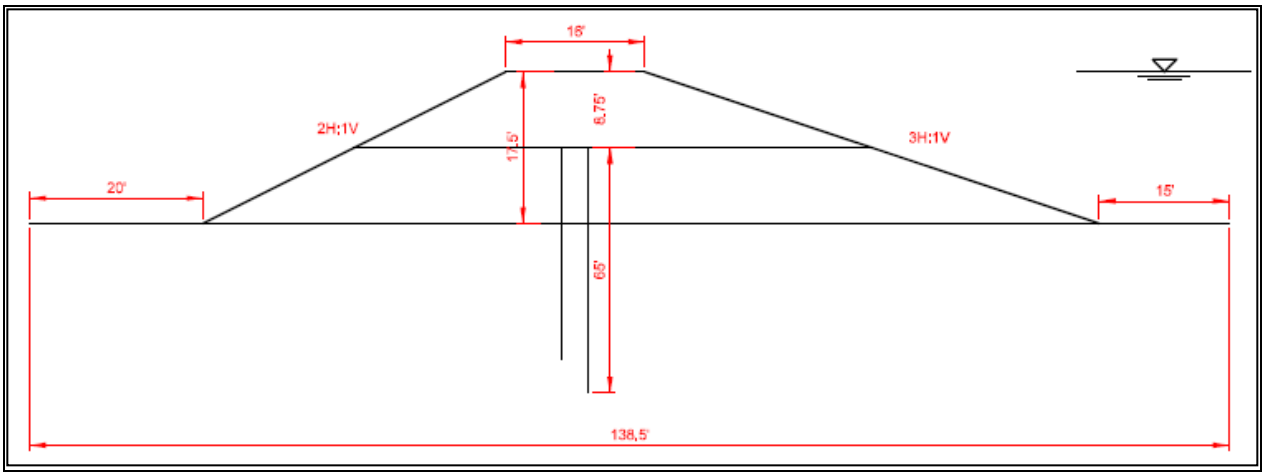


Figure 2.12B – Reach S5-C (Improvement Type 6 for 75% of Reach Length)

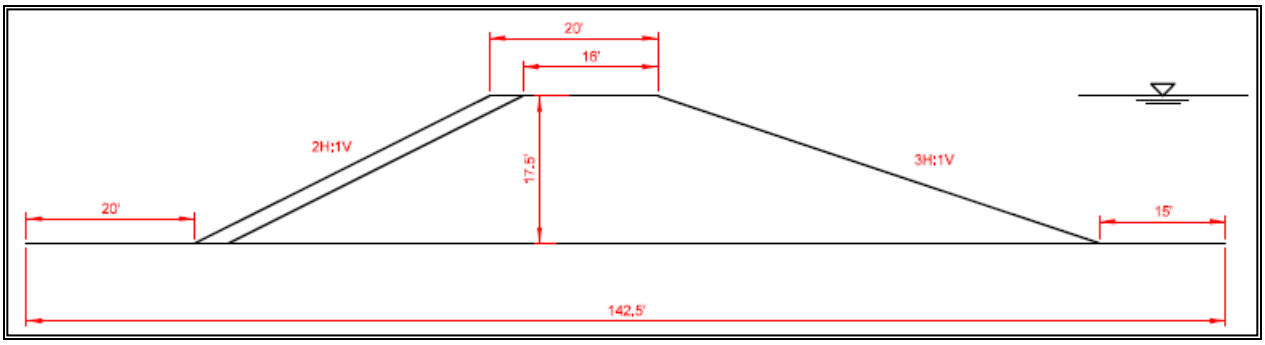


Figure 2.12C – Reach S5-C (Improvement Type 9 for 100% of Reach Length)

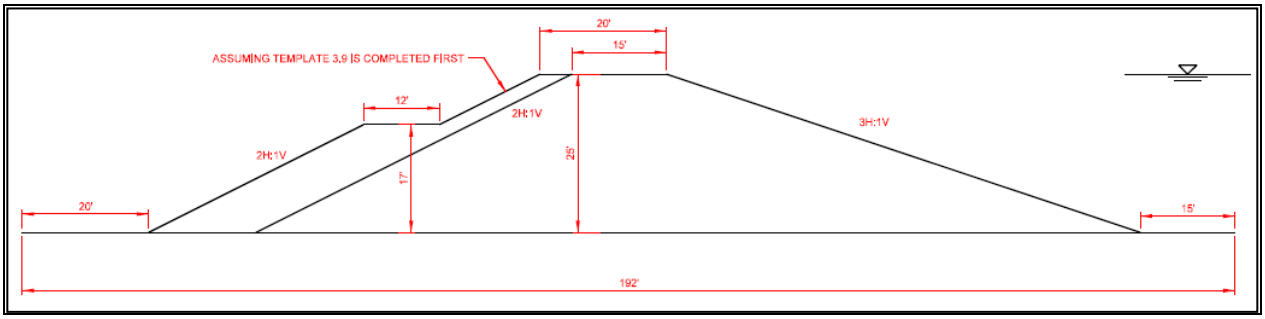


Figure 2.13A – Reach S5-D (Improvement Type 4 for 10% of Reach Length)

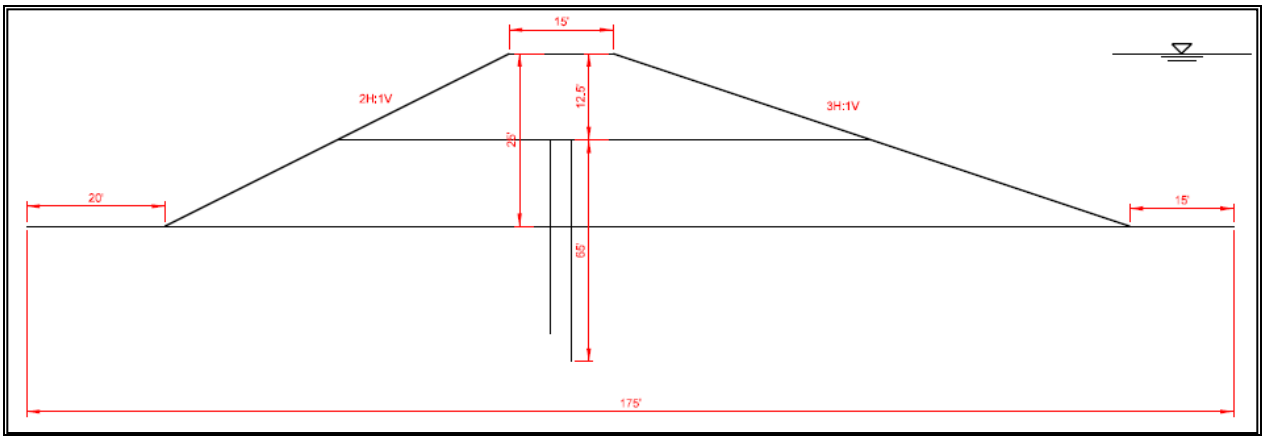


Figure 2.13B – Reach S5-D (Improvement Type 6 for 50% of Reach Length)

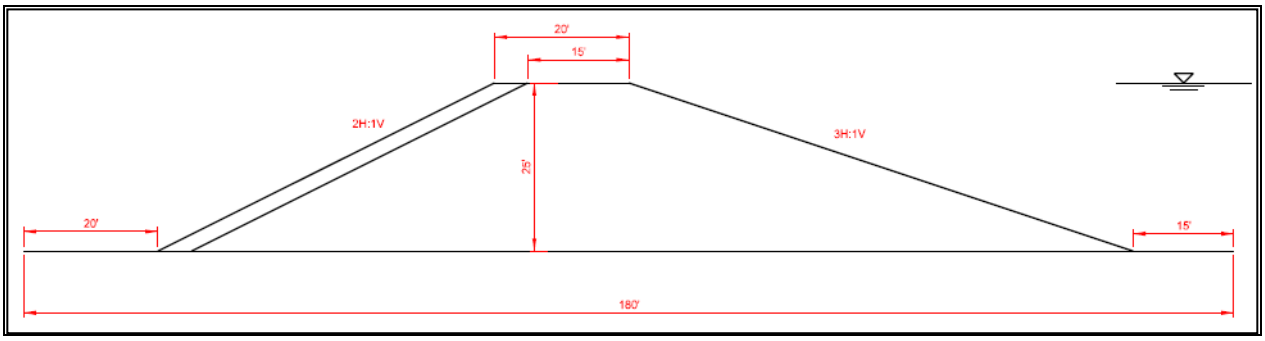


Figure 2.13C – Reach S5-D (Improvement Type 9 for 100% of Reach Length)

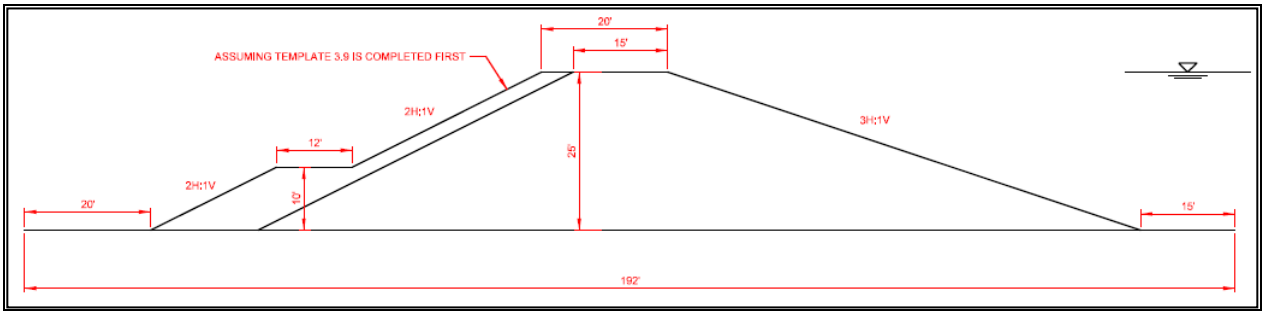


Figure 2.14A – Reach S7-D (Improvement Type 4 for 10% of Reach Length)

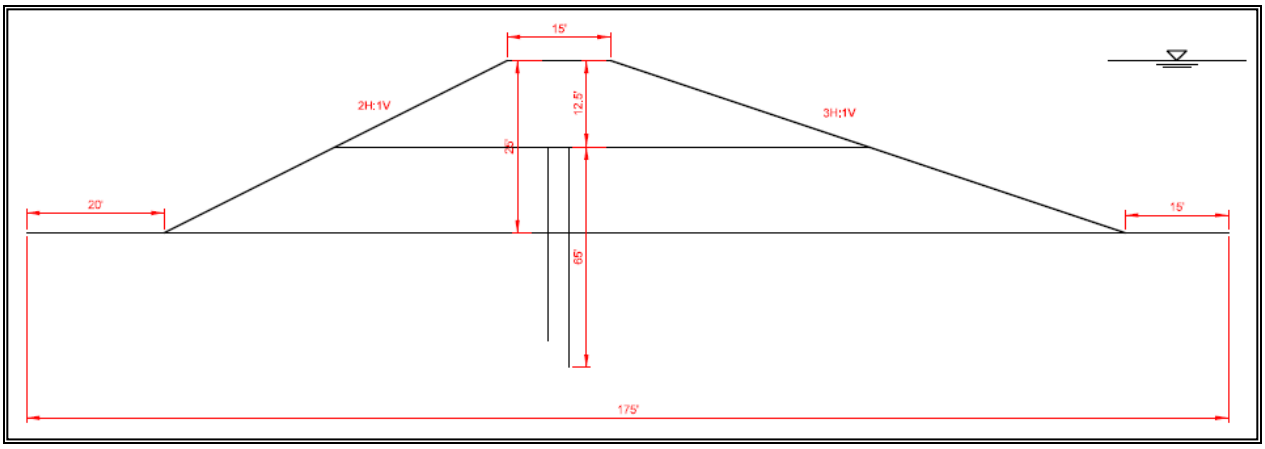


Figure 2.14B – Reach S7-D (Improvement Type 6 for 50% of Reach Length)

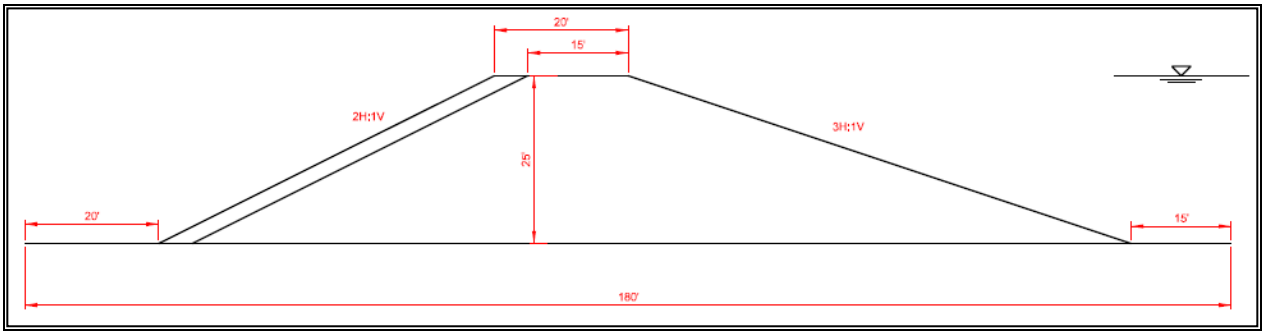


Figure 2.14C – Reach S7-D (Improvement Type 9 for 100% of Reach Length)

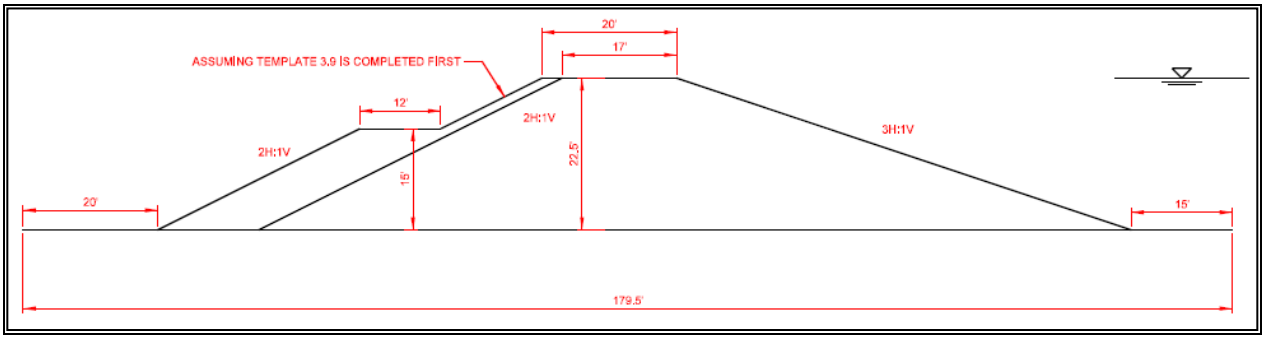


Figure 2.15A – Reach S7-E (Improvement Type 4 for 10% of Reach Length)

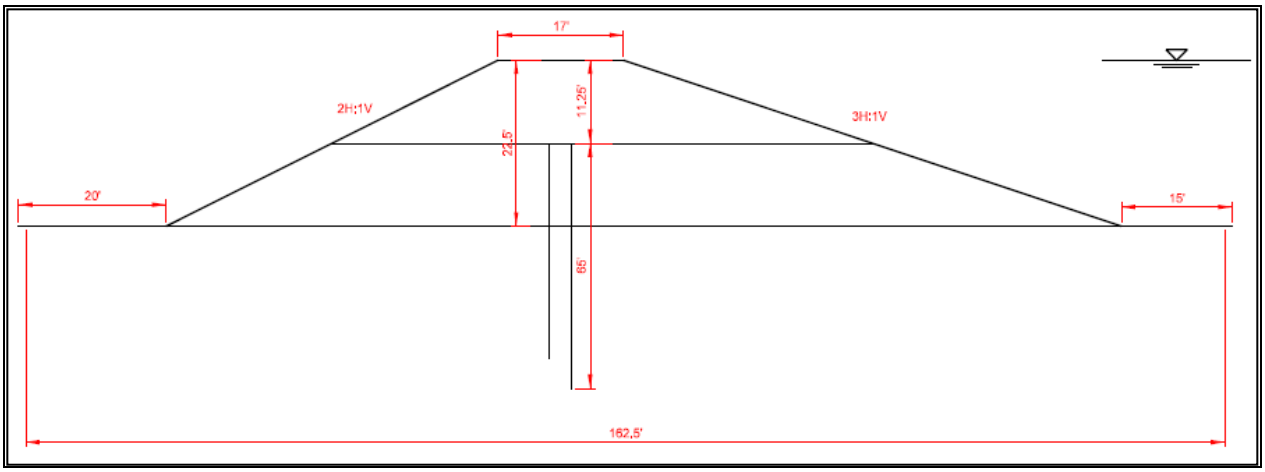


Figure 2.15B – Reach S7-E (Improvement Type 6 for 75% of Reach Length)

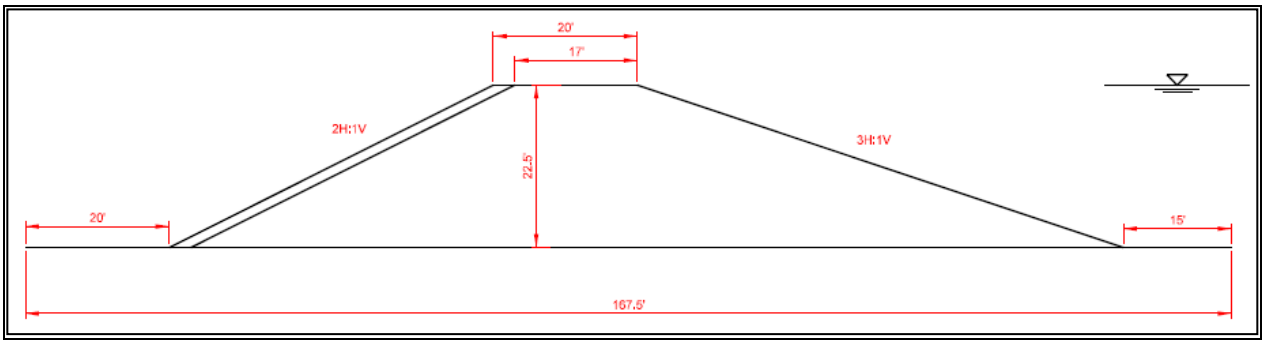


Figure 2.15C – Reach S7-E (Improvement Type 9 for 100% of Reach Length)

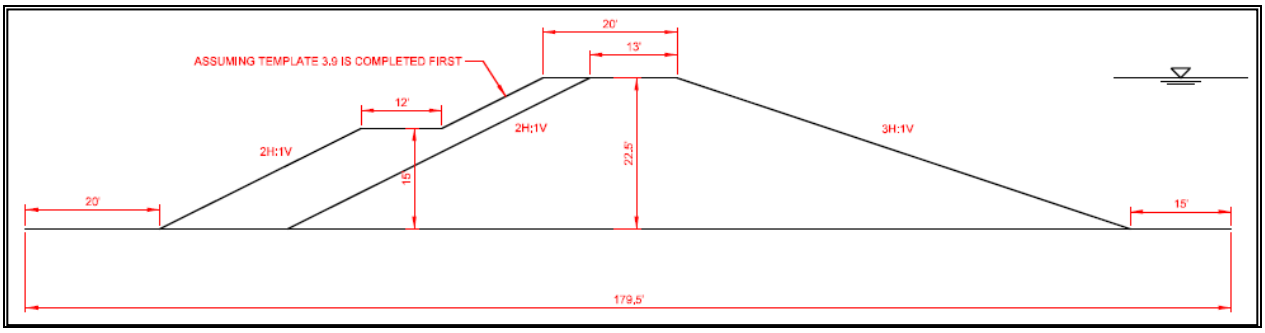


Figure 2.16A – Reach S7-F (Improvement Type 4 for 10% of Reach Length)

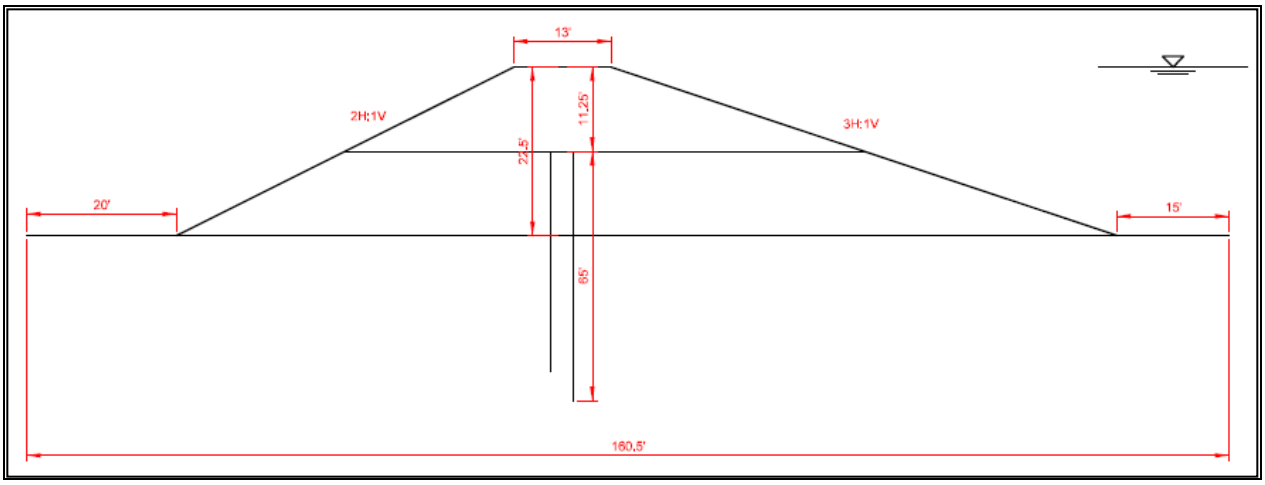


Figure 2.16B – Reach S7-F (Improvement Type 6 for 75% of Reach Length)

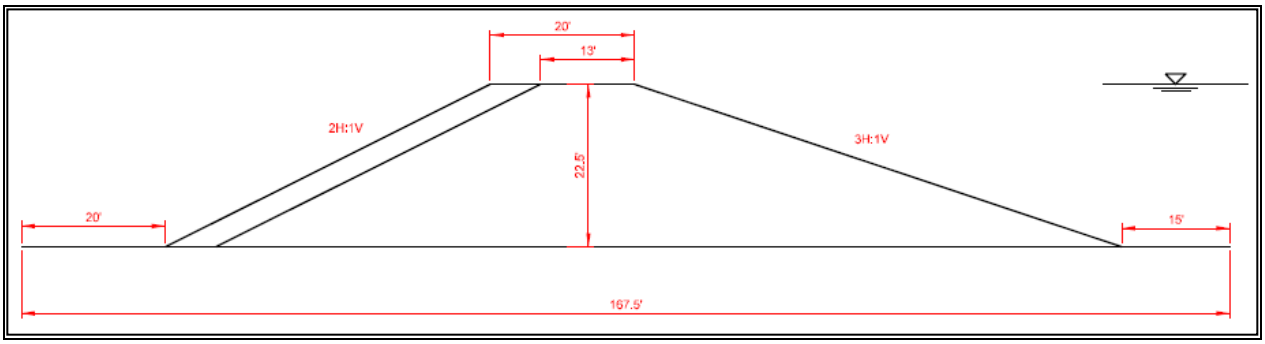


Figure 2.16C – Reach S7-F (Improvement Type 9 for 100% of Reach Length)

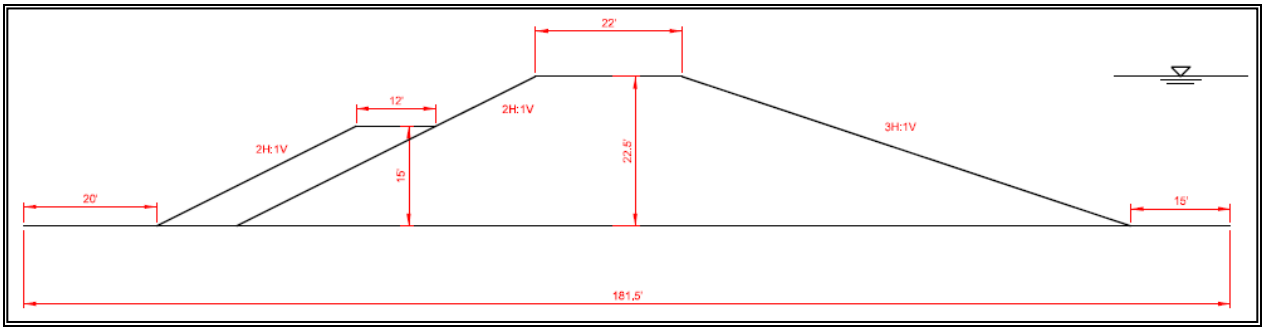


Figure 2.17A – Reach S7-G (Improvement Type 4 for 10% of Reach Length)

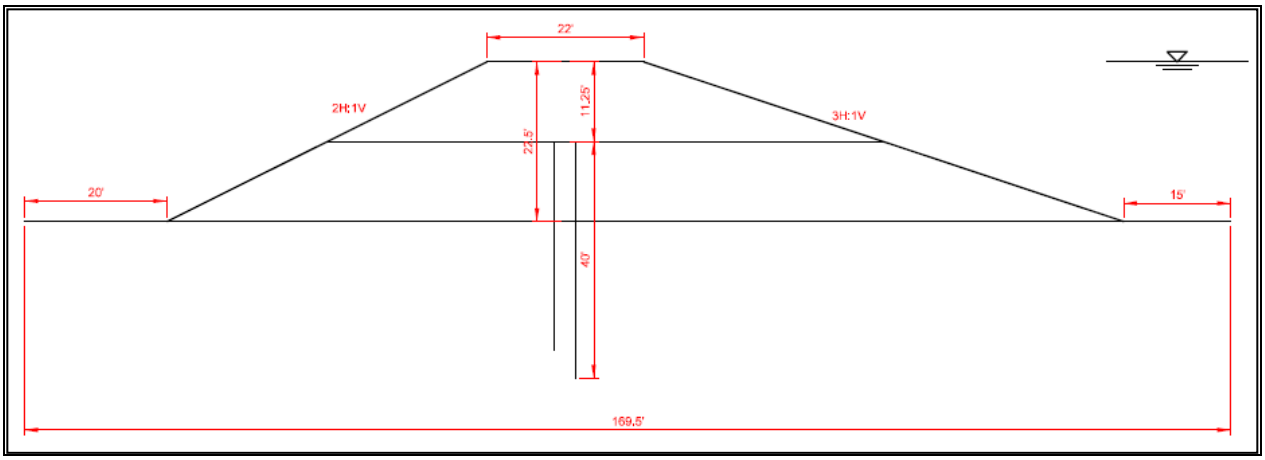


Figure 2.17B – Reach S7-G (Improvement Type 6 for 100% of Reach Length)

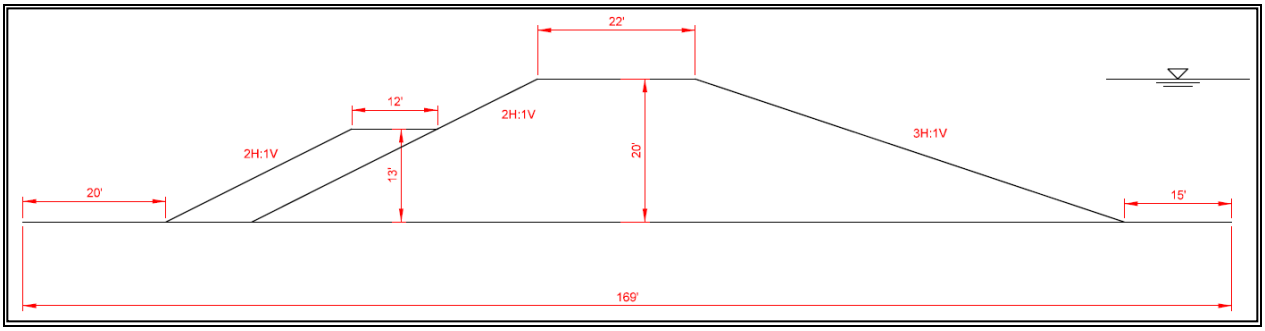


Figure 2.18A – Reach S7-H (Improvement Type 4 for 10% of Reach Length)

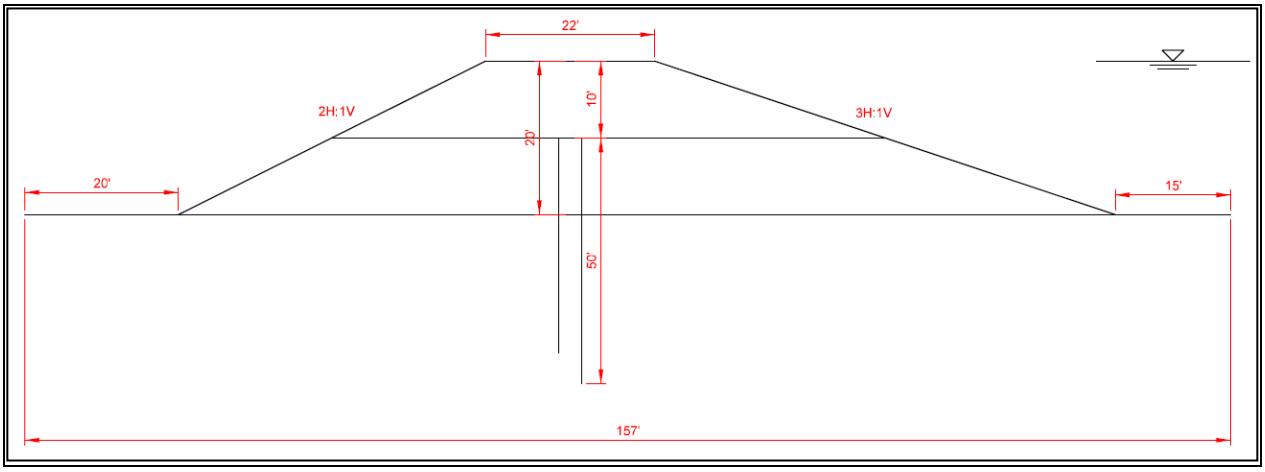


Figure 2.18B – Reach S7-H (Improvement Type 6 for 100% of Reach Length)

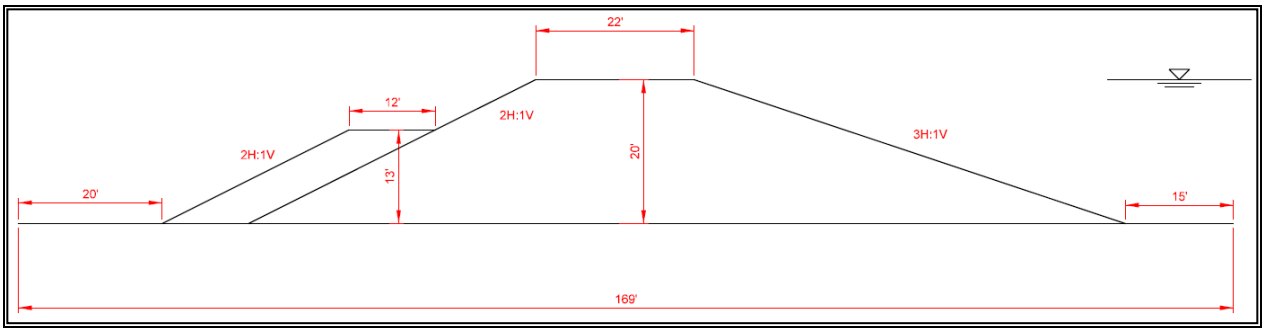


Figure 2.19A – Reach S7-I (Improvement Type 4 for 10% of Reach Length)

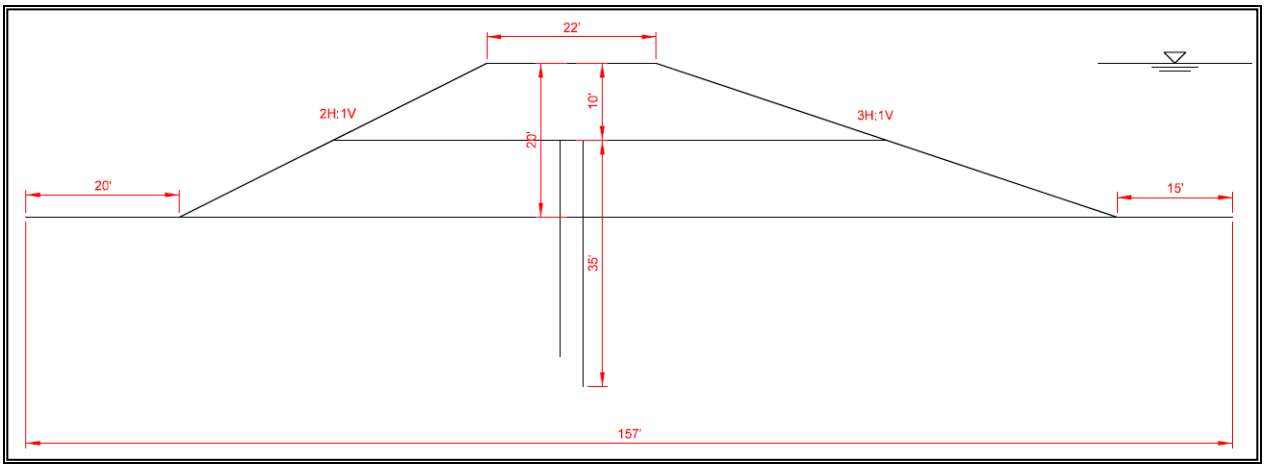


Figure 2.19B – Reach S7-I (Improvement Type 6 for 100% of Reach Length)

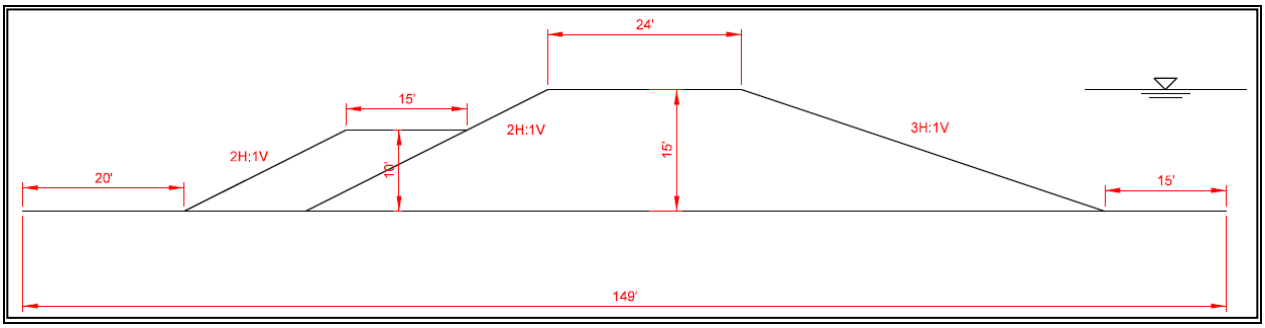


Figure 2.20A – Reach S7-J (Improvement Type 4 for 10% of Reach Length)

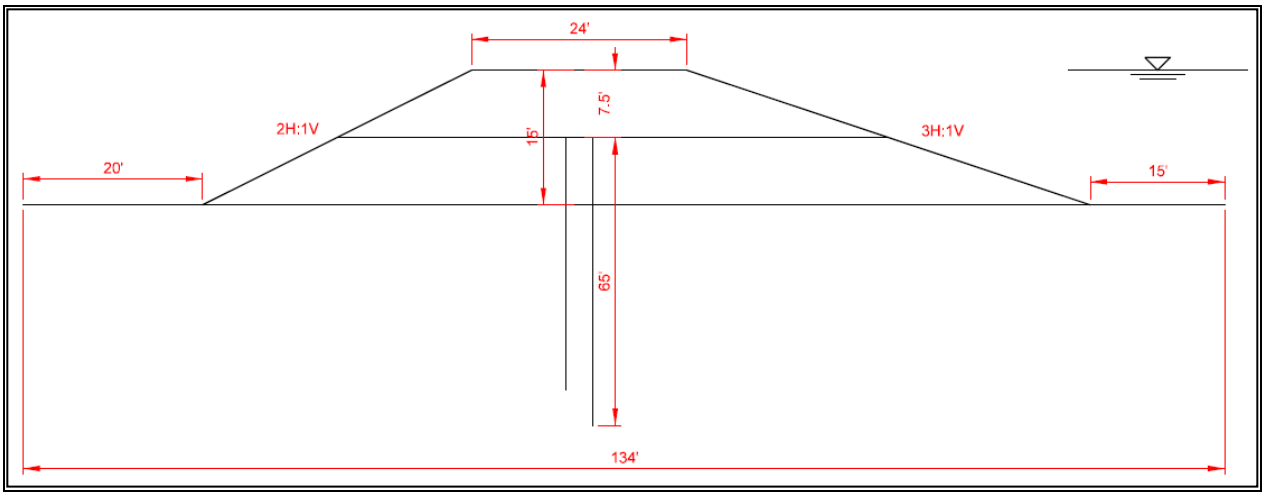


Figure 2.20B – Reach S7-J (Improvement Type 6 for 50% of Reach Length)

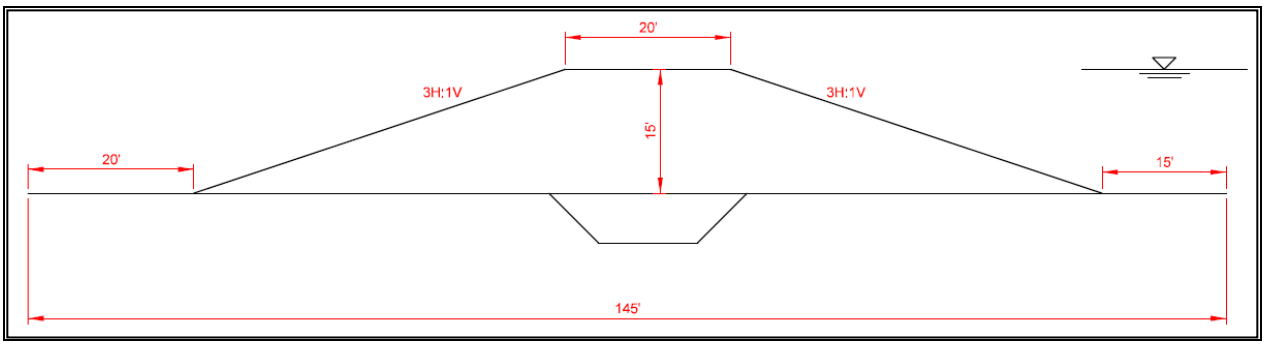


Figure 2.21A – Reach S4-South/S6-South (Improvement Type 7 for 50% of Reach Length)

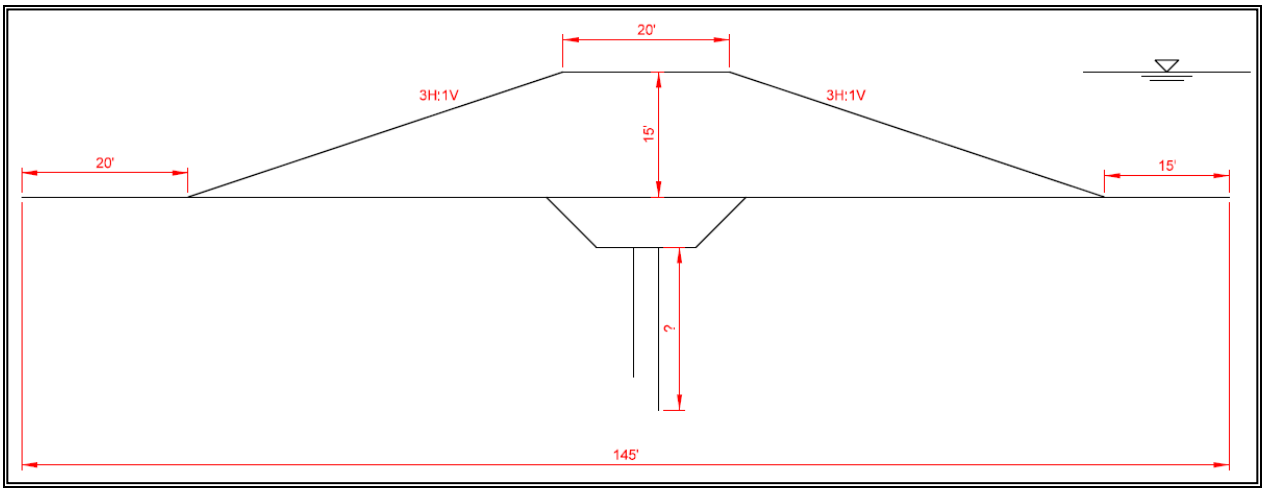


Figure 2.21B – Reach S4-South/S6-South (Improvement Type 8 for 50% of Reach Length)

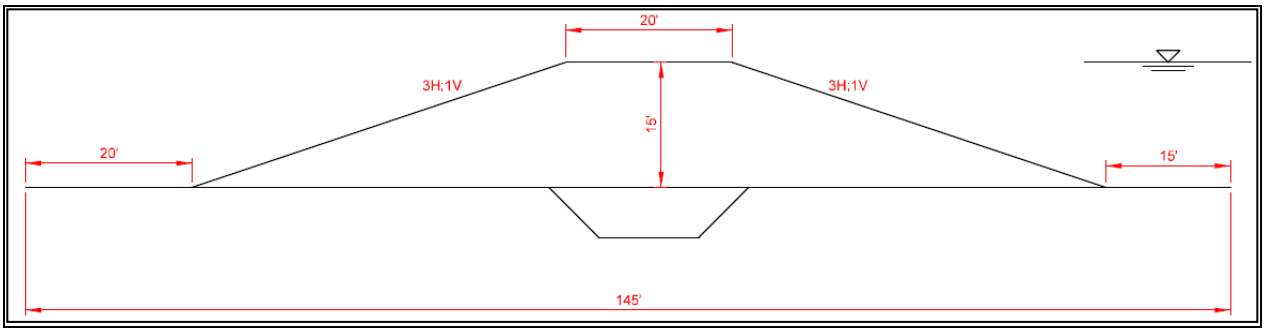


Figure 2.22A – Reach S4-West/S6-West (Improvement Type 7 for 75% of Reach Length)

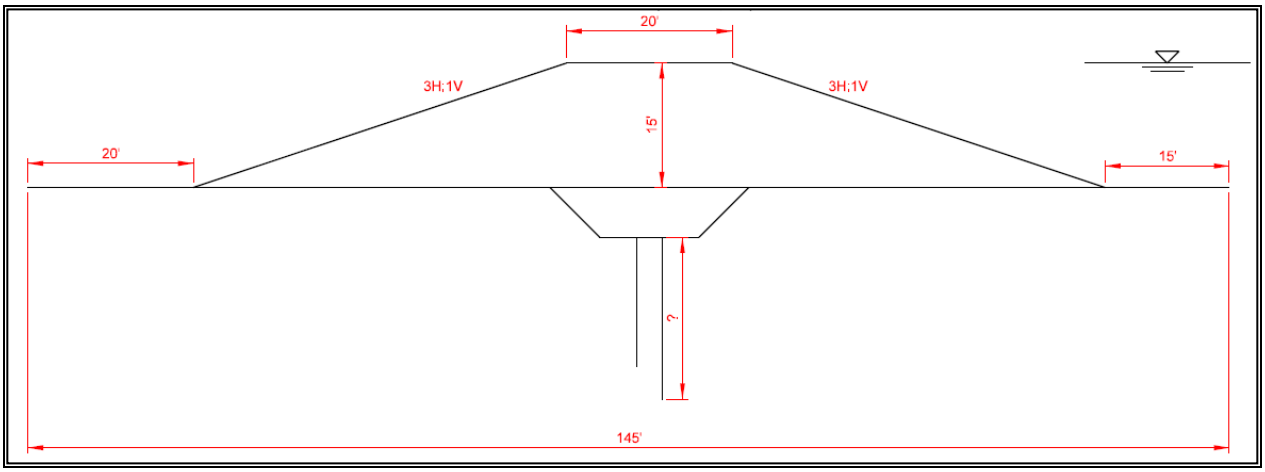


Figure 2.22B – Reach S4-West/S6-West (Improvement Type 8 for 25% of Reach Length)

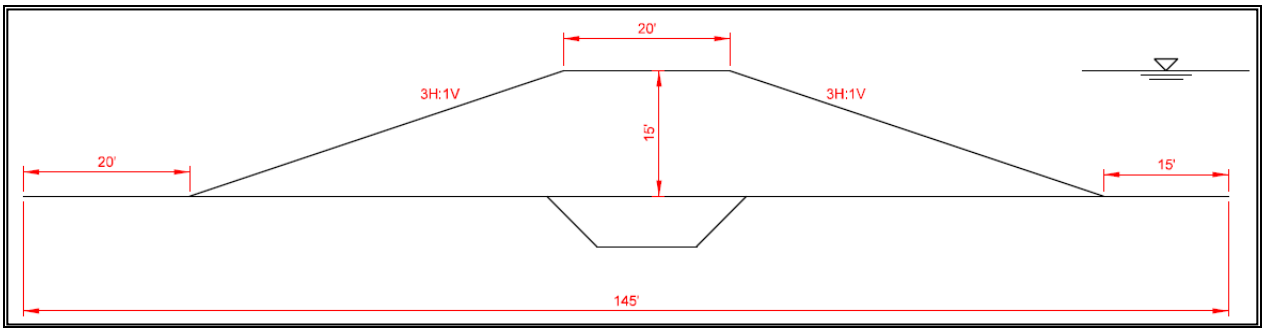


Figure 2.23A – Reach S4-North (Improvement Type 7 for 50% of Reach Length)

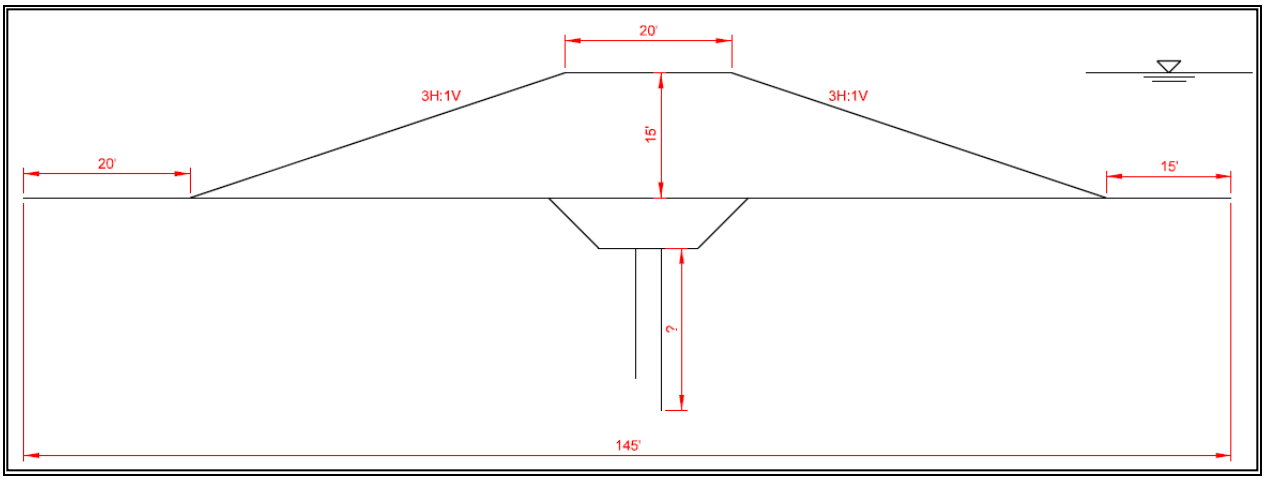


Figure 2.23B – Reach S4-North (Improvement Type 8 for 50% of Reach Length)

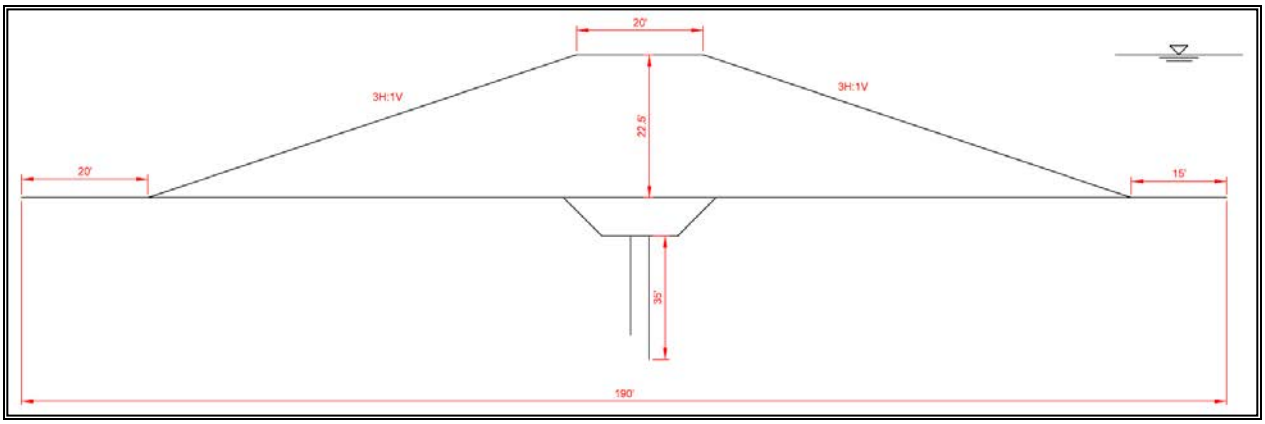


Figure 2.24 – Reach S9-G (Improvement Type 8 for 100% of Reach Length)

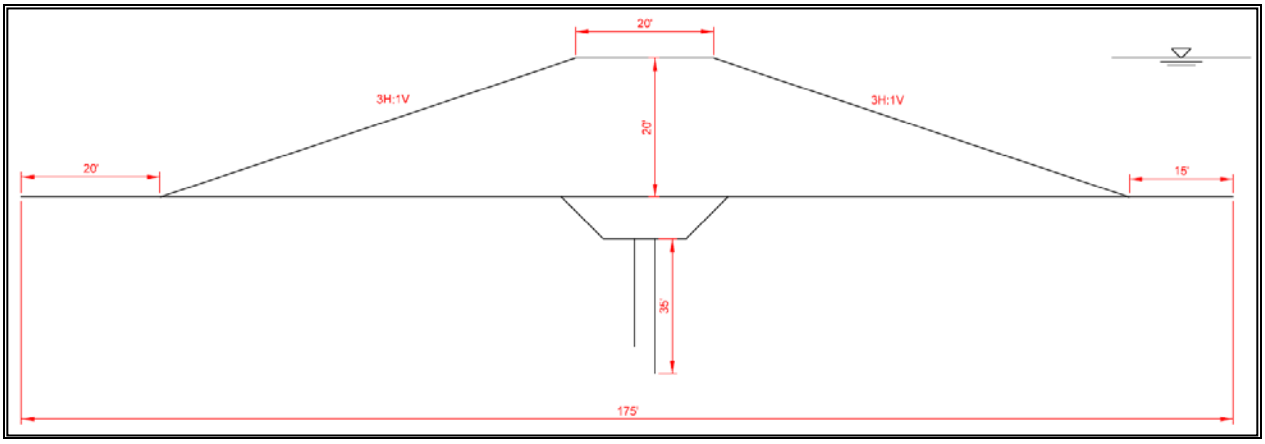


Figure 2.25 – Reach S9-H (Improvement Type 8 for 100% of Reach Length)

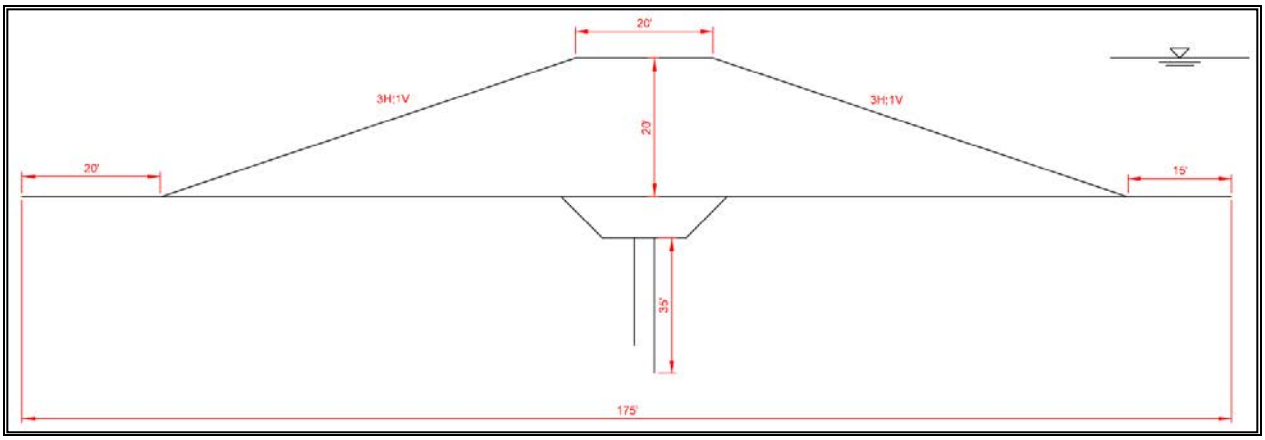


Figure 2.26 – Reach S9-I (Improvement Type 8 for 100% of Reach Length)

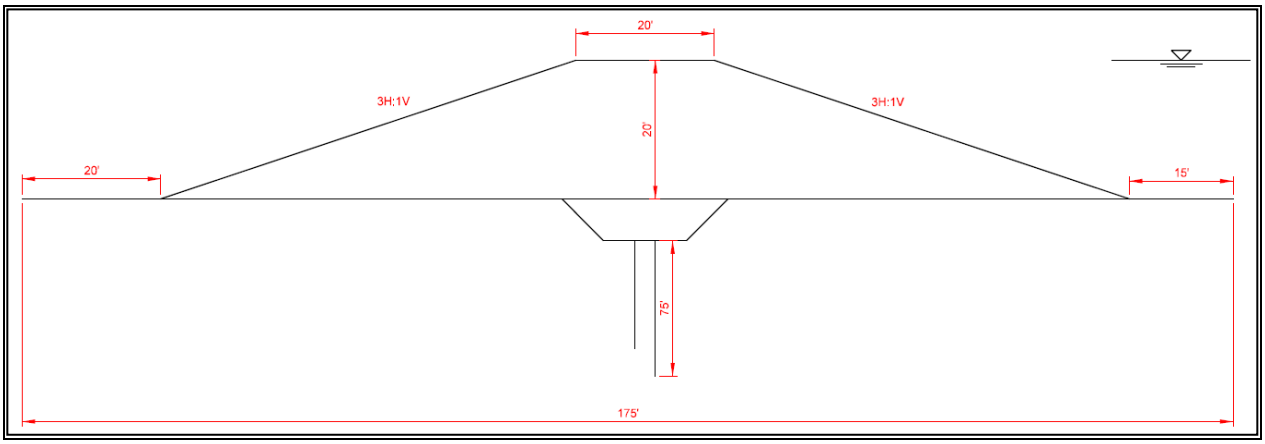


Figure 2.27 – Reach S10 (Improvement Type 8 for 100% of Reach Length)

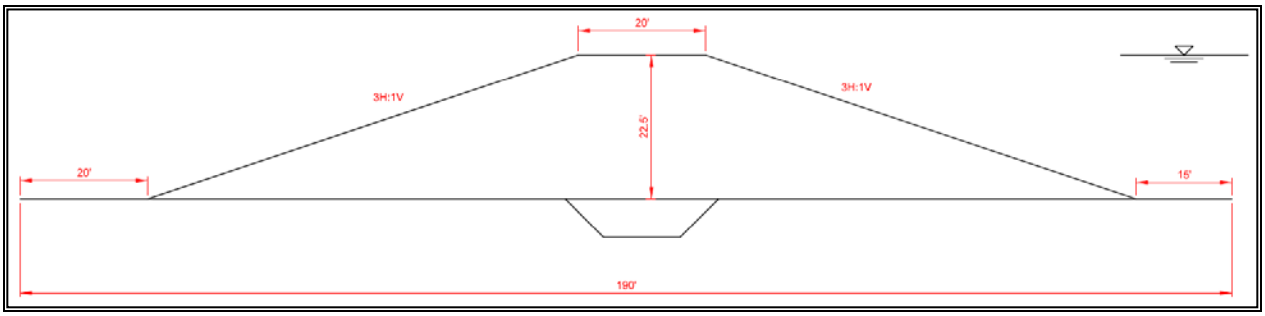


Figure 2.28A – Reach S11 (Improvement Type 7 for 50% of Reach Length)

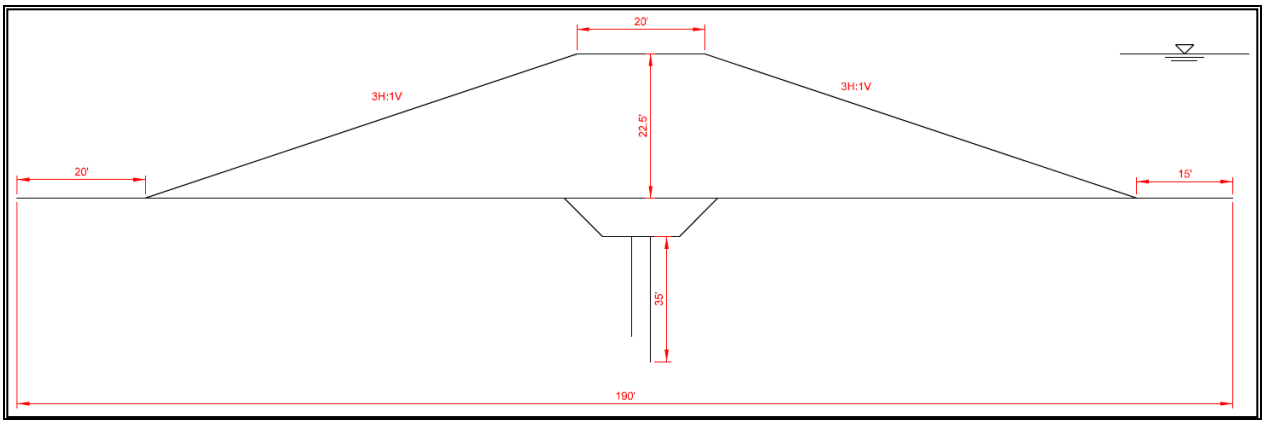


Figure 2.28B – Reach S11 (Improvement Type 8 for 50% of Reach Length)

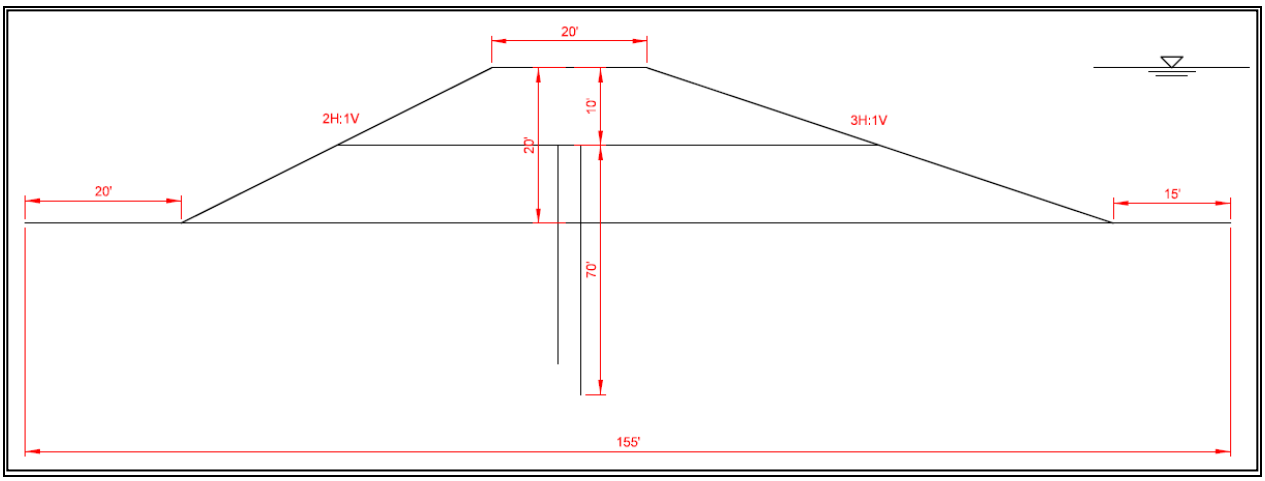


Figure 2.29A – Reach S12 (Improvement Type 6 for 25% of Reach Length)

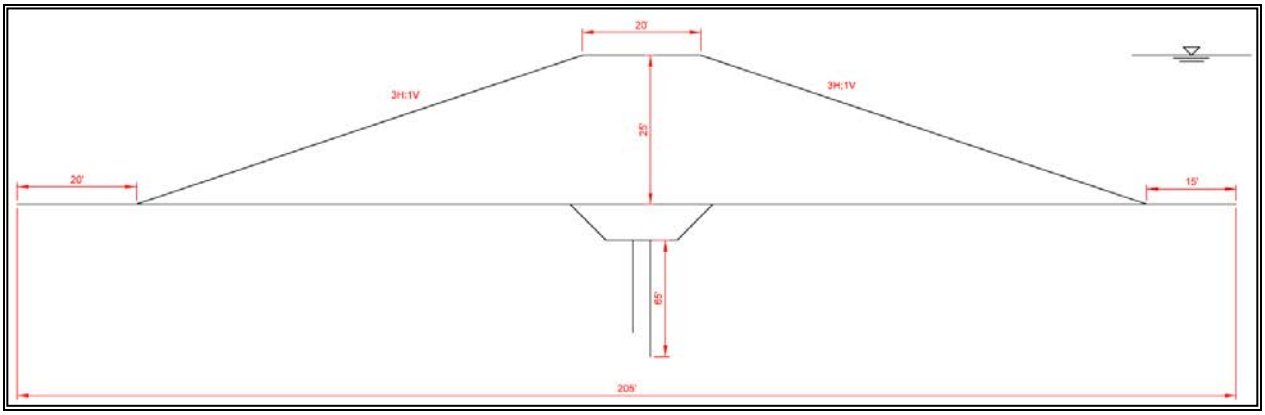


Figure 2.29B – Reach S12 (Improvement Type 8 for 75% of Reach Length)

2.5 Encroachments

The utilities (pipelines and conduits only) located within the proposed ROW for new levee segments (e.g. setback levees and ring levee segments) were not specifically addressed during this phase, Phase 2, of the study and estimated as a lump sum percentage of the total utility cost. Physical structures located within the proposed ROW, roads and canals crossing the alignment of new levee segments were specifically addressed during this phase. New levee segments were defined in table 2.2 and shown in figure 1 of section 2.3.1.

A comprehensive inventory of all encroachments (utilities, physical structures and woody vegetations) located within the proposed ROW of the existing levee segments (see figure 2.10A to 20B) was completed based on existing data and field investigations. The existing encroachment data came from multiple sources including the CVFPB encroachment list, the USACE Periodic Inspection report and as-built of various projects located along the FRWL alignment. Field investigations were conducted to validate and improve the existing inventories.

The final encroachment list (enclosure 4, Encroachment Improvements & Estimates) shows numerous pipelines (both gravity and pressurized lines) and conduits (cables, electrical lines etc.) crossing the existing alignments of the FRWL, SBEL and WCEL. The record also indicated a number of utilities running parallel to the alignments (power poles, irrigation ditches, pipelines etc.), physical structures (public, residential and commercial buildings), and woody vegetation (mature trees) currently located within the proposed ROW of the existing levee segments. These encroachments were divided into 12 groups/types.

The following paragraphs outline the approach for addressing each type of encroachment. To avoid interference with the cutoff wall construction, it is assumed that all levee penetrations will be removed prior to levee construction and disposed/replaced after the levee construction is completed. It is also assumed that temporary bypass will be provided at each utility improvement sites to avoid impacts to existing operations. All pipelines and conduits crossing the levee alignment will be modified to include positive closure devices and meet the USACE design criteria for levee penetrations in accordance with EM 1110-2-1913.

Refer to enclosure 4, Encroachment Improvements & Estimates, for the complete inventory, classification and remediation measures for all encroachments located within the proposed ROW of the existing levee segments.

2.5.1 Type 1

This group includes the major utilities those are crossing the levee prism and still in good condition. Relocation of these utility crossings above the DWSE would result in high construction cost and impacts. Therefore, the proposed remediation method is to construct jet grouting cutoff wall around the penetrations.

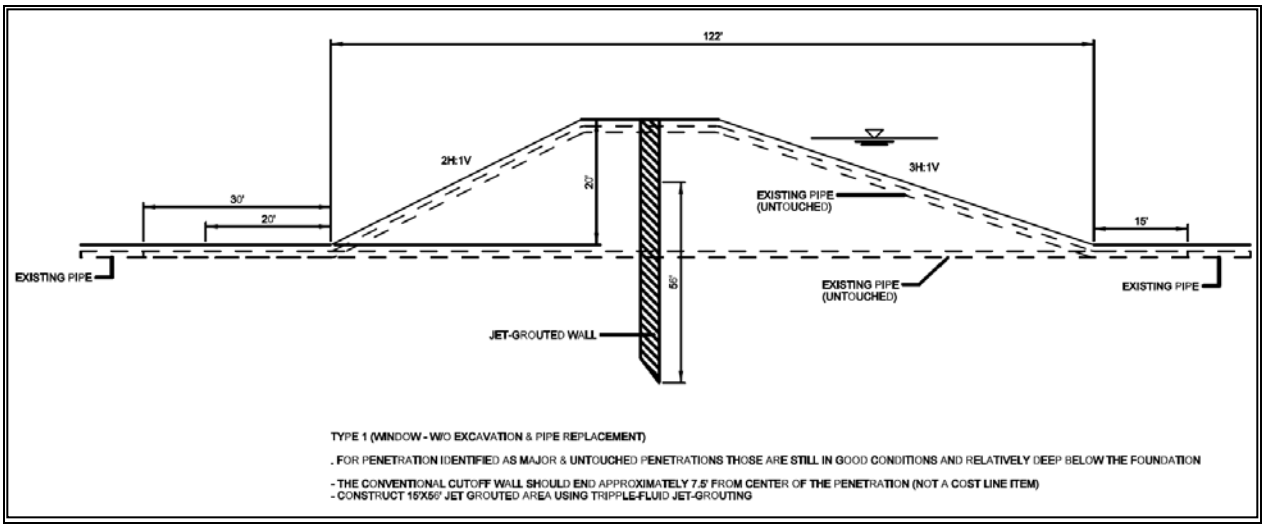


Figure 30A – Encroachment Type 1 – Section

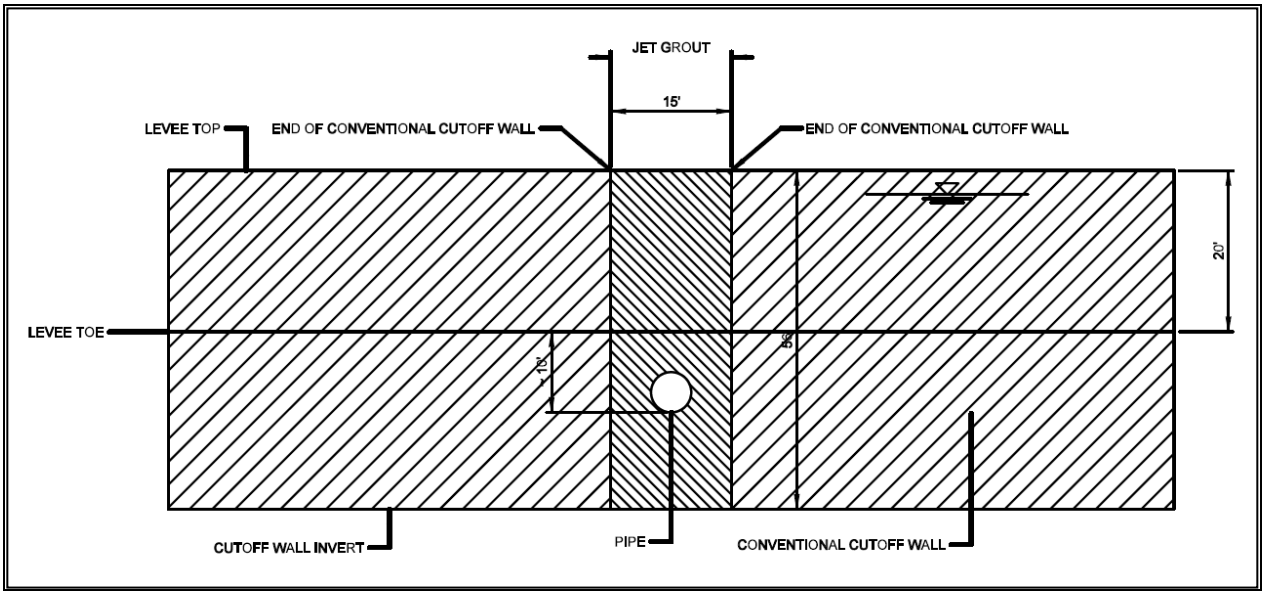


Figure 30B – Encroachment Type 1 – Profile

2.5.2 Type 2

This group includes the utilities those are crossing the levee prism (raised and through pipes/conduits) and abandoned. The proposed remediation method is to remove these abandoned penetrations.

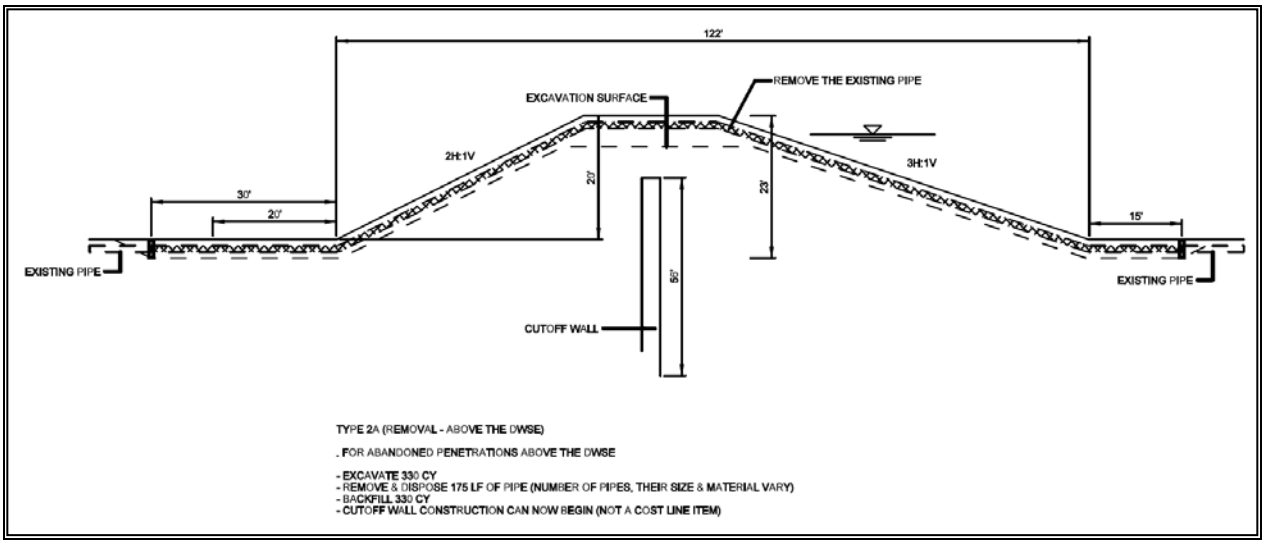


Figure 31A – Encroachment Type 2A – Section

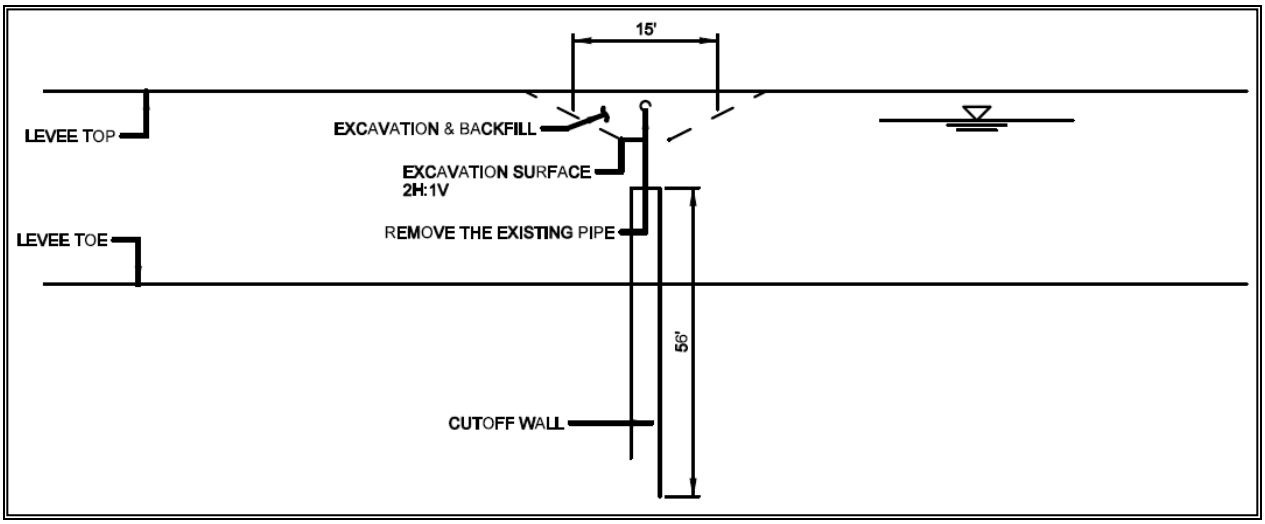


Figure 31B – Encroachment Type 2A – Profile

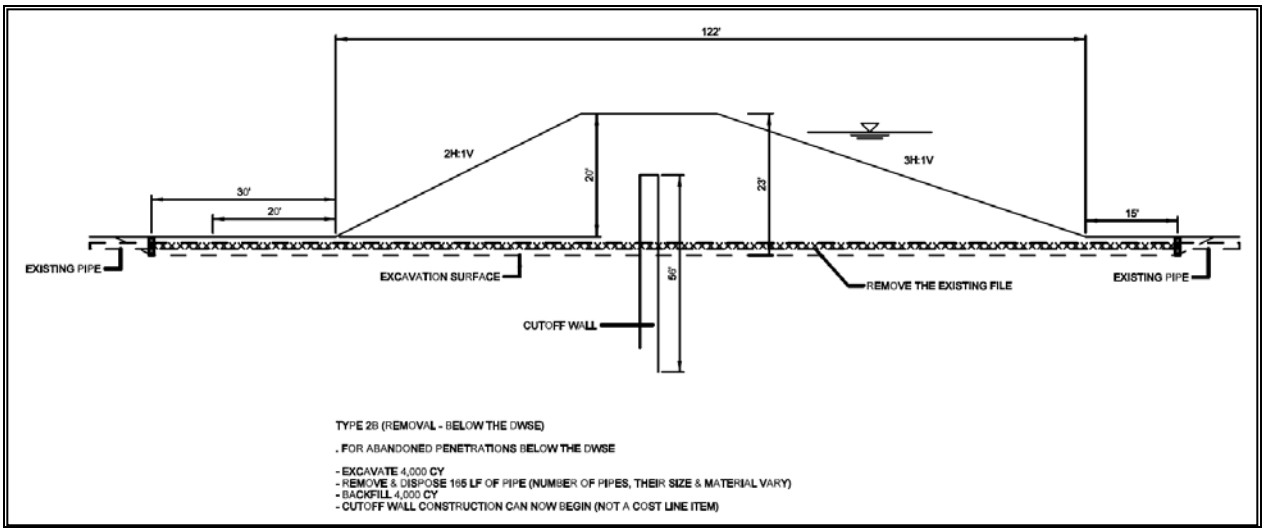


Figure 32A – Encroachment Type 2B – Section

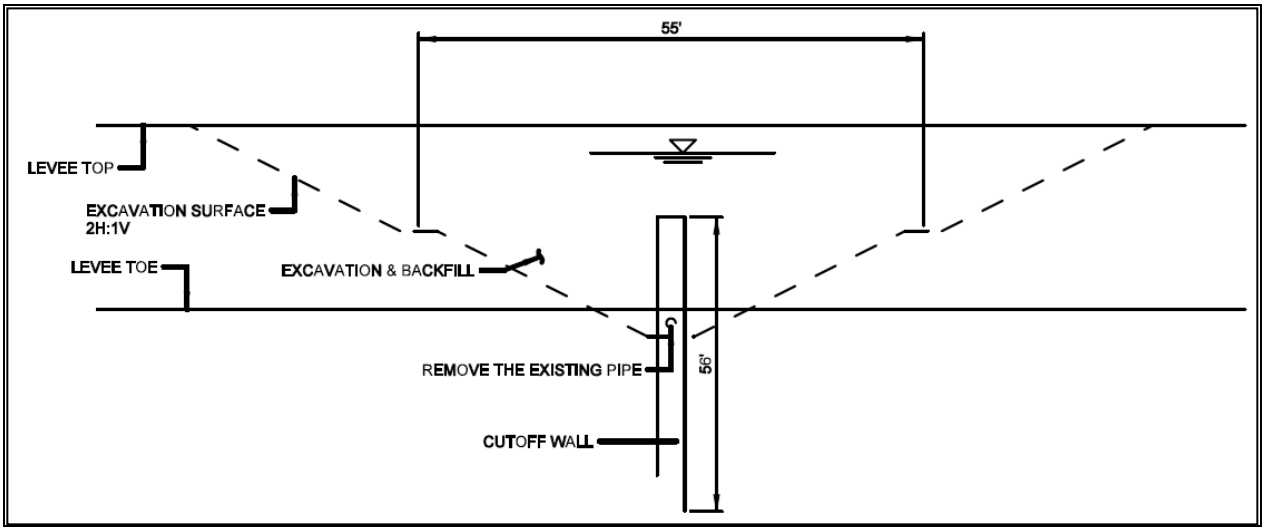


Figure 32B – Encroachment Type 2B – Profile

2.5.3 Type 3

This group includes utilities those are crossing the levee prism, dated and don't meet the current standard, include: (1) Communication conduits crossing the levee prism above the DWSE, (2) Minor pressurized pipelines crossing the levee prism above the DWSE, (3) Major pressurized pipelines crossing the levee prism below the DWSE, and (4) Gravity pipelines crossing the levee prism below the DWSE. These pipelines and conduits will be removed (before the cutoff wall construction begins) and replaced in-place (after the cutoff wall construction completes) with proper pipe materials and positive closure devices.

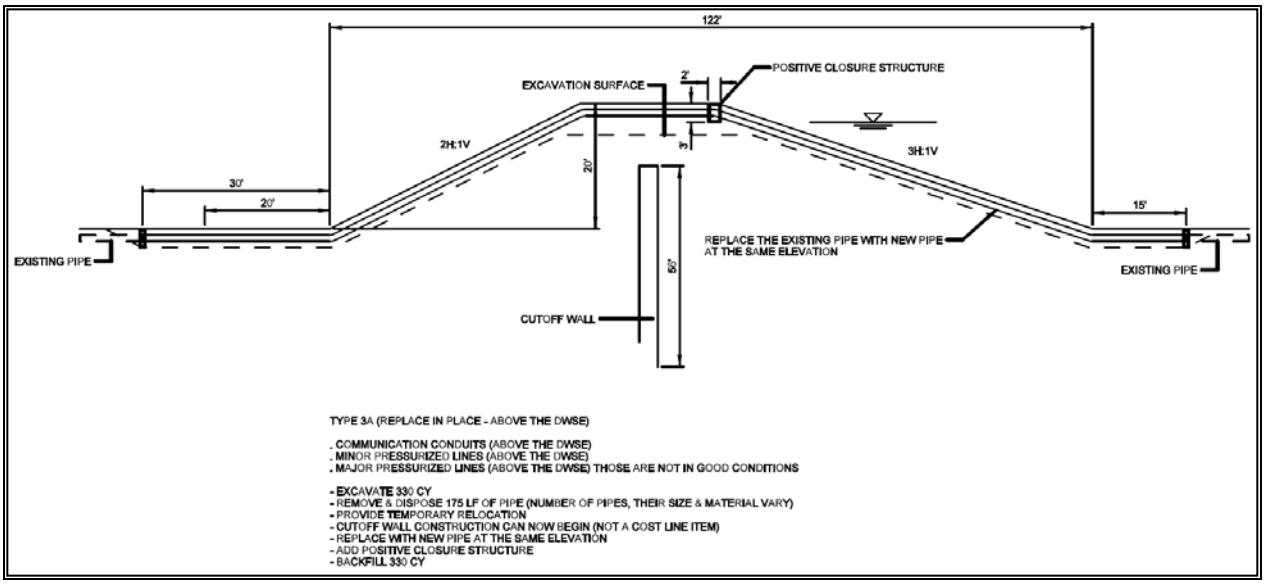


Figure 33A – Encroachment Type 3A – Section

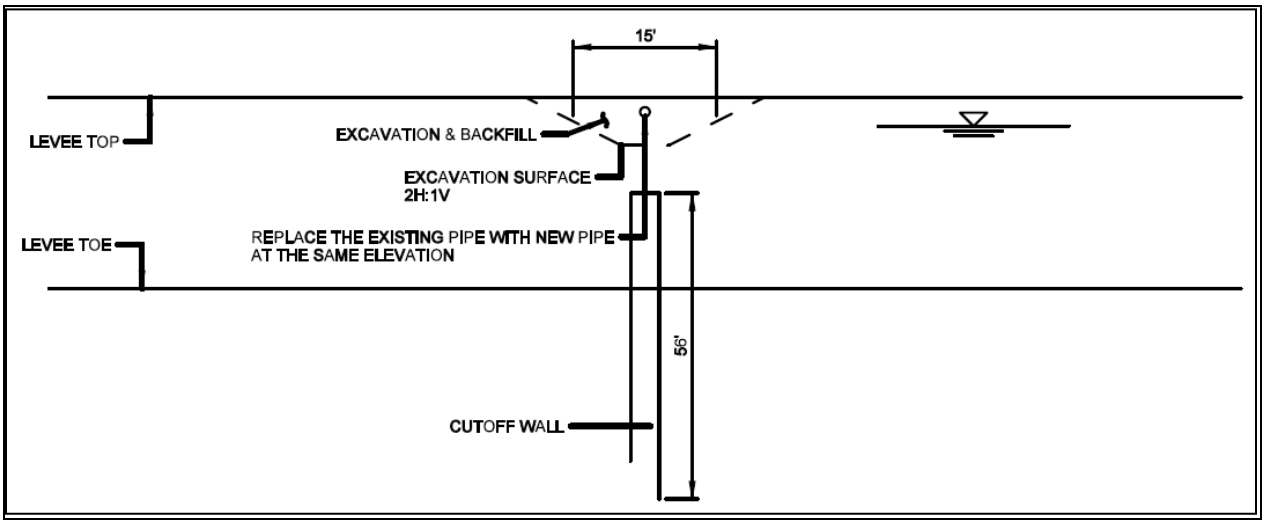


Figure 33B – Encroachment Type 3A – Profile

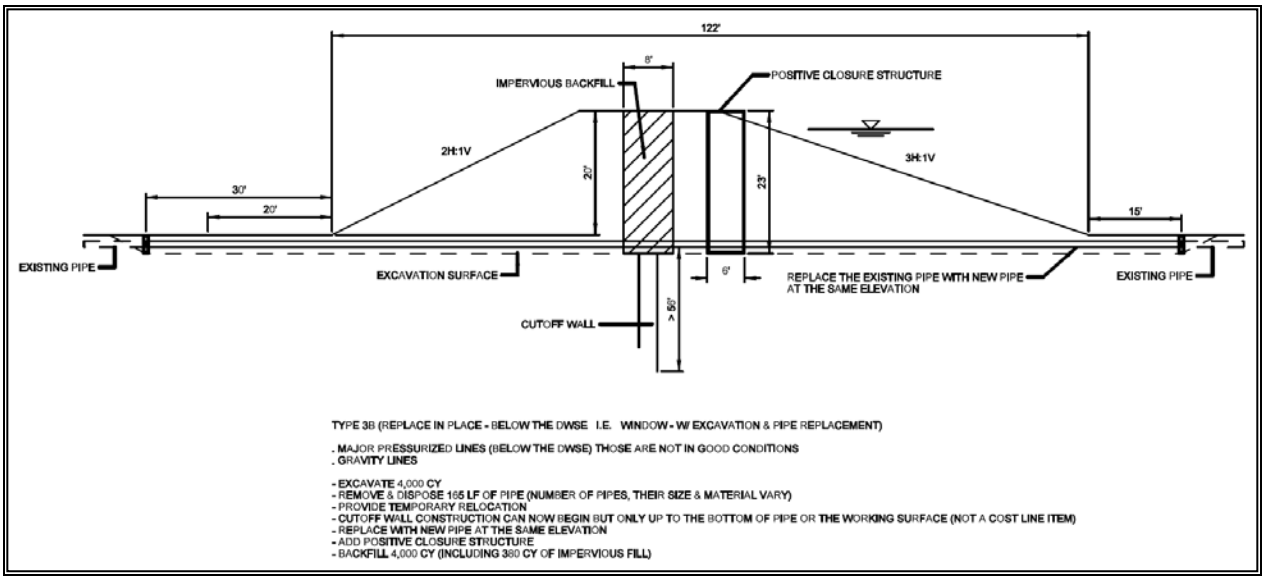


Figure 34A – Encroachment Type 3B – Section

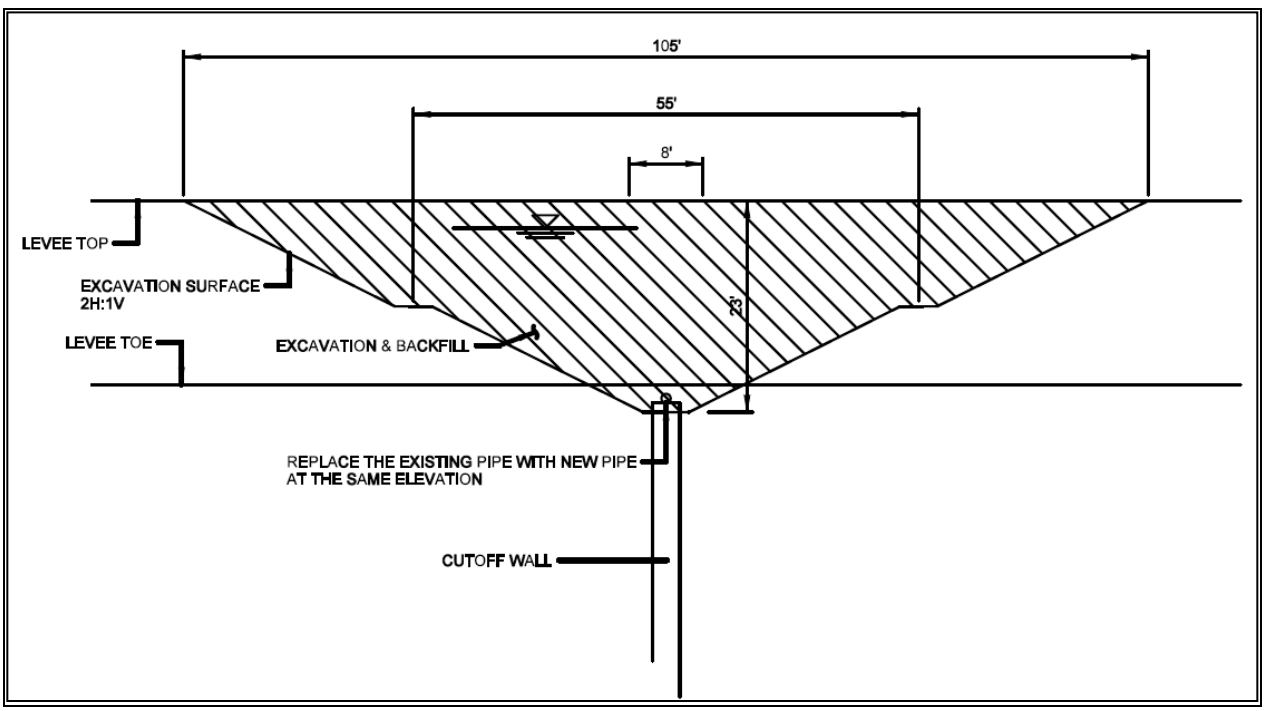


Figure 34B – Encroachment Type 3B – Profile

2.5.4 Type 4

This group includes utilities those are crossing the levee prism, dated and don't meet the current standard, include: (1) Communication conduits crossing the levee prism below the DWSE, and (2) Minor pressurized pipelines crossing the levee prism below the DWSE. These pipelines and conduits will be removed (before the cutoff wall construction begins) and replaced

and relocated above the DWSE (after the cutoff wall construction completes) with proper pipe materials and positive closure devices.

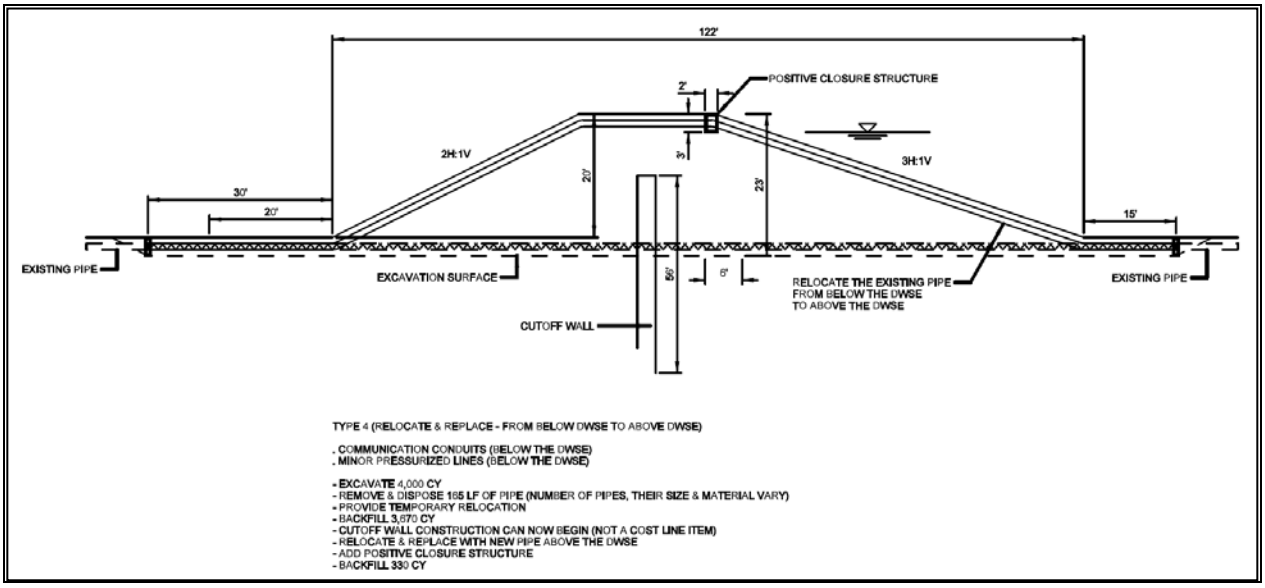


Figure 35A – Encroachment Type 4 – Section

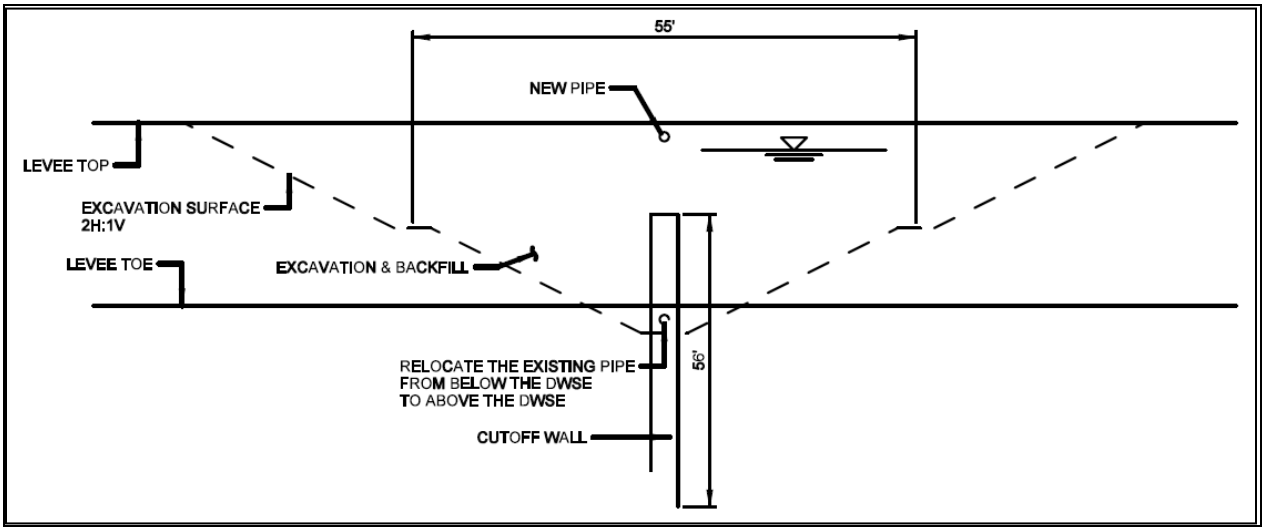


Figure 35B – Encroachment Type 4 – Profile

2.5.5 Type 5

This group includes bridges and railroads crossing the alignment of the existing levee. Deep Soil Mix (DSM) cutoff wall will be constructed at these locations.

2.5.6 Type 6

This group includes roads crossing the alignment of the new tall levee segments. Flood gate was initially considered as an option; however, because of the deep flood depth anticipated at these locations, these roads will be elevated up to the new top of levee.

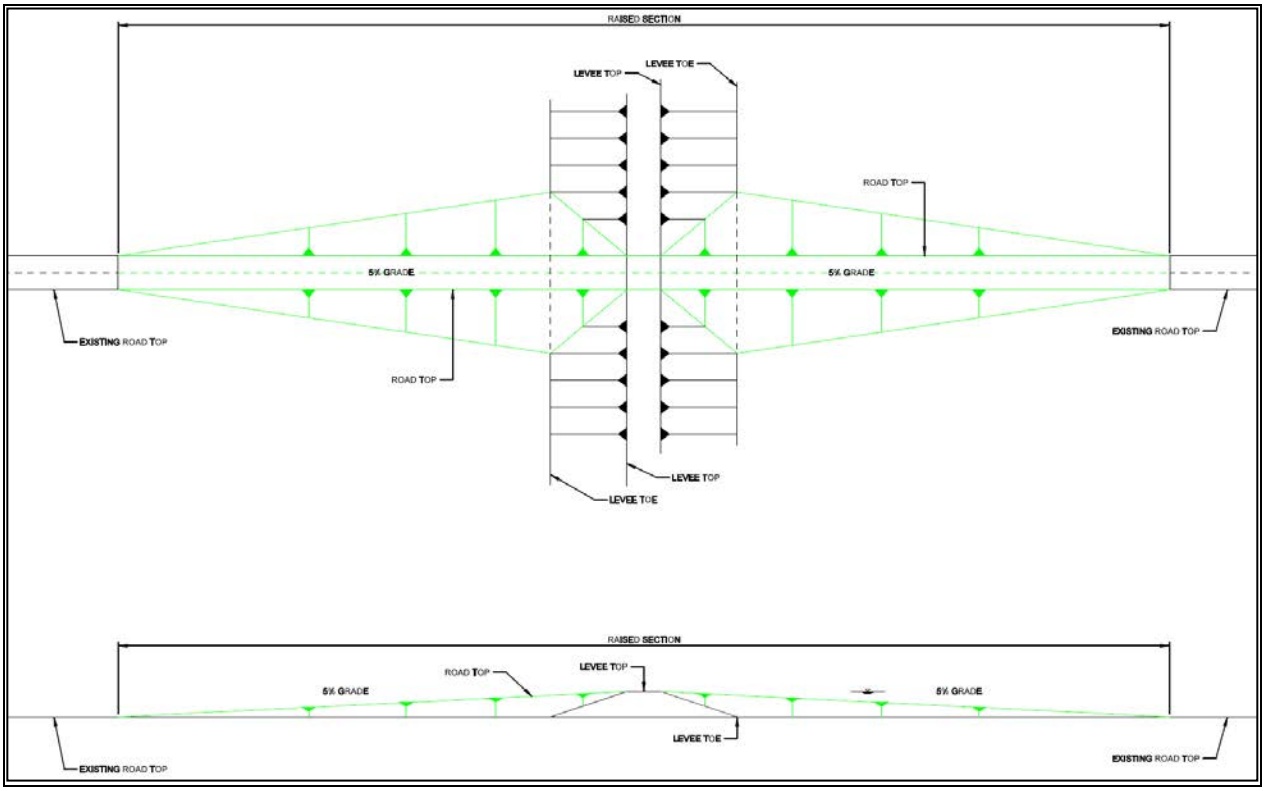


Figure 36 – Encroachment Type 6 – Plan and Section

2.5.7 Type 7

This group includes roads crossing the alignment of the new shallow levee segments. Because of the shallow flood depth anticipated at these locations, flood gate will be installed at these locations.

2.5.8 Type 8

This group includes canals crossing the alignment of the new levee segments. Relocation of these canals would result in high cost and impact. Therefore, the proposed remediation measure is to construct automatic closure structures at these canal crossings.

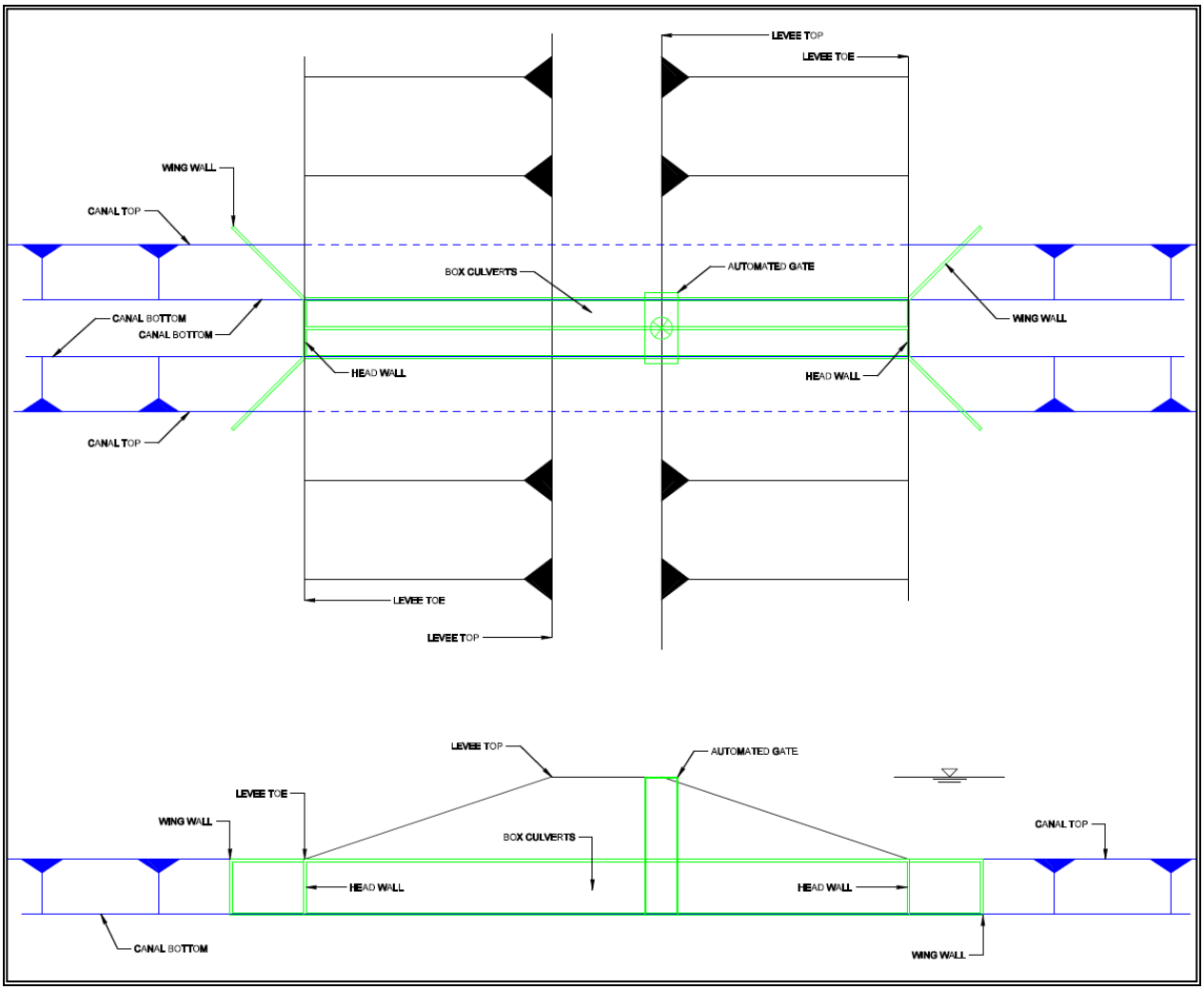


Figure 37 – Encroachment Type 8 – Plan and Section

2.5.9 Type 9

This group includes overhead power lines crossing the levee alignment. Temporary cutoff will be required to provide clearance for construction equipments where necessary. Power poles located within the proposed ROW will be relocated outside the proposed ROW, into a utility corridor.

2.5.10 Type 10

This group includes all physical structures (buildings, residential homes etc.) located within the proposed ROW of the existing and new levee segments. These structures will be relocated outside the proposed ROW.

2.5.11 Type 11

This group includes minor ditches and ponds located within the proposed ROW of the existing and new levee segments. These structures will be relocated outside the proposed ROW.

The Sutter Butte Main Canal (SBMC) falls within the proposed ROW at four locations along the FRWL alignment. Per Geotechnical Design recommendation, the SBMC encroachment was not specifically addressed during this phase of the study, however, captured as a part of the project's cost contingency during the Cost & Schedule Risk Analysis.

2.5.12 Type 12

This group includes overhead power poles, utility pipelines and conduit located within the proposed ROW. These utilities will be relocated outside the proposed ROW, into a utility corridor.

2.6 Real Estate Requirement

The general Land, Easements, Rights-of-way, Relocation and Disposal Areas (LERRD)'s requirements include land acquisitions for levee footprint, O&M roads, utility corridors, temporary work areas, borrow and mitigation areas. The LERRD's requirements also include the relocation of physical structures (buildings, residential homes etc.) currently encroaching into the ROW.

The land acquisitions for levee footprint and O&M roads are necessary for construction, operation and maintenance of project features. The levee's and O&M road's footprints were established based on the final levee geometry (shown in figure 2.10A to 2.29B) and based on the distributions of typical levee improvement measures (shown in table 2.5A and 2.5B). In the figure, the levee footprint is the base width from the landside toe to the waterside toe of levee/berm. The landside O&M road is a 20-foot corridor along the landside toe of the levee/berm. The waterside O&M road is a 15-foot O&M corridor along the waterside toe of the levee/berm.

Additional land acquisitions for utility corridors, temporary work areas, borrow and mitigation areas were considered but not specifically addressed during this phase, Phase 2, of the study. The utility corridor (approximately 20ft beyond the PRE for O&M roads) may be needed for relocation of utilities parallel to the project's alignment outside of the proposed ROW. Temporary work areas, borrow and mitigation areas are necessary for construction of the project features. These additional real estate requirements were not specifically identified and estimated as lump sum percentages of the total real estate requirements.

The number of physical structures to be relocated was estimated based on the ROW requirements (see paragraph 2.4.2).

2.7 Quantity Development

2.7.1 Levee and Cutoff Wall Constructions

The quantity estimates for levee and cutoff wall constructions (e.g. excavation and backfill, cutoff wall area etc.) were completed using the parametric approach. In this approach, the quantities were estimated as products of sectional area and length of different types of levee improvements. The sectional areas of levee improvements were based on the levee geometry shown in figure 2.10A to 2.29B. The lengths of the levee segment where a typical improvement measure applied were based on the distribution shown in table 2.5A and 2.5B. Refer to the URS Parametric Cost Estimating MII Toolbox for the quantity estimates for levee and cutoff wall constructions.

2.7.2 Improvements and Relocations of Encroachments

The quantity estimates for encroachments (type 1 through 12) are shown in enclosure 4, Encroachment Improvements & Estimates, based on the recommendations provided in paragraph 2.5.

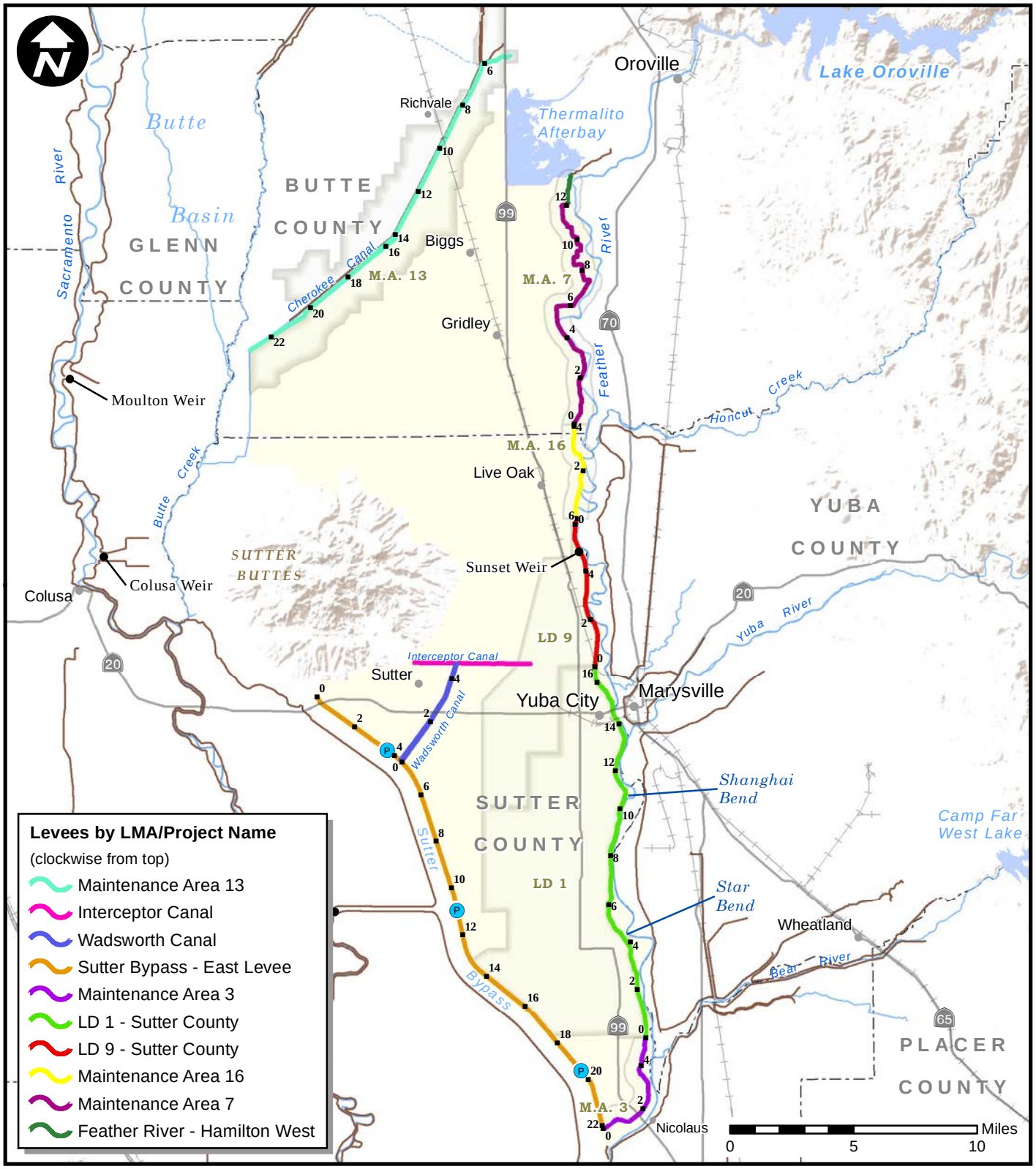
CHAPTER 3 – ALTERNATIVE DESCRIPTIONS

3.1 General

Based on table 2.3 and 2.5B, the project features included in each potential alternative will be as follows:

Table 3.1 – Draft Array of Potential Alternatives

Reach	SB1	SB2	SB3	SB4	SB5	SB6	SB7	SB8
Stability Berm								
Stability Berm with Relief Wells								
Seepage Berm								
Gravel Stability Berm		14,075	3,130	10,705	57,229	73,581	16,865	60,019
Waterside Soil-Bentonite Slurry Cutoff Wall								
Centerline Soil-Bentonite Slurry Cutoff Wall		58,325	15,650	38,375	142,517	282,108	79,250	163,442
New Levee			42,750	34,250				
New Levee w/ Centerline SB Slurry Cutoff Wall			32,250	20,750				
Levee Crest Widening		95,300	31,300	61,600	95,300	142,200	123,200	123,200



Legend

- Study Area Extent
- Levee Maintenance Agency
- Federal Levee
- Levee Mile
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

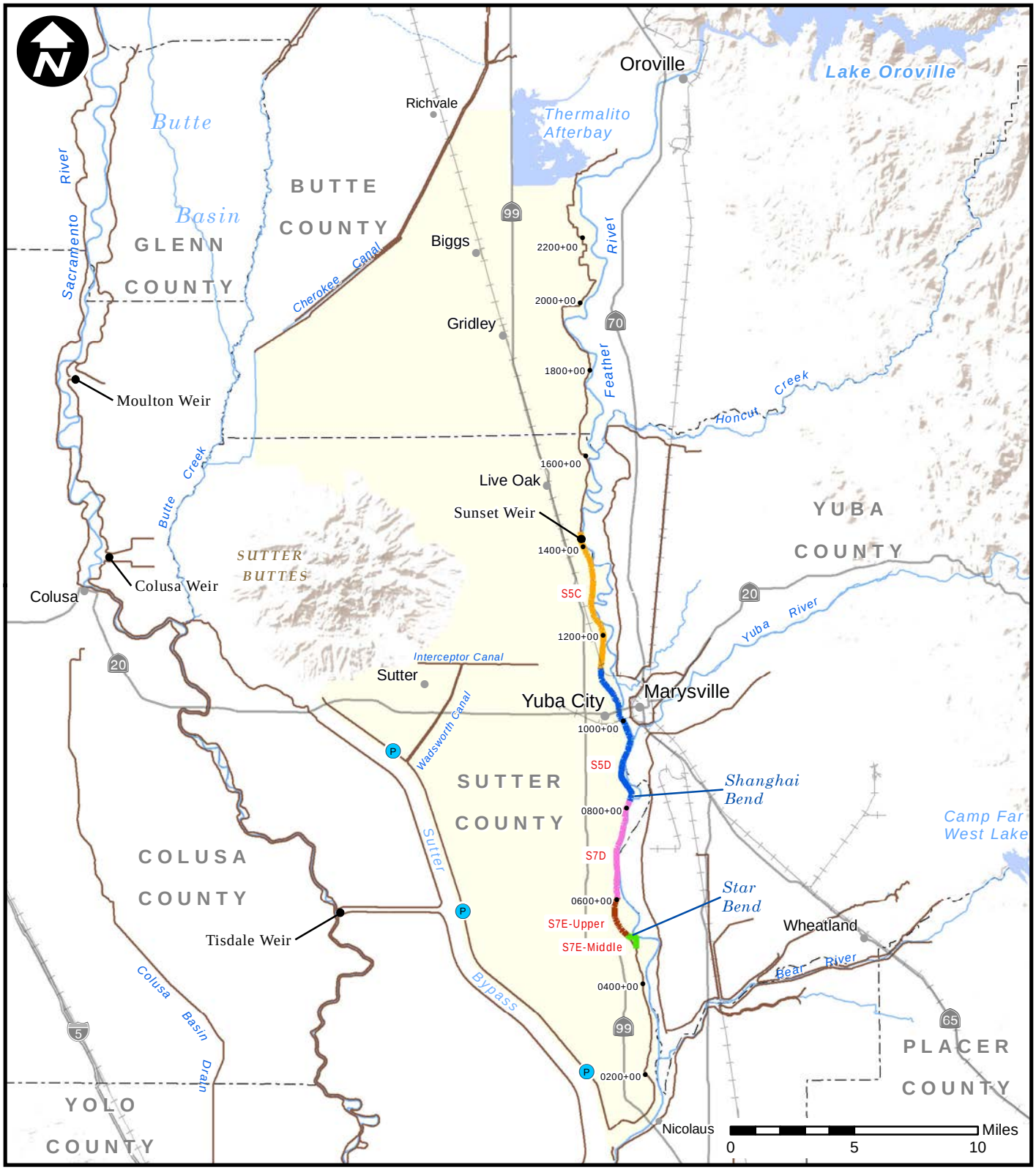
SUTTER BASIN PROJECT AREA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-1



Legend

- Study Area Extent
- Project Reach (S5B)
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

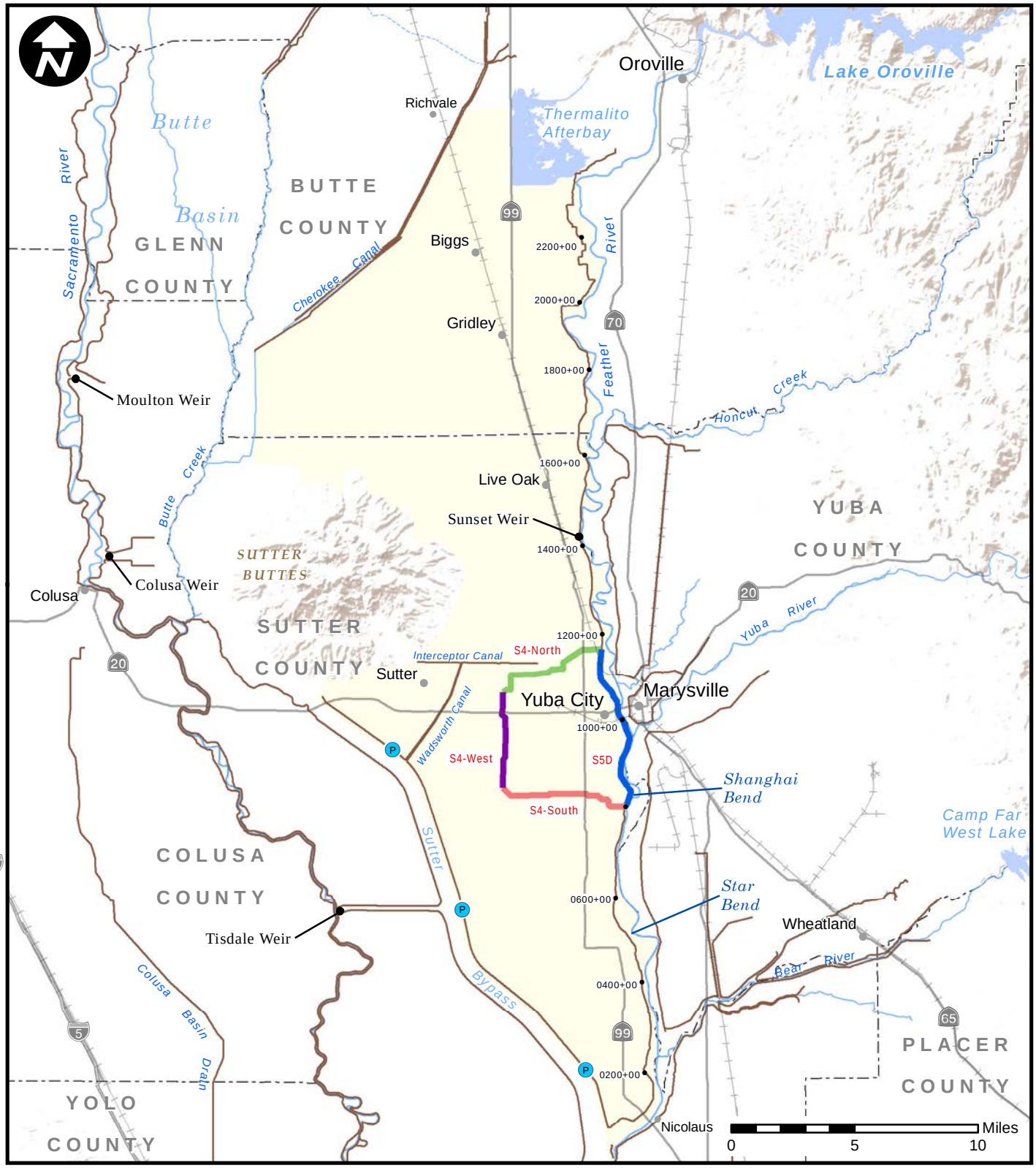
ALTERNATIVE SB-2: MINMAL FIX-IN-PLACE FEATHER RIVER LEVEES: SUNSET WEIR TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-2



Legend

- Study Area Extent
- S5B Project Reach
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

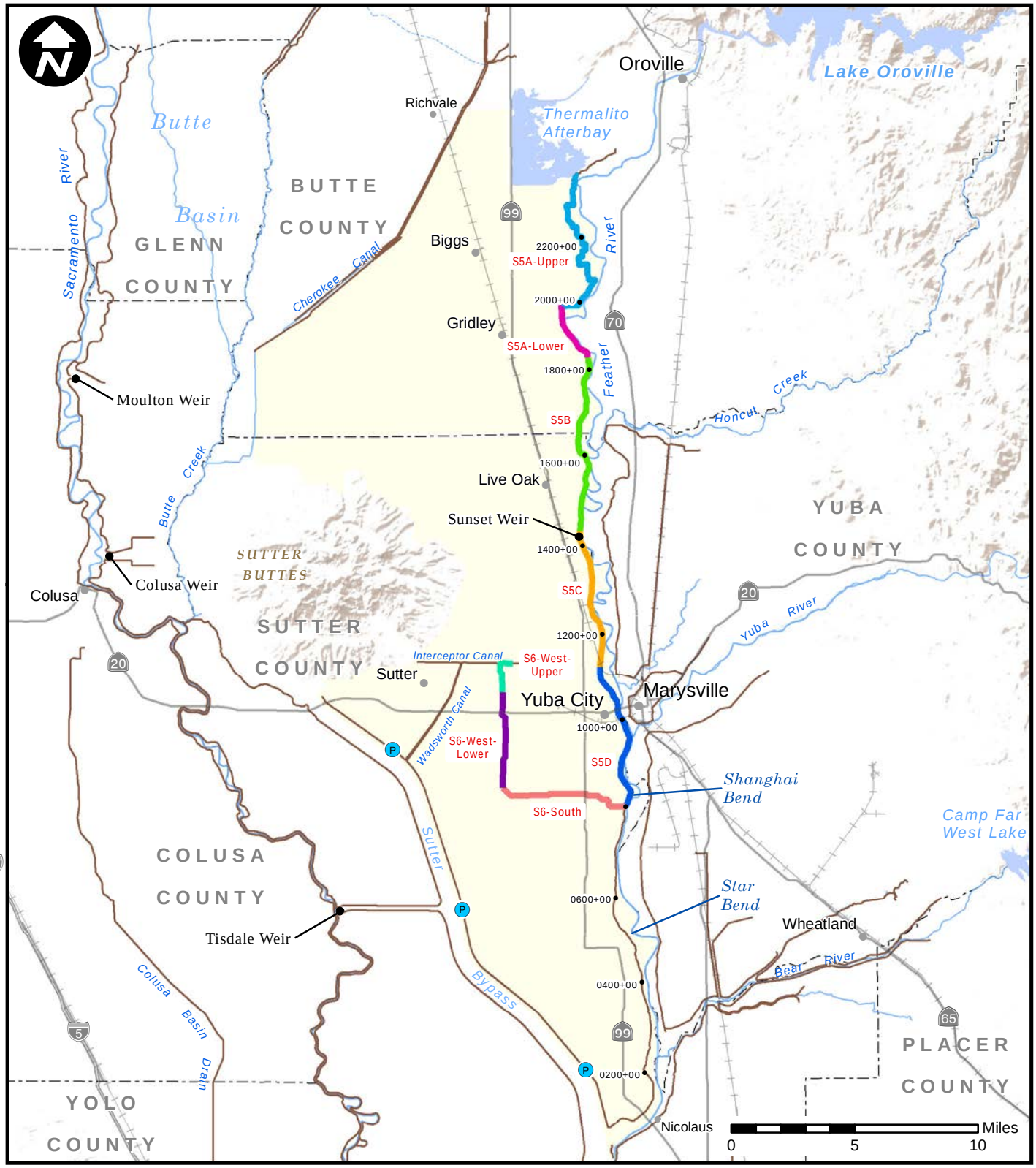
ALTERNATIVE SB-3: YUBA CITY RING LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-3



Legend

- Study Area Extent
- S5B Project Reach
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

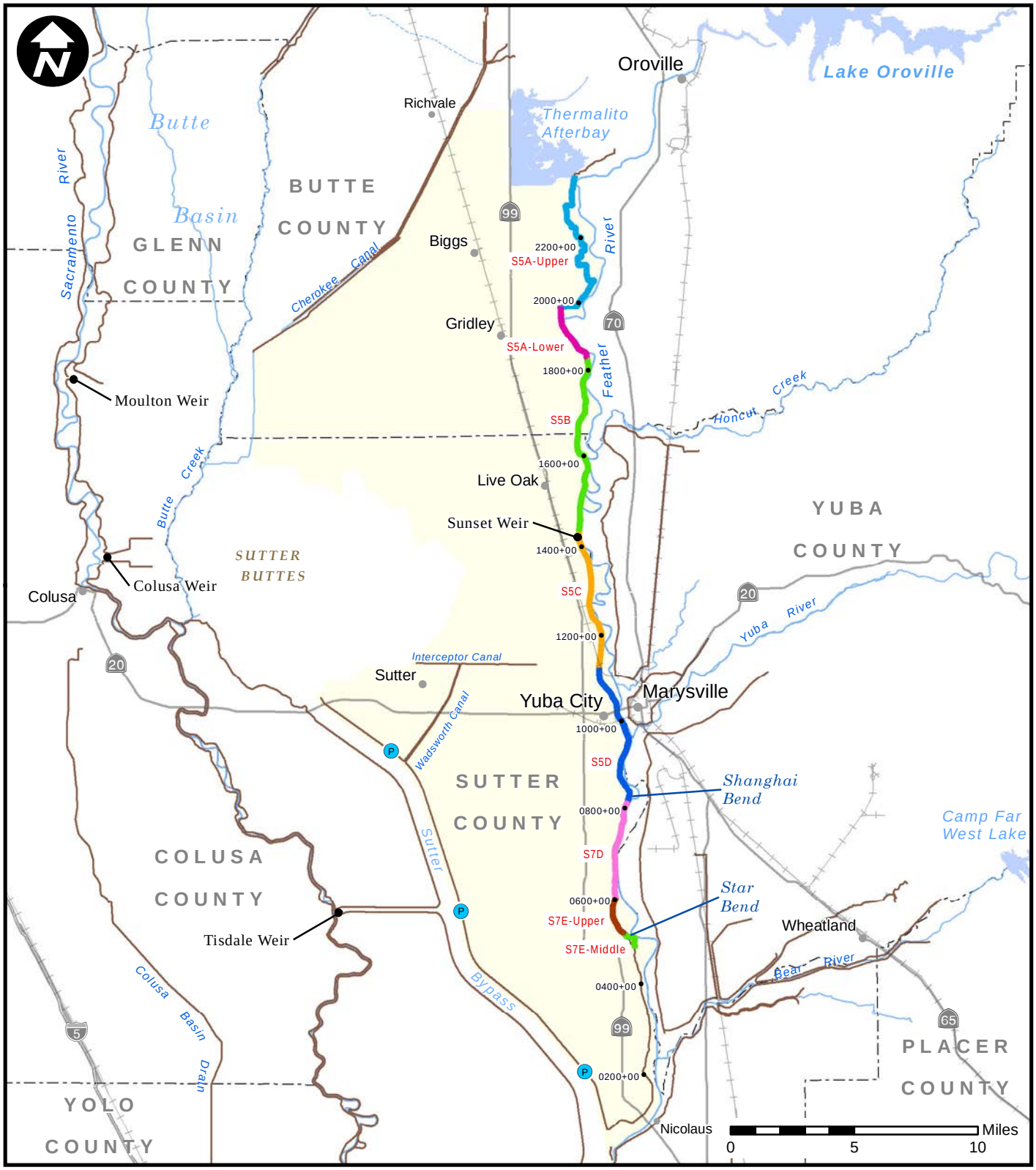
ALTERNATIVE SB-4: LITTLE J LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-4



Legend

- Study Area Extent
- S5B Project Reach
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

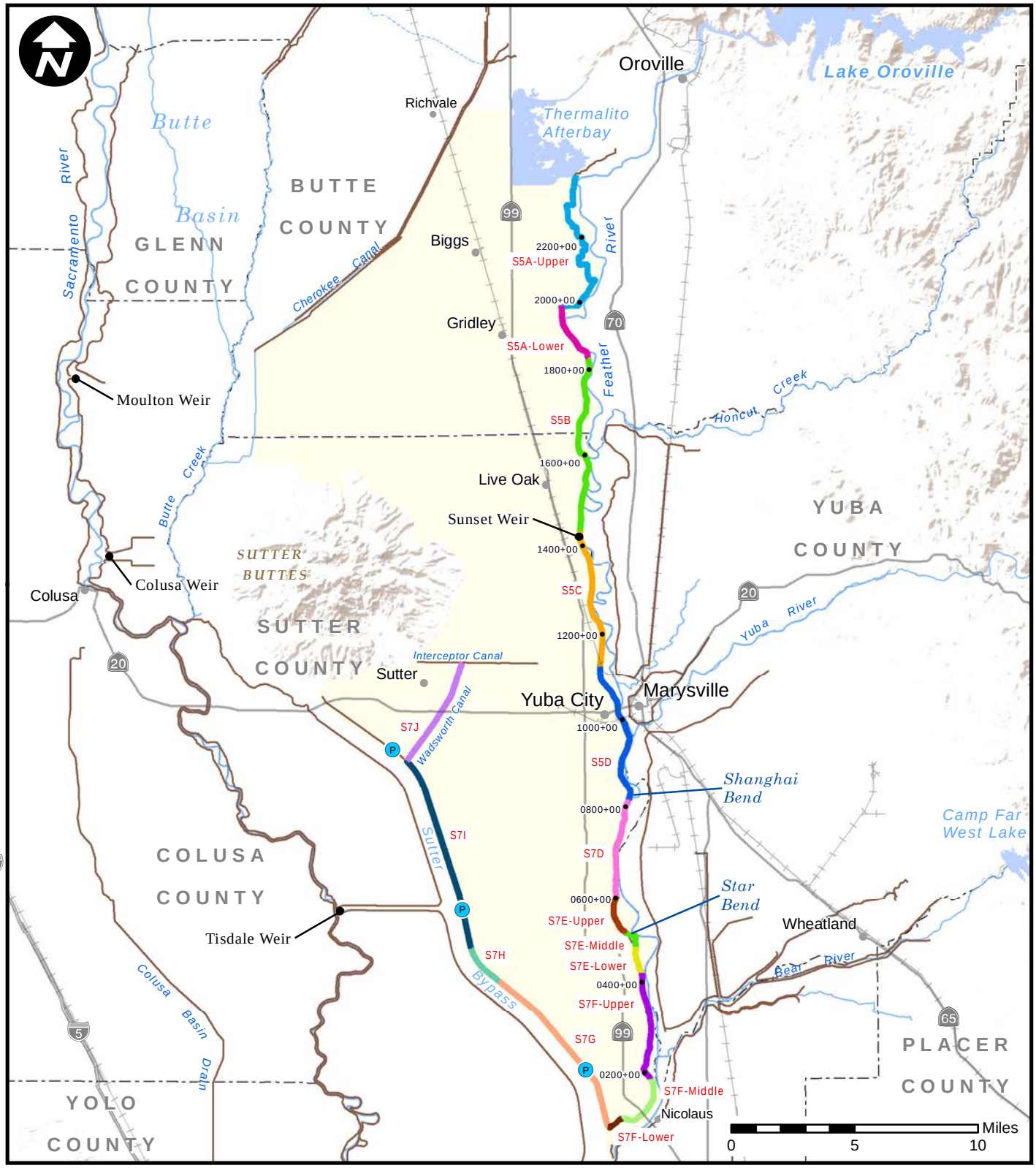
ALTERNATIVE SB-5: FIX-IN-PLACE FEATHER RIVER LEVEES: THERMAILTO TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-5



Legend

- Study Area Extent
- Project Reach (S5B)
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

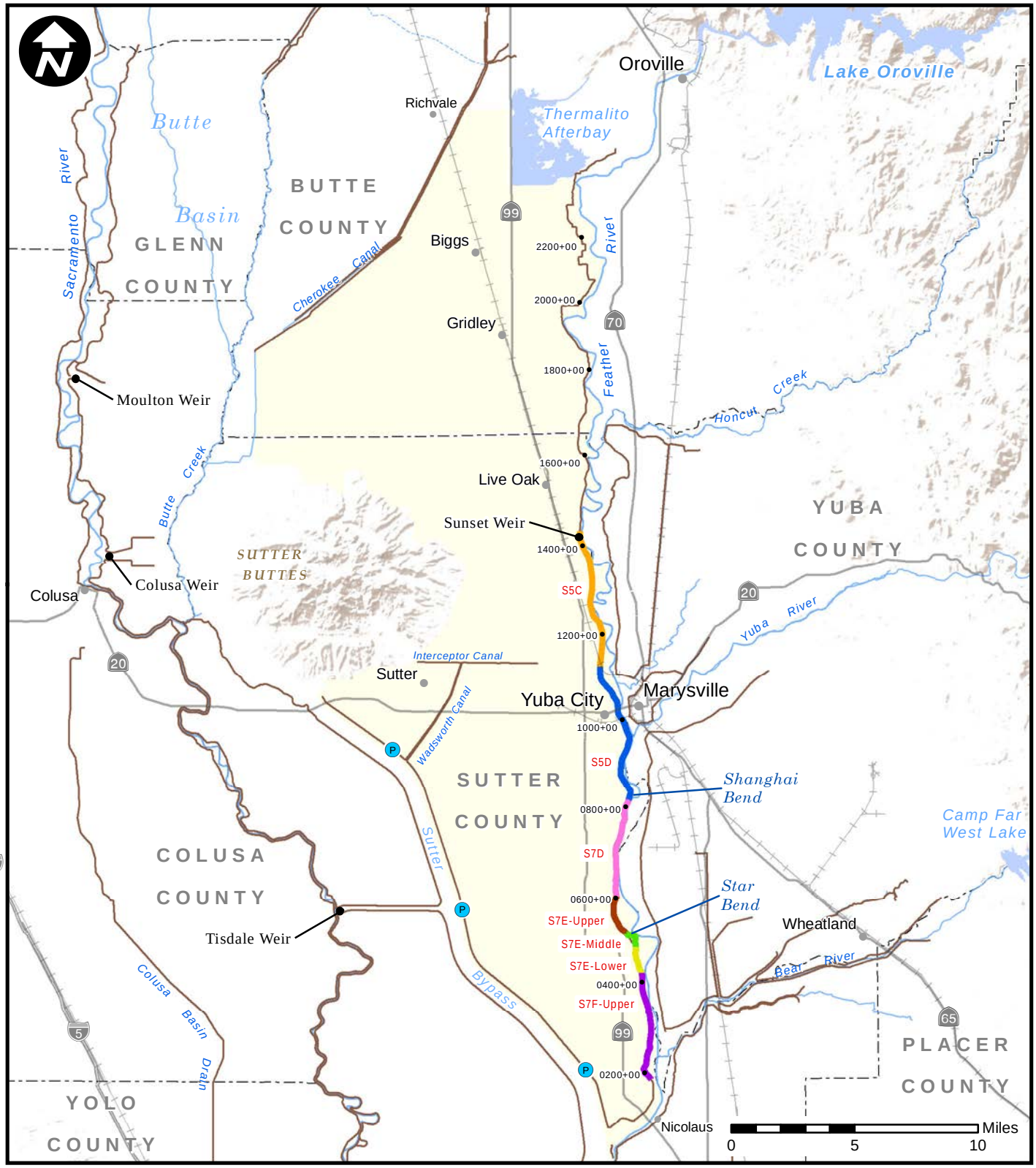
ALTERNATIVE SB-6: FIX-IN-PLACE FEATHER RIVER, SUTTER BYPASS, AND WADSWORTH CANAL LEVEES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-6



Legend

- Study Area Extent
- Project Reach (S5B)
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

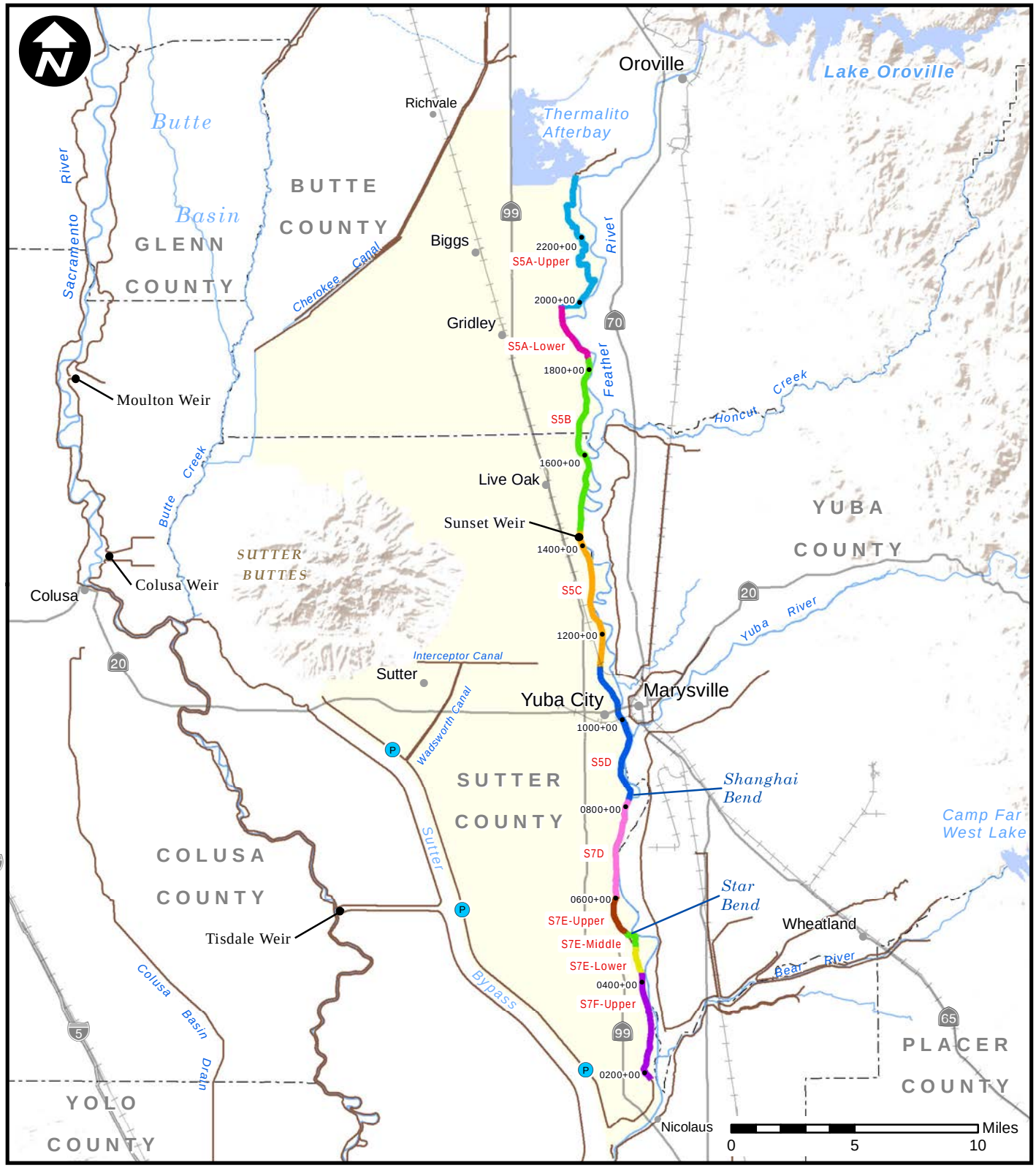
ALTERNATIVE SB-7: FIX-IN-PLACE FEATHER RIVER LEVEES: SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-7



Legend

- Study Area Extent
- S5B Project Reach
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-8: FIX-IN-PLACE FEATHER RIVER LEVEES: THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-8

SUTTER BASIN FEASIBILITY STUDY
SUTTER AND BUTTE COUNTIES

CIVIL DESIGN APPENDIX
ENCLOSURE 1
EVALUATION of PRELIMINARY of CONCEPTUAL ALTERNATIVES

Prepared by

U.S. Army Corps of Engineers
Sacramento District, Civil Design Section A

November 2011

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CHAPTER 2 – ANALYSIS of CONCEPTUAL ALTERNATIVES

2.1 Utility, Physical Obstruction and Land Acquisition Assessments
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ACRONYMS

REFERENCES

USACE EM 1110-2-1913, “Design and Construction of Levees”, 30 April 2000
CESPK-ED-G, SOP-EDG-03 “Geotechnical Levee Practice”, 11 April 2008

CHAPTER 1 – INTRODUCTION

For the purpose of developing preliminary cost estimates for each of the structural measures (S1 through S12 and S24), Civil Design was tasked to provide inputs to the U.R.S' parametric cost estimate. The primary responsibilities were to prepare initial assessments of and to provide recommendations for all existing and potential/new utility crossings and physical obstructions along the existing and proposed/new lines of protection. Civil Design was also tasked to work with the Technical Lead and the Geotechnical Design Lead to identify the common reaches/incremental cost segments, develop new stationing systems and estimate potential land acquisitions along these alignments. In addition, Civil Design was tasked with consolidating the recommendations from Hydrology, Geotechnical and Hydraulic Design.

CHAPTER 2 – ANALYSIS of CONCEPTUAL ALTERANTIVES

2.1 Utility, Physical Obstruction and Land Acquisition Assessments

The initial assessments of utility encroachments, physical obstructions and land acquisitions were carried out either by visual inspection of the aerial images along the alignments or by utilizing available information while corrected actions were recommended in the forms of typical conceptual designs. The assessment of all existing utility crossings (pipelines, conduits, culverts…) along the existing levees/lines of protection was done by extracting prudent information from the levee logs recently completed by the Department of Water Resource (D.W.R.). The results of the preliminary assessment were classified into groups of features with common characteristics and a typical conceptual design (gated concrete encasements around all penetrations) with different sizes was assigned to each group. As the utility information (pipelines, conduits, culverts…) along the proposed/new lines of protections was not available at the time of this assessment and because of the time constraint, the cost associated with potential utility relocations along the proposed/new lines of protection were estimated to be 15% of the total construction cost (consistent with the estimates for the local sponsor's Early Implementation Project and for the Corps' rural fix-in-place segments) except the Sutter Bypass' setback levee options (S9) for which the estimates were increased to 25% of the total project cost due to potential relocation of the major power line running along the alignment of the Sutter Bypass' east levee. The assessment of physical obstructions (road and canal/ditch crossings) along the existing and proposed lines of protection was completed by visual inspection of the aerial images along these alignments. Similar to the utility crossings, the results of the assessment for physical obstructions were classified into groups of features with common characteristics and typical conceptual designs (raising, flood gates, bridges, closure structures…) with different sizes was assigned to each group. As a result of the coordination among PDT members, Civil Design only provided the recommendations for potential corrected actions; however, details of the typical conceptual designs were developed by the Cost Engineer using similar projects previously done. For Real Estate related items, the potential land acquisitions for different land use categories (designated as orchard, agricultural, residential and commercial) were estimated for each of the segments/reaches as percentages of the lengths of these segments/reaches as they cross the the four different land use categories. Because of the time constraint, the estimate was also completed by visual inspection of aerial images along the alignments of the proposed/new lines of protection.

2.2 Alignments of Measures and Stationing Systems

The new stationing system includes three subsystems: The Feather River – West Levee, The Sutter Bypass East Levee and the Wadsworth Canal East Levee. The Sutter Bypass East Levee and the Wadsworth Canal East Levee alignments and stationing systems were developed based on the surveyed points/vertices from the National Levee Data Base. The Feather River – West Levee alignment and stationing system was adopted from the local sponsor's Early Implementation Project's for easier referencing. Civil Design did not prepare but reviewed the alignments for other measures (e.g. ring levees, setback sections, bypass…) and it appears that additional refinements/adjustments need to be made during the next phase to reflect more appropriate locations/footprints of these features though acknowledging that these alignments are reasonable for the purpose of the preliminary screening process.

2.3 Common Reaches/Incremental Cost Segments & Consolidated Recommendations

Civil Design was tasked to work with the Technical Lead and the Geotechnical Design Lead to identify the common reaches/incremental cost segments along the lines of protection and to provide the consolidated recommendations (from all accountable disciplines) for each of these reaches. The extent of each reach was identified by nodes that are either the end points of the geotechnical reaches or the junction of different measures. The recommendations (for utility encroachments, physical obstructions, pump stations, levee fixes and levee configurations from Civil Design, Hydrology, Hydraulic and Geotechnical Design) for each of the reaches were consolidated into one spreadsheet and provided to Cost Engineering for preparation of the cost estimates for each of the reaches and alternatives.

SUTTER BASIN FEASIBILITY STUDY
SUTTER AND BUTTE COUNTIES

CIVIL DESIGN APPENDIX
ENCLOSURE 2
EIP REVIEW & INCORPORATION

Prepared by

U.S. Army Corps of Engineers
Sacramento District, Civil Design Section A

February 2013

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- Table 1 Recommendations for Rehabilitation Measures (based on the 65% EIP with design modifications made by the COE).

ENCLOSURES

RELATED STUDIES AND REPORTS

- Technical Memorandum 26 - Sutter Butte Main Canal Encroachment
- Technical Memorandum 11 – Vegetation ETL Compliance

ACRONYMS

CCEL Cherokee Canal East Levee (Left Levee)

EIP Early Implementation Project (local sponsor's Plan)
FRWL Feather River West Levee (Right Levee)
MEIP Modified EIP (COE's modifications to the EIP)
O&M Operation and Maintenance
ROW Right of Way
SBEL Sutter Bypass East Levee (Left Levee)
SBLS Sutter Basin Levee System
WCEL Wadsworth Canal East Levee (Left Levee)
WCWL Wadsworth Canal West Levee (Right Levee)

REFERENCES

USACE EM 1110-2-1913, "Design and Construction of Levees", 30 April 2000
CESPK-ED-G, SOP-EDG-03 "Geotechnical Levee Practice", 11 April 2008

CHAPTER 1 – ANALYSIS of FINAL ALTERANTIVES

1.1 General

This report is an extension of paragraph 2.5 of the Engineering Appendix. The purpose of this report is to provide additional background information for the designs, evaluations and estimates for the final two alternatives, SB7 and SB8.

1.2 Review & Incorporation of the 65% EIP

1.2.1 General

The local sponsor had already completed a 65% design Early Implementation Project (EIP) at the time the COE began Phase 3 (evaluation of the final alternatives) of this Feasibility Study. The COE, therefore, reviewed and adopted most of the features proposed in the 65% EIP (with moderate revisions and additional remediation measures imposed on the 65% EIP to meet the USACE design criteria) for the final two alternatives SB7 and SB8. This is because the 65% EIP includes the reaches of alternatives SB7 and SB8 and because the features proposed in the 65% EIP meet the COE's design criteria.

This following paragraphs summarize the review and incorporation of the 65% EIP's designs and estimates into the final two alternatives SB7 and SB8. For the purpose of this report, MEIP is the modified EIP. MEIP is equivalent with alternative SB8.

1.2.2 Alignment and Stationing

The local sponsor's design team (HDR Inc.) developed the FRWL EIP alignment and stationing during the PFR development. The levee alignment follows the existing levee centerline of the FRWL except at Star Bend where the levee alignment follows the centerline of the setback levee. The stationing begins with station 10+00 at the confluence of the FRWL at the SBEL and increases in an upstream (North) direction. This levee stationing conforms to the

existing levee centerline and accounts for recent changes in the alignment, such as the Star Bend Setback Levee (between station 478+68 and station 512+00). The EIP stationing was adopted into the COE's preliminary and final designs and analyses. For the final two alternatives SB7 and SB8/MEIP, at locations where modifications of the EIP were determined by the COE (e.g. levee relocations roughly between station 1432+70 and station 1754+30 etc.), the COE designated the new conceptual levee alignments and the local sponsor's design team (PBI Inc.) helped establishing supplementary levee stationing necessary for designs and analyses.

1.2.3 Levee Reaches

The final two alternatives SB7 and SB8/MEIP are defined by 41 reaches starting from station 180+00 and ending at station 2368+00. These reaches are summarized in table XX. The vast majority of these reaches (2B through 41) came from the EIP except for reach 2A-North. Reach 2A-North is a subset of reach 2 of the 30% EIP. This reach was added in the MEIP to define the additional design features recommended by the COE for the final two alternatives.

1.2.4 Datum

The EIP used North American Datum of 1983 (NAD 83) State Plane California Coordinate System Zone II (U.S. Survey Feet) for horizontal control. The North American Vertical Datum of 1988 (NAVD 88) was used as vertical datum.

1.2.5 Topographic Data

The EIP employed LiDAR-based topographic information obtained from two sources, DWR's Central Valley Floodplain Evaluation and Delineation (CVFED) Program and Urban Levee Evaluation Program, to support its analyses and designs including hydraulic and geotechnical evaluations, site layouts and quantity estimates. The local sponsor's design team (Wood Rogers Inc.) also completed land survey to confirm the LiDAR topographic data. Results show that cross section profiles based on CVFED and ULE Program's LiDAR-based topographic data are comparable with land surveyed elevations.

1.2.6 Bathymetric Data

Bathymetry of the Feather River was obtained from a bathymetry survey performed by USACE during the 2002 Sacramento and San Joaquin Basins Comprehensive Study at a contour interval of 2 feet. The 2002 surveyed elevations were based on the National Geodetic Vertical Datum of 1929 (NGVD 29). The surveyed data was converted to the North American Vertical Datum of 1988 (NAVD 88) by PBI Inc. and also by HJW Inc. in 2010. The 2010 converted bathymetry was used in the COE's preliminary study and the EIP's geotechnical analyses and designs. Enclosures XX from PBI Inc. and XX from HJW Inc. documented the data conversion.

1.2.7 General Levee Design and ROW Requirements

Most of the proposed levee improvements in the EIP conform to the design criteria stated in the COE's guidance (the USACE EM 1110-2-1913 and the CESPK-ED-G, SOP-EDG-03)

except for the ROW requirements. The EIP does not provide sufficient O&M corridors at some locations, such as the areas where the Sutter Butte Main Canal is approaching the existing FRWL. The COE, therefore, imposed a 15ft landside easement and 15ft waterside easement in the MEIP to obtain O&M corridors in accordance with the CESPK-ED-G, SOP-EDG-03. (The CESPK-ED-G, SOP-EDG-03 currently requires a minimum 20ft landside easement; however, this obligation will be revised by the Sacramento District to require a minimum 15ft landside easement only, according to the Sacramento District's Levee Safety Program Manager, Marry Perlea. Also, the revised requirement will be mandated consistently for all future projects.)

As a result of this requirement, in the MEIP, the COE proposed relocating some segments of the existing FRWL toward the Feather River. Where it is impractical to relocate the existing FRWL (e.g. at major pump stations or where the levee is too close to the main channel), the Sutter Butte Main Canal will be relocated toward the landside. The relocations are necessary to provide sufficient space for maintenance and flood fighting purposes along the landside toe of the levee/berm. Relocating the FRWL was identified as the primary alternative for addressing the insufficient O&M issues because it is more cost effective and has fewer impacts compared to relocating the canal. Enclosure XX documented the analyses and designs for these relocations.

The primary feature of the EIP and MEIP is cutoff wall. The cutoff wall construction requires reconstruction of the excavated levee embankment. The EIP requires the reconstructed embankment to match the existing levee prism. The existing levee prisms of the FRWL appears to be overbuilt as compared to the hypothetical minimum levee prism geometries identified in the CESPK-ED-G, SOP-EDG-03 (SOP3). The COE adopted the EIP's embankment reconstruction proposal because the reconstructed embankment conforms to the standard levee geometries for rehabilitation of existing levees as required by the SOP3. The hypothetical minimum levee geometries from four sources (USACE EM 1110-2-1913, DWR Urban Levee Design Criteria, and the Code of California Regulations (CCR) Title 23 Division 1) are shown on figure XX. The final recommended levee prism is concluded in paragraph 2.4, geotechnical design considerations. The requirements are for a crest width of 15 feet minimum, landside slope of 2H:1V or flatter, waterside slope of 3H:1V or flatter, 15 feet minimum easement along the proposed toe of levee/berm.

1.2.8 Encroachments

The local sponsor's design team (MHM Inc.) prepared a complete inventory of all utilities and encroachments along the FRWL for the 65% EIP. The list shows numerous pipelines (both gravity and pressurized lines) crossing the existing FRWL embankment. The study also indicated a number of structures (residential homes, public buildings etc.) and utilities parallel to the existing levee (power poles, irrigation ditches, pipelines etc.) currently located within the right-of-way (ROW) proposed by the COE. Some of these structures and utilities encroach into the existing embankment.

MHM Inc. classified the inventory and developed typical improvement plans. In general, most of the pipelines crossing the existing levee embankment are dated and don't meet the current standard. These pipelines, therefore, will be removed (before the cutoff wall construction begins) and replaced (after the cutoff wall construction completes) with proper pipe material. Gravity lines will remain at the existing invert elevation. Pressurized lines will be relocated

above the 1957 WSEL profile or 200-year WSEL profile north of station 461+00, whichever is greater and above the 1957 WSEL profile or 100-yr WSEL profile south of station 461+00, which ever greater. Where it is not feasible to relocate the pressurized pipelines above the WSEL intended, the pipelines will remain at the existing invert elevation. All pipe crossings will be modified to include positive closure devices. All abandoned pipelines will be removed. All structures and utilities parallel to the existing levee and located within the COE's proposed ROW will be relocated outside the ROW. The utility improvements will not affect interior drainage because the cutoff wall will be constructed within normal construction season (April through October) during which the gravity storm drains won't be needed. Temporary bypass systems will be provided to keep irrigation and other utilities in service during the farming season.

The COE reviewed and approved most of the improvement plans proposed in the EIP because they meet the USACE design criteria for addressing utilities and encroachments stated in the EM 1110-2-1913, except for the structures located within the COE's proposed ROW. The EIP allows variance that let these structures remain within its ROW. The COE, therefore, modified the EIP to assure the MEIP meets the USACE design criteria in accordance with EM 1110-2-1913. The modifications include demolitions and relocations of all structures located within the COE's proposed ROW. The WPC assumes the local authorities comply with the OMRR&R requirements. Table XX provide detailed descriptions of all utilities, encroachments and the proposed improvement for each site.

Vegetation on levee is another discrepancy between the MEIP and EIP. The FRWL currently has mature trees on the both the levee slopes and within 15 feet of both the landside and waterside levee toes, with the majority of the trees being within 15 feet of the toes. The EIP allows the vegetations to temporarily remain within its ROW and proposed an adaptive management approach that will address this issue overtime. The COE, in the MEIP, requires the O&M corridors and embankment will be free of vegetations to meet the Vegetation Free Zone (VFZ) requirement in accordance with the USACE ETL 1110-2-571 (except for grass which will remain for providing protection against slope erosion). Enclosure XX documented the analyses and final recommendations for addressing this issue. There were two options considered by the COE to address the vegetation issues before one was selected over another. The first option was to recommend complete compliance with the ETL by removal of all vegetations within the VFZ. The second option was to recommend removal of all vegetations in the upper 2/3 of the waterside levee slope, the entire landside slope, within 15 feet of the landside toe and obtaining a vegetation variance for trees in the lower 1/3 of the waterside slope and within 15 feet of the waterside toe. The estimated cost of ETL 1110-2-571 compliance by both methods appeared to be within the overall feasibility study cost contingency. Therefore, the first option, complete compliance with the ETL 1110-2-571, was the final recommendation.

1.2.9 Quantity Estimates

- SBFCA's 65% EIP's plan drawings and quantity take-offs (QTO) – with addendum 1&2 included

- Wood Rogers (EIP Reaches 2A -18)

- HDR (EIP Reaches 19-41)

Initial review: Getting familiar with the products (plan drawings and QTO spreadsheets) to get used to the features proposed on the plan and the formulas used in the QTO spreadsheets. A complete review for a select a number of representative reaches (10% - 15% of the total number of reaches). The logics of the formulas used were verified based on construction sequence. The logics of the inputs were verified based on the plan's specifications (for the proposed features and their geometries). When there are major discrepancies between the inputs and the plan's specifications, responsible SBFCA's AE (Wood Rogers or HDR) were contacted to provide clarification to the issues and/or to update the QTO spreadsheet if necessary. If the discrepancies are determined to be minor (less 5% difference), the items were classified as reasonable and were not communicated for revision. The revised products went through another route of review the process repeated until the products were determined reasonable.

Coordination & Revision: Any discrepancies greater than 5% of the expected values were communicated with the responsible SBFCA's AE for clarifications and/or for updating the products. There were numerous discussions with HDR to resolve the issues with their QTO estimates for EIP reaches 19 – 41.

Final Review & Analysis: Because of the time constraint and a numerous number of discrepancies, not all of the issues with the products, specifically the 65% EIP's QTO, were resolved. In addition, the discrepancies resulted in higher values for some line items and lower values for other line items within each reach making it difficult to determine whether or not the impacts to the final results are significant or omissible. Therefore, instead of pursuing for a complete product (with all of the discrepancies and errors corrected), an alternative approach was employed to evaluate the reasonableness of the products. In this approach, a final review was completed for the partially corrected products. The review involved detailed analysis for each of the major line items (e.g. cutoff wall quantities, levee fills, borrows etc.) to determine if the outputs (total) are reasonable. The output of each line item was classified as reasonable if the difference is less than 1% of the expected project cost. In this case, the problematic inputs were found to be minor and, therefore, left uncorrected and unjustified. All analyses were documented for future references.

Wood Rogers's QTO: No major discrepancies were found.

HDR's QTO: Missing drawings, dated QTO spreadsheet was provided, some inappropriate formulas were used, some geometric inputs were inconsistent with the plan drawings, missing line items and double counted quantities.

1.3 Summary of Project Features

The following table summarizes project features for 41 reaches (2A-North, 2B, 3… 41) along the alignment of the FRWL.

Table 1 Recommendations for Rehabilitation Measures (based on the 65% EIP with design modifications made by the COE).

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
2A North	180+00 to 202+50	2,250	Cutoff wall with undrained seepage berm	180+00 to 202+50: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 180+00 to 202+50: Cutoff wall extending to an elevation of 25 ft.	65% EIP: Project ends at station 180+00. COE proposal: Continue the cutoff wall and seepage berm proposed for reach 2B (STA. 202+50 to STA. 218+66) in the 65% EIP to reach 2A (STA. 180+00 to STA. 202+50).
2B	202+50 to 218+66	1,616	Cutoff wall with undrained seepage berm	180+00 to 218+66: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 202+50 to 218+66: Cutoff wall extending to an elevation of 25 ft.	
3	218+66 to 300+66	8,200	Cutoff wall Cutoff wall with undrained seepage berm	218+66 to 231+00: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 218+66 to 230+00: Cutoff wall extending to an elevation of 25 ft. with 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 230+00 to 250+00: Cutoff wall extending to an elevation of -35 ft. 250+00 to 289+00: Cutoff wall extending to an elevation of -20 ft. 289+00 to 300+66: Cutoff wall extending to an elevation of -12 ft.	
4	300+66 to 410+67	11,001	Cutoff wall	300+66 to 312+00: Cutoff wall extending to an elevation of -12 ft. 312+00 to 349+00: Cutoff wall extending to an elevation of 15 ft. 349+00 to 368+00: Cutoff wall extending to an elevation of 10 ft. 368+00 to 410+67: Cutoff wall extending to an elevation of 20 ft.	
5	410+67 to 478+68	6,801	Cutoff wall Cutoff wall with undrained seepage berm	453+00 to 478+00: 300 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 410+67 to 417+00: Cutoff wall extending to an elevation of 20 ft. 417+00 to 425+00: Cutoff wall extending to an elevation of 10 ft. 425+00 to 456+00: Cutoff wall extending to an elevation of 15 ft. 456+00 to 475+35: Cutoff wall extending to an elevation of 15 ft. 475+35 to 478+68: Cutoff wall extending to an elevation of 15 ft.	65% EIP: Do nothing between station 475+35 and station 478+68 because Star Bend setback levee has been built and extent into this area. COE Proposal: Construct cutoff wall between station 475+35 and station 478+68 assuming Star Bend setback levee has not been built yet.
6 FIP	478+68 to 512+00	3,332	Cutoff wall	478+68 to 512+00: 65ft deep (from degrade line) cutoff wall.	65% EIP: Do nothing because Star Bend setback has been built. COE Proposal: Fix in-place the existing levee with a 65ft deep cutoff wall assuming the Star Bend setback levee has not been built yet. This option is recommended by the COE.

Table 1 Recommendations for Rehabilitation Measures (based on the 65% EIP with design modifications made by the COE).

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
6 SB	478+68 to 512+00	3,332	Setback levee with cutoff wall	478+68 to 512+00: Remove the existing levee and construct a setback levee with 65ft deep (from degrade line) cutoff wall.	65% EIP: Do nothing because Star Bend setback has been built. COE Proposal: Setback the existing levee with a 65ft deep cutoff wall assuming the Star Bend setback levee has not been built yet. This option is the Local Sponsor's preference.
7	512+00 to 596+00	8,563	Cutoff wall Cutoff wall with relief wells Erosion Protection	512+00 to 514+00: 65ft deep (from degrade line) cutoff wall. 514+00 to 526+00: Cutoff wall tip elevation +15 feet 526+00 to 570+00: Cutoff wall tip elevation -5 feet 545+00 to 570+00: Relief wells with 60 feet spacing and 50 feet depth over one half of the length, distributed at various locations over this stretch of levee 570+00 to 575+00: Cutoff wall tip elevation -5 feet 575+00 to 595+00: Cutoff wall tip elevation -10 feet 595+00 to 596+00: Cutoff wall tip elevation +15 feet 547+00 to 596+00: High Performance Turf Reinforce Mat (HPTRM)	65% EIP: Do nothing between station 512+00 and station 514+00 because Star Bend setback levee has been built and extent into this area. COE Proposal: Construct cutoff wall between station 512+00 and station 514+00, assuming Star Bend setback levee has not been built yet. Also, include erosion protection feature (HPTRM).
8	596+00 to 654+75	5,875	Cutoff wall Erosion Protection	596+00 to 654+75: Cutoff wall tip elevation +15 feet 596+00 to 604+60: High Performance Turf Reinforce Mat (HPTRM)	COE Proposal: Also include erosion protection feature (HPTRM).
9	654+75 to 706+50	5,175	Cutoff wall	654+75 to 670+00: Cutoff wall tip elevation +15 feet 670+00 to 697+00: Cutoff wall tip elevation +20 feet 697+00 to 706+50: Cutoff wall tip elevation -10 feet	
10	706+50 to 774+00	6750	Cutoff wall	706+50 to 726+00: Cutoff wall tip elevation -10 feet 726+00 to 746+00: Cutoff wall tip elevation -5 feet 746+00 to 754+50: Cutoff wall tip elevation +5 feet 754+50 to 774+00: Cutoff wall tip elevation +25 feet	
11	774+00 to 830+00	5,600	Cutoff wall	774+00 to 784+50: Cutoff wall tip elevation +25 feet 784+50 to 827+50: Cutoff wall tip elevation -5 feet 827+50 to 830+00: Cutoff wall tip elevation +25 feet	
12	830+00 to 845+00	1,500	No proposed rehabilitation measure with exception below Cutoff wall (transition only, at both ends of this reach)	830+00 to 831+50: Cutoff wall tip elevation +25 feet (transition only) 844+50 to 845+00: Cutoff wall tip elevation -26 feet (transition only)	829+85 to 845+25: existing cutoff wall (23.5ft deep, tip elevation 30.5)

Table 1 Recommendations for Rehabilitation Measures (based on the 65% EIP with design modifications made by the COE).

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
13	845+00 to 927+00	8,200	Cutoff wall	844+50 to 849+00: Cutoff wall tip elevation -20' to -29' 848+00 to 863+00: Cutoff wall tip elevation -29' 863+00 to 877+00: Cutoff wall tip elevation -30' 877+00 to 887+00: Cutoff wall tip elevation -31' 887+00 to 893+00: Cutoff wall tip elevation -30' 893+00 to 897+50: Cutoff wall tip elevation -29' 897+50 to 923+75: Cutoff wall tip elevation +25'	Abandon existing relief wells, if non-functional. Otherwise, convert the existing relief wells to observation wells. 923+23 to 927+00: existing cutoff wall (32.5ft deep, tip elevation 42.5)
14	927+00 to 954+40	2,740	No proposed rehabilitation measure	---	927+00 to 954+40: existing cutoff wall (32.5ft deep, tip elevation 42.5) No as-built drawing available for the existing cutoff wall.
15	954+40 to 968+50	1,410	No proposed rehabilitation measure	---	954+40 to 968+50: existing cutoff wall (32.5ft deep, tip elevation 42.5) No as-built drawing available for the existing cutoff wall.
16	968+50 to 1080+00	11,150	Jet grouting cutoff wall at 5th Street bridge crossing. Toe berm at 10th Street bridge crossing. Cutoff wall (transition only, at the end of Reach 16 to overlap existing cutoff wall).	1006+04 to 1007+90 (5th Street bridge crossing): Jet grouting cutoff wall tip elevation +40 feet 1023+90 to 1027+50 (10th Street bridge crossing): Toe berm, 23 feet wide, approximately 7 feet thick at the levee toe, 4H:1V slope at toe berm. 1077+85 to 1080+00: Cutoff wall tip elevation +30 feet and backfill landside toe depression (transition only).	968+50 to 983+23: existing cutoff wall (32.5ft deep, tip elevation 42.5) 983+23 to 996+23: existing cutoff wall (22.5ft deep, tip elevation 52.5) 996+23 to 1006+24: existing cutoff wall (32.5ft deep, tip elevation 42.5) 1007+90 to 1015+70: existing cutoff wall (32.5ft deep, tip elevation 42.5) 1015+70 to 1024+42: existing cutoff wall (43ft deep, tip elevation 35) 1026+99 to 1079+66: existing cutoff wall (39ft deep, tip elevation 38)

Table 1 Recommendations for Rehabilitation Measures (based on the 65% EIP with design modifications made by the COE).

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
17	1080+00 to 1130+86	5,086	Cutoff wall Jet grouting cutoff wall at Yuba city water treatment plant Jet grouting cutoff wall at Railroad North of Yuba City Landside toe depression filled Closure Structure	1107+00 to 1125+70: Backfill landside toe depression 1080+00 to 1089+00: Cutoff wall tip elevation +30 feet 1089+00 to 1096+00: Cutoff wall tip elevation +35 feet 1095+80 to 1098+30: Jet grouting cutoff wall tip elevation +35 feet 1098+10 to 1125+00: Cutoff wall tip elevation +35 feet 1125+00 to 1129+99: Cutoff wall tip elevation +0 feet 1129+50 to 1130+67: Jet grouting cutoff wall tip elevation +0 feet 1130+20 to 1130+86: Cutoff wall tip elevation +0 feet 1130+00: Stop log closure structure or equivalence	
18	1130+86 to 1213+85	8,299	Cutoff wall	1130+86 to 1151+50: Cutoff wall tip elevation +0 feet 1151+50 to 1159+50: Cutoff wall tip elevation +30 feet 1159+50 to 1169+50: Cutoff wall tip elevation +25 feet 1169+50 to 1189+50: Cutoff wall tip elevation +30 feet 1189+50 to 1209+50: Cutoff wall tip elevation +40 feet 1209+50 to 1213+85: Cutoff wall tip elevation +35 feet	
19	1213+85 to 1297+83	8,398	Cutoff wall	1213+85 to 1219+75: Cutoff wall tip elevation +35 feet 1219+75 to 1224+00: Cutoff wall tip elevation +5 feet 1224+00 to 1238+00: Cutoff wall tip elevation -28 feet 1238+00 to 1248+00: Cutoff wall tip elevation -42 feet 1248+00 to 1268+75: Cutoff wall tip elevation +3 feet 1268+75 to 1297+83: Cutoff wall tip elevation +35 feet	
20	1297+83 to 1374+33	7,650	Cutoff wall	1297+83 to 1298+75: Cutoff wall tip elevation +35 feet 1298+75 to 1359+00: Cutoff wall tip elevation +50 feet 1359+00 to 1369+00: Cutoff wall tip elevation +40 feet 1369+00 to 1374+33: Cutoff wall tip elevation +32 feet	

Table 1 Recommendations for Rehabilitation Measures (based on the 65% EIP with design modifications made by the COE).

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
21	1374+33 to 1433+83	5,950	Cutoff wall Levee relocation with cutoff wall (transition only) Canal relocation	1374+33 to 1386+50: Cutoff wall tip elevation +32 feet 1386+50 to 1408+50: Cutoff wall tip elevation +55 feet 1408+50 to 1433+83: Cutoff wall tip elevation +40 feet 1432+50 to 1433+83: Levee relocation (20ft riverward, transition only) 1429+00 to 1433+83 Sutter Butte Main Canal relocation.	65% EIP: Fix in-place the existing levee with cutoff wall. COE Proposal: Relocate the existing levee 20ft riverward between station 1432+50 and station 1433+83 (this is a transition section only NOT a full 20ft levee shift) to create room for O&M corridor. Construct cutoff wall along the new levee alignment. Relocate the Sutter Butte Main canal between station 1429+00 and station 1433+83 to create room for O&M corridor without relocating Sunset Weir pump station.
22	1433+83 to 1503+83	7,000	Cutoff wall Cutoff wall with full levee degrade Levee relocation with cutoff wall	1433+83 to 1450+00: Levee relocation (20ft riverward) 1451+50 to 1451+50: Levee relocation (20ft riverward, transition only) 1455+00 to 1461+00: Full levee degrade and re-construction 1433+83 to 1448+75: Cutoff wall tip elevation +40 feet 1448+75 to 1468+83: Cutoff wall tip elevation +50 feet 1468+83 to 1503+83: Cutoff wall tip elevation +55 feet	65% EIP: Fix in-place the existing levee with cutoff wall. COE Proposal: Relocate the existing levee 20ft riverward between station 1433+83 and station 1451+50 (levee relocation between station 1450+00 and station 1451+50 is a transition section only NOT a full 20ft levee shift) to create room for O&M corridor. Construct cutoff wall along the new levee alignment. Full levee degrade and reconstruction recommended for a portion of this reach due to severe animal burrowing
23	1503+83 to 1609+37	10,554	Cutoff wall Levee relocation with cutoff wall (transition only) Erosion Protection	1503+83 to 1508+50: Cutoff wall tip elevation +55 feet 1508+50 to 1528+75: Cutoff wall tip elevation +60 feet 1528+75 to 1566+50: Cutoff wall tip elevation +55 feet 1566+50 to 1608+75: Cutoff wall tip elevation +60 feet 1608+50 to 1609+37: Levee relocation (20ft riverward, transition only) 1582+00 to 1601+00: High Performance Turf Reinforce Mat (HPTRM)	65% EIP: Fix in-place the existing levee with cutoff wall. COE Proposal: Relocate the existing levee 20ft riverward between station 1608+50 and station 1609+37 (this is a transition section only NOT a full 20ft levee shift) to create room for O&M corridor. Construct cutoff wall along the new levee alignment. Also, include erosion protection feature (HPTRM).

Table 1 Recommendations for Rehabilitation Measures (based on the 65% EIP with design modifications made by the COE).

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
24	1609+37 to 1623+86	1,449	Cutoff wall Levee relocation with cutoff wall	1609+37 to 1612+00: Levee relocation (20ft riverward, transition only) 1612+00 to 1623+00: Levee relocation (20ft riverward) 1623+00 to 1623+86: Levee relocation (20ft riverward, transition only) 1608+75 to 1623+86: Cutoff wall tip elevation +28 feet	65% EIP: Fix in-place the existing levee with cutoff wall. COE Proposal: Relocate the existing levee 20ft riverward between station 1609+37 and station 1623+86 (levee relocation between station 1609+37 and station 1612+00 and between station 1623+00 and station 1623+86 are transition sections only NOT a full 20ft levee shift) to create room for O&M corridor. Construct cutoff wall along the new levee alignment.
25	1623+86 to 1674+37	5,051	No proposed rehabilitation measure with exception below Cutoff wall (transition only, at both ends of this reach) Levee relocation with cutoff wall (transition only)	1623+86 to 1624+50: Levee relocation (20ft riverward, transition only) 1623+86 to 1625+00: Cutoff wall tip elevation +28 feet (transition only) 1673+00 to 1674+37: Cutoff wall tip elevation +65 feet (transition only) 1673+00 to 1674+37: Levee relocation (20ft riverward, transition only)	65% EIP: Do nothing except at both ends of this reach where cutoff wall from other reaches will extent into these areas. COE Proposal: Relocate the existing levee 20ft riverward between station 1608+50 and station 1609+37 (levee relocation between station 1623+86 and station 1624+50 and between station 1673+00 and station 1674+37 are transition sections only NOT a full 20ft levee shift) to create room for O&M corridor. Construct cutoff wall along the new levee alignment (between station 1623+86 and station 1625+00 and between station 1673+00 and station 1674+37 only).
26	1674+37 to 1707+11	3,274	Cutoff wall Levee relocation with cutoff wall	1674+37 to 1675+00: Levee relocation (20ft riverward, transition only) 1675+00 to 1707+11: Levee relocation (20ft riverward) 1674+37 to 1707+11: cutoff wall tip elevation +65 feet	65% EIP: Fix in-place the existing levee with cutoff wall. COE Proposal: Relocate the existing levee 20ft riverward between station 1674+37 and station 1707+11 (levee relocation between station 1674+37 and station 1675+00 is a transition section only NOT a full 20ft levee shift) to create room for O&M corridor. Construct cutoff wall along the new levee alignment. Cutoff wall tip elevations to be confirmed by additional exploration (planned)

Table 1 Recommendations for Rehabilitation Measures (based on the 65% EIP with design modifications made by the COE).

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
27	1707+11 to 1721+60	1,449	Cutoff wall Levee relocation with cutoff wall	1707+11 to 1721+60: Levee relocation (20ft riverward) 1707+11 to 1721+60: cutoff wall tip elevation +65 feet	65% EIP: Fix in-place the existing levee with cutoff wall. COE Proposal: Relocate the existing levee 20ft riverward between station 1707+11 and station 1721+60 to create room for O&M corridor. Construct cutoff wall along the new levee alignment. Cutoff wall tip elevations to be confirmed by additional exploration (planned)
28	1721+60 to 1769+31	4,771	Cutoff wall Canal relocation Levee relocation with cutoff wall	1721+60 to 1753+00: Levee relocation (20ft riverward) 1753+00 to 1754+50: Levee relocation (20ft riverward, transition only) 1752+00 to 1766+00: Sutter Butte Main Canal Relocation 1721+60 to 1727+75: cutoff wall tip elevation +65 feet 1727+75 to 1748+50: cutoff wall tip elevation +75 feet 1748+50 to 1769+31: cutoff wall tip elevation +45 feet	65% EIP: Fix in-place the existing levee with cutoff wall. COE Proposal: Relocate the existing levee 20ft riverward between station 1721+60 and station 1754+50 (levee relocation between station 1753+00 and station 1754+50 are transition sections only NOT a full 20ft levee shift) to create room for O&M corridor. Construct cutoff wall along the new levee alignment. Relocate the Sutter Butte Main canal between station 1752+00 and station 1766+00 to create room for O&M corridor without encroaching into the main channel. Cutoff wall tip elevations to be confirmed by additional exploration (planned)
29	1769+31 to 1813+33	4,402	No proposed rehabilitation measure	---	No proposed rehabilitation measure as existing conditions meet criteria
30	1813+33 to 1902+00	8,867	Cutoff wall Jet grouting cutoff wall	1813+33 to 1816+50: cutoff wall tip elevation +80 feet 1816+50 to 1848+25: cutoff wall tip elevation +30 feet 1848+25 to 1866+00: cutoff wall tip elevation +70 feet 1866+00 to 1877+75: cutoff wall tip elevation +47 feet 1877+75 to 1883+00: cutoff wall tip elevation +40 feet 1883+00 to 1900+50: cutoff wall tip elevation +27 feet 1900+00 to 1902+00: jet grouting cutoff wall tip elevation +27 feet	Waterside slope maintenance to address sloughing of steep channel bank slopes may be required in the future.

Table 1 Recommendations for Rehabilitation Measures (based on the 65% EIP with design modifications made by the COE).

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
31	1902+00 to 1958+00	5,600	Cutoff wall Jet grouting cutoff wall	1902+00 to 1904+00: jet grouting cutoff wall tip elevation +27 feet 1903+50 to 1907+50: cutoff wall tip elevation +27 feet 1907+50 to 1917+50: cutoff wall tip elevation +44 feet 1917+50 to 1927+50: cutoff wall tip elevation +75 feet 1927+50 to 1937+00: cutoff wall tip elevation +50 feet 1937+00 to 1958+00: cutoff wall tip elevation +40 feet	An existing 10ft bench on the landside slope of the existing levee already exists and the O&M corridor will be reduced from 15ft to 10ft-minimum in this area.
32	1958+00 to 1989+00	3,100	Cutoff wall	1958+00 to 1971+00: cutoff wall tip elevation +40 feet 1971+00 to 1987+25: cutoff wall tip elevation +48 feet 1987+25 to 1989+00: cutoff wall tip elevation +10 feet	
33	1989+00 to 2122+00	13,300	Cutoff wall	1989+00 to 2002+00: cutoff wall tip elevation +10 feet 2002+00 to 2016+75: cutoff wall tip elevation +90 feet 2016+75 to 2036+75: cutoff wall tip elevation +20 feet 2036+75 to 2041+00: cutoff wall tip elevation +53 feet 2041+00 to 2067+00: cutoff wall tip elevation +38 feet 2067+00 to 2088+00: cutoff wall tip elevation +33 feet 2088+00 to 2122+00: cutoff wall tip elevation +90 feet	
34	2122+00 to 2182+00	6,000	Cutoff wall	2122+00 to 2137+00: cutoff wall tip elevation +90 feet 2137+00 to 2148+00: cutoff wall tip elevation +20 feet 2148+00 to 2164+00: cutoff wall tip elevation +90 feet 2164+00 to 2182+00: cutoff wall tip elevation +50 feet	
35	2182+00 to 2224+00	4,200	Cutoff wall	2182+00 to 2196+50: cutoff wall tip elevation +40 feet 2196+50 to 2212+00: cutoff wall tip elevation +45 feet 2212+00 to 2218+25: cutoff wall tip elevation +50 feet 2218+25 to 2224+00: cutoff wall tip elevation +55 feet	
36	2224+00 to 2259+00	3,500	Cutoff wall	2224+00 to 2233+50: cutoff wall tip elevation +55 feet 2233+50 to 2258+25: cutoff wall tip elevation +70 feet 2258+25 to 2259+00: cutoff wall tip elevation +42 feet	

Table 1 Recommendations for Rehabilitation Measures (based on the 65% EIP with design modifications made by the COE).

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
37	2259+00 to 2290+00	3,100	Cutoff wall	2259+00 to 2277+00: cutoff wall tip elevation +42 feet 2277+00 to 2290+00: cutoff wall tip elevation +45 feet	
38	2290+00 to 2303+00	1,300	Seepage berm Seepage berm with cutoff wall (transition only, extend from Reach 37 into Reach 38,)	2290+00 to 2303+00: Seepage berm up to 11 foot high that extends horizontally at elevation 200 year + 4 feet for a distance of 50 feet from the landside slope of the levee before tapering to a height of 3 feet at the berm toe at a distance of 170 feet from the centerline of the existing levee. 2290+00 to 2292+00: Cutoff wall with tip elevation of +45 feet to (transition only).	Grading work to generate a level platform area will be required prior to construction of seepage berm
39	2303+00 to 2319+00	1,600	No proposed rehabilitation measure	---	No as-built drawing available for the existing cutoff wall.
40	2319+00 to 2359+00	4,000	Seepage Berm	2319+00 to 2331+00: No mitigation measure 2331+00 to 2335+00: Seepage berm 120 feet wide, 9 feet thick at the levee toe and 3 feet at the berm toe 2335+00 to 2359+00: Seepage berm 100 feet wide, 9 feet thick at the levee toe and 3 feet at the berm toe	Grading work to generate a level platform area will be required prior to construction of seepage berm
41	2359+00 to 2368+00	900	Seepage berm with filter drain	2359+00 to 2368+00: Seepage berm 100 feet wide, 5 feet thick at levee toe with a 1 foot thick filter layer (ASTM C33 fine aggregate) at bottom and across seepage berm. Seepage berm thickness of 5 feet includes 1 foot of filter layer and 4 feet of seepage berm material at levee toe. A geotextile separator, compatible with ASTM C33 fine aggregate, should be placed on top of the ASTM C33 fine aggregate layer.	Near Thermalito Afterbay dam and outfall facility and old Sutter Butte Canal channel

APPENDIX C

From: Le, Tung SPK
Sent: Wednesday, May 23, 2012 4:14 PM
To: Vrchoticky, Robert D SPK; Duong, Tri H SPK
Cc: Blodgett, Peter J SPK; James, Erik W SPK
Subject: Sutter Basin - Ring and J levee Height (UNCLASSIFIED)
Attachments: Sutter Basin FS-Ring and J Levee Height.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Bob/Tri - Per our discussion, the followings summarize how the estimates for the ring and J levees are going to be revised to include the new levee heights.

- J levee

1. S6A (south levee): levee height should be changed from 13ft to 15ft

2. S6B (lower west levee): levee height should be changed from 8ft to 13ft

3. S6C (upper west levee): levee height should stay at 8ft

- Ring levee

1. S4A (existing levee): no changes

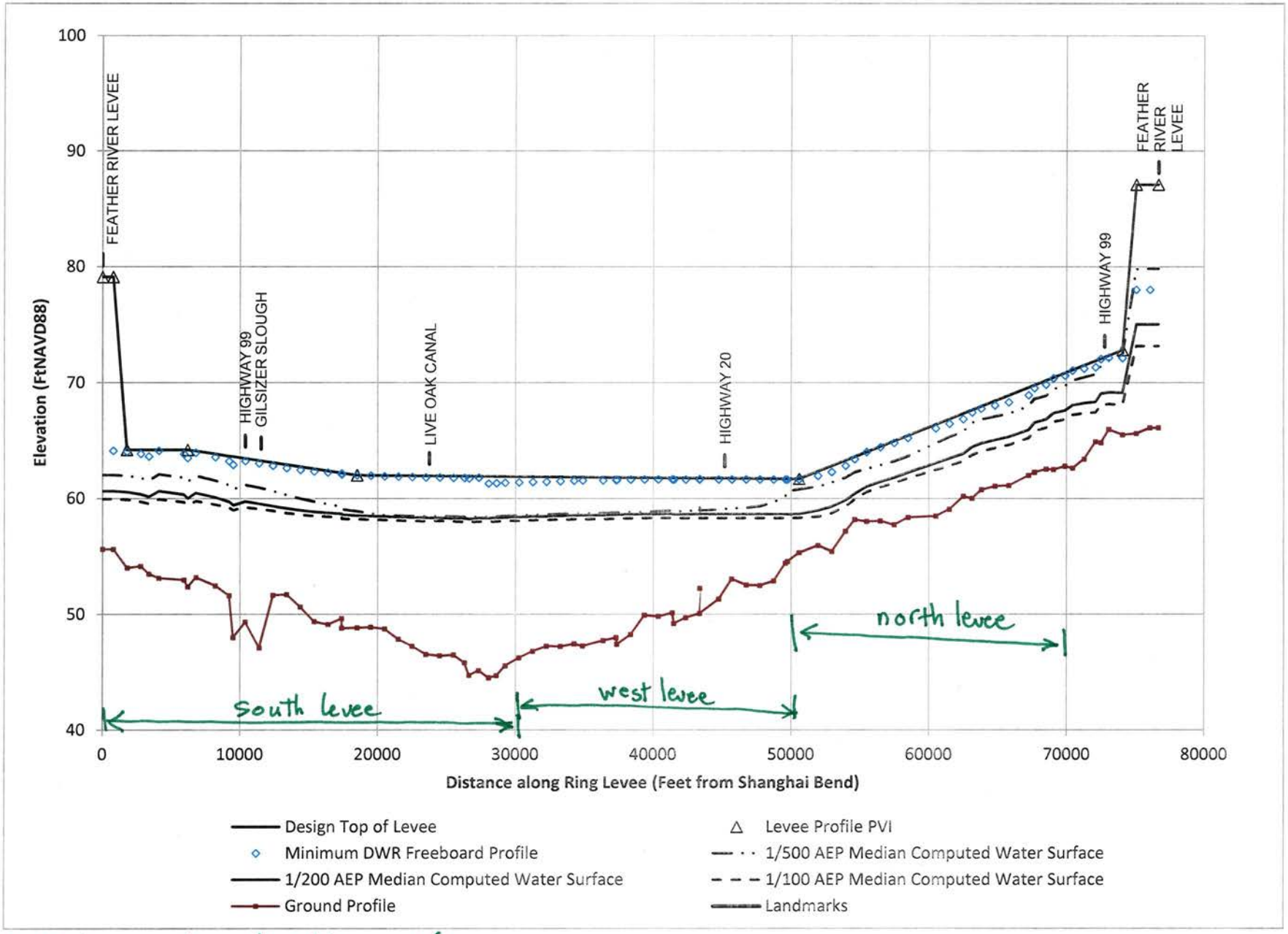
2. S4B (north levee): levee height should stay at 8ft

3. S4C (west levee): levee height should be changed from 8ft to 13ft

4. S4D (south levee): levee height should be changed from 13ft to 15ft

This is based on the recent hydraulic design information (see the attached).

Erik – Please confirm the cutoff wall depth.



1. North levee : levee height ~ 8′
2. West levee : levee height ranges from 8′ to 18′ → average levee height ~ 13′
3. South levee : levee height ranges from 10′ to 18′ → average levee height ~ 15′

Levee Geometries (Weighted Average Method)

Levee reach	Levee height (ft)	Levee length (mi)	(ft.mi)	Average levee height (ft)	Levee width w/ berm (ft)	Levee length (ft)	(ft.mi)	Levee width w/o berm (ft)	Levee length (ft)	(ft.mi)	Average levee width (ft)	Cutoff wall depth (ft)	Cutoff wall length (mi)	(ft.mi)	Average cutoff wall depth (ft)
S5A	17.50	10.36	181.30		119.50	2.59	309.51	107.50	7.77	835.28		65.00	10.36	673.40	
S5B	12.50	7.44	93.00		94.50	5.58	527.31	82.50	1.86	153.45		65.00	5.58	362.70	
S5C	17.50	5.74	100.45		119.50	1.44	171.48	107.50	4.31	462.79		65.00	4.31	279.83	
S5D	25.00	5.93	148.25		157.00	0.59	93.10	145.00	5.34	773.87		65.00	2.97	192.73	
S7D	25.00	4.03	100.75		157.00	0.40	63.27	145.00	3.63	525.92		65.00	2.02	130.98	
S7E	22.50	3.66	82.35		144.50	0.37	52.89	132.50	3.29	436.46		65.00	2.75	178.43	
S7F	22.50	7.77	174.83		144.50	0.78	112.28	132.50	6.99	926.57		65.00	5.83	378.79	
S7G	22.50	7.58	170.55		146.50	0.76	111.05	134.50	6.82	917.56		40.00	7.58	303.20	
S7H	20.00	1.76	35.20		134.00	0.18	23.58	122.00	1.58	193.25		50.00	1.76	88.00	
S7I	20.00	8.13	162.60		134.00	0.81	108.94	122.00	7.32	892.67		35.00	8.13	284.55	
S7J	15.00	4.62	69.30		114.00	0.46	52.67	102.00	4.16	424.12		65.00	2.31	150.15	
		67.02	1,318.58	20		13.95	1,626.07		53.07	6,541.92	122		53.58	3,022.74	56

FIGURE 4 - DECISION CHART

Decision Chart

Penetrations****	Untouched major/big lines*	Abandoned lines	Communication conduits (*above* DWSE)	Communication conduits (*below* DWSE)
	-	-	Minor/small pressurized lines (*above* DWSE)	Minor/small pressurized lines (*below* DWSE)
	-	-	Major/big pressurized lines	
	-	-	Gravity lines**	
Repairs	**Typical 1**	**Typical 2a** (above DWSE); **Typical 2b** (below DWSE)	**Typical 3a** (above->above); **Typical 3b** (below->below)	**Typical 4** (below->above)
	Jet-grout	Remove	Temporary relocation	Temporary relocation
	-	-	Remove	Remove
	-	-	Replace	Replace
	-	-	-	Relocate (above DWSE)

Obstructions****	Cutoff wall construction at bridge crossings	Hwy's & roads crossing ring levee (in deep flood zones)	Hwy's & roads crossing ring levee (in shallow flood zones)	Canals/ditches crossing ring levees	Overhead power lines
	Cutoff wall construction at railroad crossings	-	Railroads crossing ring levee	-	-
	-	-	-	-	-
	-	-	-	-	-
Repairs	**Typical 5**	**Typical 6**	**Typical 7**	**Typical 8**	**Typical 9**
	Temporary traffic redirection	Temporary traffic redirection	Temporary traffic redirection	Temporary pump	Relocation
	DSM	Raise	Gate	Closure structure (automated => ~~relocated~~)	-
	-	-	-	-	-

Adjacent structures****	Buildings/structures	Canals/ditches***	Pipelines
	-	Ponds	Communication conduits
	-	-	Overhead power lines
	-	-	-
Repairs	**Typical 10**	**Typical 11**	**Typical 12**
	Relocation	Temporary pump	Relocation (20ft away from LS toe)
	-	Relocation (500ft away from LS toe)	-
	-	-	-

** In good conditions and meet standards*
*** Can be relocated above the DWSE if pump stations are provided (TBD by Geotechnical Engineering)*
**** Can be left in place if mitigation measures are provided (TBD by Geotechnical Engineering)*
***** For penetrations through the existing levees only. For the new levee segments (including the ring, J and setback levees), assume 15% to 25% of alternative cost for utilities.*

APPENDIX B
ENCROACHMENT INVENTORY
TYP 1 - 4

Reach	System	Levee mile	Stationing	Encroachment	Classification	Repair Type	Size	Material	Single/Multiple Pen.
S7F-Lower	FRWL		10+81.69	Two 48 inch culverts with canal gates on upstream side of Nelsoncanal gates on upstream side of Nelson Crossing of Spur Levee	Gravity lines	Typical design 3b	48" - 60"	Concrete	2 penetrations
S7F-Middle	FRWL		52+24.96	2-18 inch steel pipes with concrete "U" headwall at waterside toe.	Abandoned lines (below DWSE)	Typical design 2b	12" - 24"	Metal	2 penetrations
	FRWL		52+24.96	Hamatani Ranch Storm Drainage Pump Station. The pump dischargeis a 20 inch pipe and pump is Bryon Jackson 17H0H with 50 HPelectrical motor.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	FRWL		97+61.40	U.S. Communication cable	Communication conduits (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL		124+32.08	24 inch culvert pipe. Part of Sacramento Avenue Irrigation Pump Station	Minor/small pressurized lines (below DWSE)	Typical design 4	12" - 24"	Metal	Single
S7F-Upper	FRWL		209+23.00	Private Irrigation Pump Station. 14 inch welded steel pipe crossing	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
S7F-Middle	FRWL		174+91.00	12 inch pipe	Abandoned lines (above DWSE)	Typical design 2a	12" or less	Metal	Single
S7E-Lower	FRWL		219+63.00	12 inch pipe	Abandoned lines (above DWSE)	Typical design 2a	12" or less	Metal	Single
	FRWL		298+37.98	Garden Highway Mutual Water 54 inch Irrigation Pump Station Discharge Pipeline through Levee. The improvements include a inlet channel from the river to the 200 feet from waterside toe of levee and irrigation canal at the toe of the landside of levee.	Major/big pressurized lines (below DWSE)	Typical design 3b	48" - 60"	Concrete	Single
	FRWL		298+83.19	Abandon 36 inch steel pipe through levee - in waterside slope - Pipe removed in 1964 per permit 4667	Abandoned lines (above DWSE)	Typical design 2a	24" - 36"	Metal	Single
	FRWL		364+99.91, 386+70.95, 396+37.65	Abandon 8 inch pipe crossing	Abandoned lines (above DWSE)	Typical design 2a	12" or less	Metal	3 penetrations
	FRWL		409+50.46	Taylor Brother Farm Irrigation Pump Station. A 14 inch irrigation discharge pipe through levee	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	FRWL		409+55.78, 409+58.48, 409+62.65, 409+66.27	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	4 penetrations
	FRWL		409+83.87	1.25 inch electrical conduit	Communication conduits (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL		417+66.00	Abandon Existing 24 inch pipe through levee. The permit was revised to removal of 24 inch via 4666A so there should not be any pipe.	Abandoned lines (above DWSE)	Typical design 2a	12" - 24"	Metal	Single
S7-E-Middle	FRWL		459+88.85	Abandon 8" steel drainpipe	Abandoned lines (above DWSE)	Typical design 2a	12" or less	Metal	Single
S7-E-Upper	FRWL		510+19.91, 510+24.81	Tudor Mutual Water Company South 30 inch steel irrigation discharge pipes crossing of levee	Minor/small pressurized lines (above DWSE)	Typical design 3a	24" - 36"	Metal	2 penetrations
	FRWL		510+35.50	Volcano Vista Farms 18 inch steel irrigation discharge pipe crossing of levee.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	FRWL		512+03.58, 512+08.26	Corp of Engineers Star Bend Road Relief Well Pump Station south 15" Steel Discharge Pipe Crossings	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	2 penetrations
	FRWL		526+83.00	Abandon 6 inch pipe	Abandoned lines (above DWSE)	Typical design 2a	12" or less	Metal	Single
	FRWL		527+75.00	5 inch steel drainage pipe	Gravity lines	Typical design 3b	12" or less	Metal	Single
	FRWL		536+72.87	Existing 10 inch steel pipe. Removed in 1964 by Levee District No. 1 as part of permit 4775	Abandoned lines (above DWSE)	Typical design 2a	12" or less	Metal	Single
S7-D	FRWL		647+60.75, 647+65.55, 647+70.15, 647+73.96	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Major/big pressurized lines (above DWSE)	Typical design 3a	24" - 36"	Metal	4 penetrations
	FRWL		664+24.93	Sierra Gold Nursery. An 8 inch steel pipe through levee. This pipe was pressure checked and in 1984 as part of permit 13980 to connect to existing pipe.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL		689+13.12, 689+13.12	Oswald Mutual Water Company (Boyds Pump) 18 inch epoxy coated mortar lined steel pipe through existing 24 inch concrete pipe crossing of levee.	Minor/small pressurized lines (below DWSE)	Typical design 4	12" - 24"	Metal	2 penetrations
S5-D	FRWL		828+55.54	City of Yuba City Sewer 24 inch welded steel pipe mortar lined and coated pipe (wall thickness 0.188" min) Discharge Pipe to river diffuser	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	FRWL		856+08.34	South Yuba City Seepage Interceptor Pump Station 24 inch 7 GA Steel Pipe asphalt coated and wrapped with asphalt saturated felt discharge pipe.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	FRWL		881+40.99	Levee District No. 1 Relief Well Pump Station 6" and 14" pipes located just southeast of the Waste Water Treatment Plant	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	2 penetrations
	FRWL		893+84.36	Burns Drive Storm Water Pump Station. 16 inch steel storm drain discharge pipe through levee. Garden Highway Industrial Park. A 12 inch steel storm drain discharge pipe through levee.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	2 penetrations
	FRWL		897+62.00	12 inch steel pipe through levee	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL		912+93.50	Two 16 inch gas lines	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	FRWL		1018+99.04	Abandon 4 inch pipe	Abandoned lines (above DWSE)	Typical design 2a	12" or less	Metal	Single
	FRWL		1038+50.00	Abandoned 8 inch gas line through levee	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL		1043+20.80	Gilsizer Slough Storm Drain Facilities. A 16 inch welded steel discharge pipe crossing of levee. (copy of record drawings)	Minor/small pressurized lines (below DWSE)	Typical design 4	12" - 24"	Metal	Single
	FRWL		1043+26.07, 1043+31.62, 1043+37.87	24 inch steel pipe storm drainage discharge pipe, 24 inch wrapped steel pipe, 36 inch steel pipeline	Minor/small pressurized lines (above DWSE)	Typical design 3a	24" - 36"	Metal	3 penetrations
	FRWL		1043+40.00	Abandoned 27 inch Centrifugal Spun Concrete Pipe. City of Yuba City Drawing 214-D per 1949 plans	Abandoned lines (below DWSE)	Typical design 2b	24" - 36"	Concrete	Single
	FRWL		1043+31.62	Abandon 36 inch pipe	Abandoned lines (below DWSE)	Typical design 2b	24" - 36"	Concrete	Single
	FRWL		1073+41.11	16 inch Gas Line	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	FRWL		1094+40.00	3 inch steel pipe	Abandoned lines (above DWSE)	Typical design 2a	12" or less	Metal	Single

	FRWL	1096+61.97	Yuba City Water Treatment Plant 42"cement mortor lined and coated welded steel pipe waterline crossing of levee (copy of record drawings).	Major/big pressurized lines (above DWSE)	Typical design 3a	36" - 48"	Concrete	Single
	FRWL	1096+72.37, 1096+86.37	Yuba City Water Treatment Plant 24"and 28" 7 GA welded steel waterline pipe crossing of levee. New permit included installation of automatic drainage gates on pipelines. (copy of record drawings).	Minor/small pressurized lines (above DWSE)	Typical design 3a	24" - 36"	Metal	2 penetrations
	FRWL	1111+44.89	North Yuba City Drainage Area. 16 Inch welded steel 7 GA asphalt coated storm drain discharge pipe over levee connected to 24 inch pipe in overflow area, outfall ditch, and pipes in floodway.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	FRWL	1127+47.99	10 inch storm drain for Mobile home park through levee	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
S5-C	FRWL	1130+47.20	Union Pacific Railroad Crossing. There is no stop log structure.	Untouched major/big lines	Typical design 1			
	FRWL	1132+61.05	8-5/8" steel pipeline within railroad right-of-way parallel to tracks	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL	1135+36.44	16 inch gas line through the levee. Marker post on the waterside shoulder	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	FRWL	1180+85.00	One 12 inch steel pipe through levee. Pipe exposed on landside slope	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL	1180+97.50	3 inch steel pipe through levee crown.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL	1182+20.00	Abandoned 8 inch steel pipe through levee. Pipe plugged on the waterside toe.	Abandoned lines (above DWSE)	Typical design 2a	12" or less	Metal	Single
	FRWL	1182+75.00	20 Inch steel pipeline through levee (not installed)	Abandoned lines (above DWSE)	Typical design 2a	12" - 24"	Metal	Single
	FRWL	1200+69.03	Abandoned 10 inch steel pipe through levee. Waterside end open. Steel Plate welded on landward end. Pump and Standpipe at the landside end.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL	1229+42.99	Kewall Singh IR PS. A 16 inch steel pipe through levee. Pump in pump house on channel bank. Gate valve on the waterside end. Concrete standpipe.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	FRWL	1265+54.04	Sullivan Pump Station. 18 inch steel pipe through the levee. Pump and Gate valve in pump house on the channel bank. Concrete well on the bank. Siphon breaker in CMP riser on landside slope. (Sullivan Pump Station)	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	FRWL	1314+79.05	Micheli Storm Drianage Pump Station. A 20 inch discharge pipe through levee. Siphon breaker on waterside shoulder. Pump at landside toe.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	FRWL	1347+06.69	Underground communication cable through levee	Communication conduits (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL	No Station listed	36" CM pipe crossing through levee	Gravity lines	Typical design 3b	24" - 36"	Metal	Single
S5-B	FRWL	1430+39.39, 1430+46.56	Sunset Pump Station owned an operated by Sutter Extension Main Pump Station. This is the 60 Inch steel pipe a through the levee. Pump end has gate valves on structure. Automatic drainage gates on the landside end.	Major/big pressurized lines (below DWSE)	Typical design 3b	48" - 60"	Metal	2 penetrations
	FRWL	1430+54.03	Sunset Pump Station owned an operated by Sutter Extension Main Pump Station. This is the 36 inch steel pipe through the levee. Pump end has gate valves on structure. Automatic drainage gates on the landside end.	Minor/small pressurized lines (below DWSE)	Typical design 4	24" - 36"	Metal	Single
	FRWL	1528+35.14, 1532+86.49	Potential Pipe Crossing. 6" Steel through levee	Gravity lines	Typical design 3b	12" or less	Metal	2 penetrations
	FRWL	1536+15.72	RD 777 Lateral 7. There is a 36 inch CM pipe through levee. Automatic drainage gate on waterside end of pipe.	Major/big pressurized lines (below DWSE)	Typical design 3b	24" - 36"	Metal	Single
	FRWL	1549+70.00, 1556+50.00, 1585+60.00	Abandoned 12 inch, 8 inch, and 12 inch CM pipe through levee. Automatic drainage gate on waterside end of pipe.	Gravity lines	Typical design 3b	12" or less	Metal	3 penetrations
	FRWL	1610+91.31	RD 777 Lateral 12. An 18 inch CM pipe through levee. Automatic drainage gate on waterside end of pipe.	Gravity lines	Typical design 3b	12" - 24"	Metal	Single
	FRWL	1638+98.21	RD 777 Lateral 11. There are 2-24 inch steel pipes through levee. Automatic drainage gates on waterside end of pipe.	Gravity lines	Typical design 3b	12" - 24"	Metal	2 penetrations
	FRWL	1675+27.01	Butte County Drainage District No. 1. 60" x 72" RCP culvert through levee. Slide gate in concrete well on waterside slope.	Gravity lines	Typical design 3b	60" or greater	Concrete	Single
	FRWL	1741+31.92	Butte County Drainage District No. 1. A 16-Inch pipe through Levee. Emergency Repair Work on Pipe 3/5/02	Gravity lines	Typical design 3b	12" - 24"	Metal	Single
	FRWL	1756+26.91	Abandoned 12-inch CM pipe through the Levee. Slide Gate on the landside end and concrete distribution box on waterside.	Abandoned lines (above DWSE)	Typical design 2a	12" or less	Metal	Single
	FRWL	1765+15.31	12 inch steel pipe over levee and through crown	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL	1765+32.60	12 inch plastic sleeved conrete irrigation pipe through levee. Concrete Headwall at the waterside toe	Major/big pressurized lines (above DWSE)	Typical design 3a	12" or less	PVC	Single
	FRWL	1767+57.16, 1767+66.57	South 60 Inch drain pipes through Levee. Slide Gates in 78 inch CM pipe wells on the waterside slope. Concrete bulkhead on both ends. Reinforced concrete spillway at the waterside end.	Major/big pressurized lines (above DWSE)	Typical design 3a	48" - 60"	Metal	2 penetrations
	FRWL	1776+99.83, 1784+70.00, 1785+25.31	24 Inch CM drain pipe through levee. Concrete Headwall at land side. Automatic Drainage Gate on Waterside.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	3 penetrations
	FRWL	1792+95.52	Abandoned 24 inch CM drainage pipe through levee. Automatic drainage gate on waterside and concrete distribution box at waterside toe.	Minor/small pressurized lines (below DWSE)	Typical design 4	12" - 24"	Metal	Single
	FRWL	1799+42.87	8" irrigation pipeline through levee	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL	1809+65.27	24 Inch CM pipe through levee. Automatic drainage gate on waterside proped open and concrete headwall on land side.	Gravity lines	Typical design 3b	12" - 24"	Metal	Single
	FRWL	1813+70.00	24 Inch CM pipe through levee. Concrete saddle and apron with Calco Slide gate.	Gravity lines	Typical design 3b	12" - 24"	Metal	Single
	FRWL	1818+72.08	24 Inch CM pipe through levee. Slide gate in 36 inch CM riser on the waterside slope.	Gravity lines	Typical design 3b	12" - 24"	Metal	Single
S5-A-Lower	FRWL	1823+04.93	12 Inch cement coated and lined steel sewer pipe sleeved through the existing 24 inch CM pipe. Annular space pressure grouted.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	FRWL	1823+04.93	24 Inch CM pipe through levee. 36 inch RCP riser on the waterside slope. Same pipe as below	Gravity lines	Typical design 3b	12" - 24"	Metal	Single

	FRWL		1834+41.20	24 inch CM drainage pipe through levee. Automatic drainage gate on waterside toe. 12 inch pipe sleeved through 24 inch pipe.	Gravity lines	Typical design 3b	12" - 24"	Metal	Single
	FRWL		1850+02.02	18 inch cast iron sewer pipe through levee. Concrete thrust block for cutoff walls on both shoulders. Siphon breaker in concrete pipe riser on the waterside shoulder.	Minor/small pressurized lines (below DWSE)	Typical design 4	12" - 24"	Metal	Single
	FRWL		1868+17.41	Butte County Drainage District No. 1. An 18-Inch pipe through Levee.	Abandoned lines (above DWSE)	Typical design 2a	12" - 24"	Metal	Single
	FRWL		1888+51.56	8 inch steel pipe through levee	Minor/small pressurized lines (above DWSE)	Typical design 3a			
	FRWL		1893+70.00	3/4 inch galvanized iron waterline through levee	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL		1934+52.29	36 inch CM pipe through levee. Slide gate in concrete box on the water side slope.	Gravity lines	Typical design 3b	24" - 36"	Metal	Single
S5-A-Upper	FRWL		1957+90.00	Abandoned 24 inch CM irrigation pipe through levee. Slide gate in concrete riser pipe on landside berm.	Gravity lines	Typical design 3b	12" - 24"	Metal	Single
	FRWL		1961+10.54	Two 60 inch CM drainpipes through levee. Automatic drainage gates on waterside end and concrete headwalls on both ends.	Gravity lines	Typical design 3b	48" - 60"	Metal	2 penetrations
	FRWL		2014+00.00	7 inch steel pipe sleeved through the existing 12 inch steel pipe through levee. The annular space between the two pipes is plugged with concrete on both ends. Slide gate in concrete risers on both ends.	Gravity lines	Typical design 3b	12" or less	Metal	Single
	FRWL		2017+19.92	22 inch reinforced concrete encased steel irrigation pipe through levee. Slide gate in 36 inch concrete standpipe at waterside toe.	Gravity lines	Typical design 3b	12" - 24"	Concrete	Single
	FRWL		2026+00.00, 2032+50.00	12 inch reinforced concrete encased steel irrigation pipe through levee. Slide gate in 24 inch concrete standpipe at waterside toe.	Gravity lines	Typical design 3b	12" - 24"	Concrete	2 penetrations
	FRWL		2092+70.00	5" aluminum irrigation pipe through levee.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL		2138+80.00	2 inch galvanized steel irrigation pipeline through levee	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL		2178+37.42	16 inch steel irrigation pipe through levee. Slide gate in 36 inch concrete standpipe at the waterside toe. Concrete distributation box at the landside toe.	Gravity lines	Typical design 3b	24" - 36"	Metal	Single
	FRWL		2201+91.82	Abandoned 10 inch reinforced concrete encased steel irrigation pipe through levee. Slide gate in 24 inch concrete standpipe at the waterside toe.	Abandoned lines (below DWSE)	Typical design 2b	12" - 24"	Concrete	Single
	FRWL		2239+56.18, 2244+80.00	24 Inch CM drain pipe through levee. Concrete headwall at both toes and automatic Drainage Gate in 36 inch concrete standpipe on berm.	Gravity lines	Typical design 3b	12" - 24"	Metal	2 penetrations
	FRWL		2248+70.49	Underground telephone cable through levee at south side of paved road over levee.	Communication conduits (above DWSE)	Typical design 3a	12" or less	Metal	Single
	FRWL		2250+76.10	24 Inch CM irrigation pipe through levee. Slide gate in 36 inch CM pipe riser on the waterside slope and slide gate in 48 inch RCP standpipe on landside toe.	Gravity lines	Typical design 3b	12" - 24"	Metal	Single
	FRWL		2256+60.63	24 Inch reinforced concrete encased CM irrigation pipe through levee. Slide Gate in 36 inch CM pipe riser on the waterside slope. Buried Automatic Drianage Gate outlet.	Gravity lines	Typical design 3b	12" - 24"	Concrete	Single
	FRWL		2257+15.00, 2260+95.00	24 Inch CM pipe through levee. Concrete saddle and apron with Calco Slide gate. Calco automatic drainage gate.	Gravity lines	Typical design 3b	12" - 24"	Metal	2 penetrations
	FRWL		2262+64.78	24 Inch CM drain pipe through levee with landside headwall. Automatic Drainage Gate on the waterside end with splash pan but no headwall.	Gravity lines	Typical design 3b	12" - 24"	Metal	Single
	FRWL		2268+26.63	24 Inch reinforced concrete encased CM irrigation pipe through levee Landside buried and slide Gate in 36 inch CM pipe riser on the waterside slope with waterside outlet broken off and plugged.	Gravity lines	Typical design 3b	12" - 24"	Concrete	Single
	FRWL		2274+56.00	24 Inch CM pipe through levee. Concrete saddle and apron with Calco automatic drainage gate.	Gravity lines	Typical design 3b	12" - 24"	Metal	Single
	FRWL		2274+86.40	24 Inch reinforced concrete encased CM drainage pipe through leve Slide Gate in 36 inch CM pipe riser on the waterside slope. been blocked.	Gravity lines	Typical design 3b	12" - 24"	Concrete	Single
	FRWL		2283+41.59	24 Inch reinforced concrete encased CM irrigation pipe through levee. Slide Gate in 36 inch CM pipe riser on the waterside slope.	Gravity lines	Typical design 3b	12" - 24"	Concrete	Single
	FRWL		2283+62.00	24 Inch CM pipe through levee. Concrete saddle and apron with Calco automatic drainage gate.	Gravity lines	Typical design 3b	12" - 24"	Metal	Single
	FRWL		2352+96.00, 2353+04.00	24 Inch CM pipe through levee. Concrete saddle and apron with Calco automatic drainage gate.	Gravity lines	Typical design 3b	12" - 24"	Metal	2 penetrations
S7-J	WCEL	0.02	105.6	3-1/2-inch steel gas line through the levee, 3.0 feet below the crown. Bank rock revetted. (App. 5286 - Atlantic Oil CO.).	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
	WCEL	1.2	6336	18-inch steel irrigation pipe through the levee, 3.7 feet below the crown. Siphon breaker on the water ward slope. Pump on channel bank on steel structure. (App. 1605 - Schnable) Service pole at the water ward toe. Anchor in water ward slope. (App 1631-Schnable).	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	WCEL	1.24	6547.2	4-inch steel conduit attached to downstream side of bridge. Two buried telephone cables through the levee, 2.6 feet below crown. (App. 6906 13362 - PT&T).	Communication conduits (above DWSE)	Typical design 3a	12" or less	Metal	Single
	WCEL	1.24	6547.2	12-inch gas line through the levee and attached to the upstream side of Franklin Road bridge. (App. 7676 - Anacapa Oil Corp)	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	WCEL	1.26	6652.8	Underground telephone cable through the levee, 2.6 feet below the ground. (App. 6906 - PT&T).	Communication conduits (above DWSE)	Typical design 3a	12" or less	Metal	Single
	WCEL	1.87	9873.6	14-inch steel irrigation pipe through the levee, 5.7 feet below the crown. Siphon breaker on landward side. Vertical pump on water ward side. Meter pole on berm.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	WCEL	3.04	16051.2	7-inch steel gas line through the levee, 1.1-feet below the crown. (App. 764 & 9191 - PG&E).	Communication conduits (above DWSE)	Typical design 3a	12" or less	Metal	Single

	WCEL	3.06	16156.8	36-inch CM drain pipe through the levee, 14-feet below the crown. Lap gate on waterward end.	Gravity lines	Typical design 3b	24" - 36"	Metal	Single
	WCEL	3.54	18691.2	24-inch steel irrigation pipe through the levee, 11.0 feet below the crown. Slide gate in 4-foot by 6-foot concrete distribution box at the waterward toe. Vertical pump mounted on a timber structure in channel. Service pole on the berm.	Gravity lines	Typical design 3b	12" - 24"	Metal	Single
	WCEL	4.37	23073.6	4-inch steel conduit through the levee, 2.3-feet below the crown. Telephone cable placed through conduit. Annular space between pipe and conduit grouted. The pipe is secured to downstream side of bridge. (App. 4680 PT&T).	Communication conduits (above DWSE)	Typical design 3a	12" or less	Metal	Single
	WCEL	4.38	23126.4	12-inch CM pipe through the levee, 8.7 feet below crown. Pipe is open at both ends.	Gravity lines	Typical design 3b	12" - 24"	Concrete	Single
S7-I	SBEL	7.5	77193.6	8-inch gas pipeline through levee, 2-feet below levee crown. (App. 13800-Greenleaf Power Corp.).	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" or less	Metal	Single
	SBEL	10.93	59083.2	Six 54-inch diameter reinforced concrete discharge pipes through levee, 21.2-feet below crown. Flap gates, slide gates in outlet structure and reinforced concrete headwall and splash apron on discharge end of the pipes on the waterward side of levee. Six 350 H.P. motors inside pumping plant structure on landward side. New State Drainage Pumping Plant No. 2 (1982). (App. 13021).	Minor/small pressurized lines (below DWSE)	Typical design 4	48" - 60"	Concrete	6 penetrations
	SBEL	11	58713.6	Five 4-feet by 6-foot concrete box culverts through levee, 31.0 feet below crown. Slide gates in concrete well on waterward shoulder. Flap gates and concrete headwall on waterward end. Wooden steps on landward slope. Concrete steps on waterward side.	Gravity lines	Typical design 3b	24" - 36"	Concrete	5 penetrations
	SBEL	11	58713.6	10-inch drainage pipe through levee, 7.0-feet below crown. Siphon breaker in a 36-inch CM pipe riser on waterward shoulder. Flap gate on waterward end. (App. 3165-DWR).	Gravity lines	Typical design 3b	12" or less	Metal	Single
	SBEL	13.55	45249.6	18-inch pipe through levee, 5.5- feet below crown. Siphon breaker in a 24-inch corrugated metal pipe riser on landward slope. Pump on pile structure in channel. Meter and pole on bank.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
S7-G	SBEL	14.68	39283.2	24-inch steel pipe through levee, 4.0-feet below crown. Siphon breaker in an 18-inch concrete pipe riser on landward shoulder. Pump on steel pile structure in the channel. (App. 1674-Etcheverry).	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	SBEL	14.89	38174.4	16-inch standpipe through levee, 3.5-feet below crown. Siphon breaker on landward shoulder. Discharges into a concrete lined irrigation ditch on the landward side. Pump on pile structure in stream. Meter and pole at waterward toe. Overhead power line crosses levee. Pole and anchor on waterward shoulder.	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single
	SBEL	19.47	13992	Three 4-foot by 6-foot concrete box culverts through levee, 26.0-feet below crown. Slide gates in a concrete riser on waterward shoulder. Flap gates and concrete headwall on waterward side. Concrete steps and staff gage on waterward slope.	Gravity lines	Typical design 3b	24" - 36"	Concrete	3 penetrations
	SBEL	19.47	13992	10-inch drainage pipe through levee, 4.0- feet below crown. Siphon breaker in 36-inch corrugated metal pipe riser on waterward shoulder. Flap gate on waterward end. (App. 3165-DWR).	Gravity lines	Typical design 3b	12" or less	Metal	Single
	SBEL	19.54	13622.4	Four 36-inch diameter reinforced concrete discharge pipes through levee, 20.0-feet below crown. Flap gates, slide gates in outlet structure and reinforced concrete headwall. Four 200 H.P. motors inside pumping plant structure on landward side New State Drainage Pumping Plant No. 1 (1981) (App. 13020).	Major/big pressurized lines (below DWSE)	Typical design 3b	24" - 36"	Concrete	4 penetrations
	SBEL	21.44	3590.4	24-inch steel pipe through levee, 3.0-feet below crown. Pump on wooden structure on bank. Siphon breaker on waterward shoulder. Discharges into irrigation ditch in field on landward side. (App. 1545-Hanatani).	Minor/small pressurized lines (above DWSE)	Typical design 3a	12" - 24"	Metal	Single

APPENDIX B

ENCROACHMENT INVENTORY

TYP 5

Reach	System	Stationing	Obstruction	Method	Length (ft)	Depth (ft)	
S5-A-Lower	FRWL	1900+00	Bridge crossing	DSM	110	65	
S5-C & S4-East	FRWL	1130+00	Railroad crossing	DSM	290	65	**
S5-D & S4-East	FRWL	1030+00	Bridge crossing	DSM	140	65	
	FRWL	1010+00	Bridge crossing	DSM	110	65	*
	FRWL	1010+00	Railroad crossing	DSM	85	65	
S7-F-Midle & S11	FRWL	98+00	Bridge crossing	DSM	110	65	
S7-G & S9-G	SBEL	300+00	Bridge crossing	DSM	110	40	
S7-J	WCEL	130+00	Bridge crossing	DSM	100	65	

** There might be overhead clearance constraints*

*** Down time cost might be expensive*

APPENDIX B
ENCROACHMENT INVENTORY
TYP 6 - 8

Increment	Description	Stationing USACE Stationing STA. System (USACE, preliminary)	STA. (Start)	STA. (End)	Length (LF)	Length (Mi.)
FRM Structural & Ecosystem Restoration Measures						
S4 (= S4-north + S4-south + S4-east + S4-west)	Yuba City Ring Levee	-	-	-	105,072	19.90
S4-north	Yuba City Ring Levee - Northern Portion	-	-	-	23,460	4.44
S4-south (= S6-south)	Yuba City Ring Levee - Souththern Portion	-	-	-	27,410	5.19
S4-east (= S5-D)	Yuba City Ring Levee - Eastern Portion	-	-	-	33,600	6.36
S4-west (= S6-west-lower)	Yuba City Ring Levee - Western Portion	-	-	-	20,600	3.90
S5-A-upper	Fix-In-Place Feather River West Levee - Geotechnical Reach A - Upper Part	Feather River - West Levee	1958+00	2372+17	41,417	7.84
S5-A-lower	Fix-In-Place Feather River West Levee - Geotechnical Reach A - Lower Part	Feather River - West Levee	1825+00	1958+00	13,300	2.52
S5-B	Fix-In-Place Feather River West Levee - Geotechnical Reach B	Feather River - West Levee	1432+00	1825+00	39,300	7.44
S5-C	Fix-In-Place Feather River West Levee - Geotechnical Reach C	Feather River - West Levee	1129+00	1432+00	30,300	5.74
S5-D	Fix-In-Place Feather River West Levee - Geotechnical Reach D	Feather River - West Levee	816+00	1129+00	31,300	5.93
S6 (= S6-south + S6-west-lower + S6-west-upper)	New-Levee Portion of Small J-Levee	-	-	-	54,390	10.30
S6-south (= S4-south)	New-Levee Portion of Small J-Levee - Southern Portion	-	-	-	27,410	5.19
S6-west-lower (= S4-west)	New-Levee Portion of Small J-Levee - Western Portion - Lower Part	-	-	-	20,600	3.90
S6-west-upper	New-Levee Portion of Small J-Levee - Western Portion - Upper Part	-	-	-	6,400	1.21
S7-D	Fix-In-Place Feather River West Levee - Geotechnical Reach D	Feather River - West Levee	603+00	816+00	21,300	4.03
S7-E-upper	Fix-In-Place Feather River West Levee - Geotechnical Reach E - Upper Part	Feather River - West Levee	512+00	603+00	9,100	1.72
S7-E-middle	Fix-In-Place Feather River West Levee - Geotechnical Reach E - Middle Part	Feather River - West Levee	479+00	512+00	4,310	0.82
S7-E-lower	Fix-In-Place Feather River West Levee - Geotechnical Reach E - Lower Part	Feather River - West Levee	420+00	479+00	5,900	1.12
S7-F-upper	Fix-In-Place Feather River West Levee - Geotechnical Reach F - Upper Part	Feather River - West Levee	200+00	420+00	22,000	4.17
S7-F-middle	Fix-In-Place Feather River West Levee - Geotechnical Reach F - Middle Part	Feather River - West Levee	47+00	200+00	15,300	2.90
S7-F-lower	Fix-In-Place Feather River West Levee - Geotechnical Reach F - Lower Part	Feather River - West Levee	10+00	47+00	3,700	0.70
S7-G	Fix-In-Place Sutter Bypass East Levee - Geotechnical Reach G	Sutter Bypass - East Levee	0+00	400+00	40,000	7.58
S7-H	Fix-In-Place Sutter Bypass East Levee - Geotechnical Reach H	Sutter Bypass - East Levee	400+00	493+00	9,300	1.76
S7-I	Fix-In-Place Sutter Bypass East Levee - Geotechnical Reach I	Sutter Bypass - East Levee	493+00	922+16	42,916	8.13
S7-J	Fix-In-Place Wadsworth Canal East Levee - Geotechnical Reach J	Wadsworth Canal - East Levee	0+00	244+00	24,400	4.62
S9-G	Sutter Bypass Setback Levee - Geotechnical Reach G	Sutter Bypass - East Levee	0+00	400+00	40,000	7.58
S9-H	Sutter Bypass Setback Levee - Geotechnical Reach H	Sutter Bypass - East Levee	400+00	493+00	9,300	1.76
S9-I	Sutter Bypass Setback Levee - Geotechnical Reach I	Sutter Bypass - East Levee	493+00	922+16	42,916	8.13
S10	Northern Feather River Setback Levee	Feather River - West Levee	1958+00	2372+17	27,984	5.30
S11	Sutter Bypass and Feather River Confluence Setback Levee	Feather River - West Levee	47+00	200+00	11,088	2.10
S12	Star Bend Setback Levee	Feather River - West Levee	479+00	512+00	3,341	0.63

	Levee Fix																												
	Structural Element 1									Structural Element 2									Structural Element 3									Length of Existing Levee to be removed (Mi)	Setback mitigation (Mi)
Increment	% of Total Length	Length (LF)	Length (Mi.)	Depth of Cutoff Wall (LF)	Height of Levee (LF)	Crest Width (LF)	Berm Height (LF)	Berm Width (LF)	Degrade Depth (LF)	% of Total Length	Length (LF)	Length (Mi.)	Depth of Cutoff Wall (LF)	Height of Levee (LF)	Crest Width (LF)	Berm Height (LF)	Berm Width (LF)	Degrade Depth (LF)	% of Total Length	Length (LF)	Length (Mi.)	Depth of Cutoff Wall (LF)	Height of Levee (LF)	Crest Width (LF)	Berm Height (LF)	Berm Width (LF)	Degrade Depth (LF)		
FRM Structural & Ecosystem Restoration Measures					SEE APPENDIX C									SEE APPENDIX C															
S4 (= S4-north + S4-south + S4-east + S4-west)	34%				8.0	20.0				34%			35.0	8.0	20.0				17%			65.0	25.0	15.0					
S4-north																													
S4-south (= S6-south)																													
S4-east (= S5-D)																													
S4-west (= S6-west-lower)																													
S5-A-upper	25%				17.5	19.0	12.0	12.0		100%			65.0	17.5	19.0			9.0											
S5-A-lower	25%				17.5	19.0	12.0	12.0		100%			65.0	17.5	19.0			9.0											
S5-B	75%				12.5	19.0	8.0	12.0		75%			65.0	12.5	19.0			6.0											
S5-C	25%				17.5	16.0	12.0	12.0		75%			65.0	17.5	16.0			9.0											
S5-D	10%				25.0	15.0	17.0	12.0		50%			65.0	25.0	15.0			13.0											
S6 (= S6-south + S6-west-lower + S6-west-upper)	50%				8.0	20.0				50%			35.0	13.0	20.0														
S6-south (= S4-south)																													
S6-west-lower (= S4-west)																													
S6-west-upper																													
S7-D	10%				15.0	25.0	10.0	12.0		50%			65.0	25.0	15.0			13.0											
S7-E-upper	10%				22.5	17.0	15.0	12.0		75%			65.0	22.5	17.0			11.0											
S7-E-middle	10%				22.5	17.0	15.0	12.0		75%			65.0	22.5	17.0			11.0											
S7-E-lower	10%				22.5	17.0	15.0	12.0		75%			65.0	22.5	17.0			11.0											
S7-F-upper	10%				22.5	13.0	15.0	12.0		75%			65.0	22.5	13.0			11.0											
S7-F-middle	10%				22.5	13.0	15.0	12.0		75%			65.0	22.5	13.0			11.0											
S7-F-lower	10%				22.5	13.0	15.0	12.0		75%			65.0	22.5	13.0			11.0											
S7-G	10%				22.5	22.0	15.0	12.0		100%			40.0	22.5	22.0			11.0											
S7-H	10%				20.0	22.0	13.0	12.0		100%			50.0	20.0	22.0			10.0											
S7-I	10%				20.0	22.0	13.0	12.0		100%			35.0	20.0	22.0			10.0											
S7-J	10%				15.0	24.0	10.0	12.0		50%			65.0	15.0	24.0			7.5											
S9-G																												7.58	1
S9-H																												1.76	0.3
S9-I																												8.13	0.7
S10	100%			75.0	20.0	20.0																						7.2	
S11	50%				22.5	20.0				50%			35.0	22.5	19.0													2.75	
S12	75%			65.0	25.0	20.0				25%			70.0	20.0	20.0			7.0										0.8	

	Special Items																										
	Pump Station		No. of structures to be relocated	Utility Conflicts	Obstructions																			New Ditch		Additional Asphalt (% of Total Length)
				Approximated % of total construction cost (for unidentified utility conflicts)	Local/ Minor Road Crossing (Raising)					Major Road Crossing (Flood Gates)			Major Road Crossing (Raising)			Major Road Crossing (Bridge)		Canal/Ditch Crossing (Closure Structures)					Stretch (Raising And Extending The Roads)				
Increment	Capacity (CFS)	Cost ($)			15-ft wide	20-ft wide	25-ft wide	30-ft wide	35-ft wide	50-ft wide	70-ft wide	90-ft wide	45-ft wide	70-ft wide	95-ft wide	Width (LF)	Length (LF)	20-ft wide	25-ft wide	30-ft wide	35-ft wide	50-ft wide	Width (LF)	Length (LF)	Width (LF)	Length (Mi)	
FRM Structural & Ecosystem Restoration Measures																											
S4 (= S4-north + S4-south + S4-east + S4-west)	919	$22,970,019		15%	-	17	3	-	-	4	-	-	-	1	1		-	5	-	1	1	1					-
S4-north	-	-		15%	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S4-south (= S6-south)	-	-		15%	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S4-east (= S5-D)	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					70%
S4-west (= S6-west-lower)	-	-		15%	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S5-A-upper	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S5-A-lower	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S5-B	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S5-C	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S5-D	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					70%
S6 (= S6-south + S6-west-lower + S6-west-upper)	919	$22,970,019		15%	-	8	2	-	-	1	-	-	-	1	1		-	5	-	1	1	1					-
S6-south (= S4-south)	-	-		15%	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S6-west-lower (= S4-west)	-	-		15%	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S6-west-upper	-	-		15%	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S7-D	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S7-E-upper	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S7-E-middle	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S7-E-lower	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S7-F-upper	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S7-F-middle	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S7-F-lower	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S7-G	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S7-H	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S7-I	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S7-J	-	-		-	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S9-G	-	-	4	25%	2	2	-	-	-	-	-	-	-		-		-	-	-	-	-	-	30-ft	600-ft	15-ft	17.5-mi	-
S9-H	-	-		25%	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S9-I	-	-		25%	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-
S10	-	-	72	15%				-	-	-	-	-	-		-		-	-	-	-	-	-					-
S11	-	-	10	15%	-		-	-	-	-	-	-	-		-	45-ft	3,300-ft	-	-	-	-	-					-
S12	-	-		15%	-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-					-

APPENDIX B
ENCROACHMENT INVENTORY
TYP 11

		Encroachment	Repair	Starting STA	Ending STA	Length (ft)	Culverts Minor	Culverts Major
FRWL	S5A-Upp							
	S5A-Low	85ft wide canal (landside, next to levee)	Left in place (cutoff wall required)	1956+00	1903+00	5,300	-	-
	S5B	50ft wide canal (landside, next to levee)	Left in place (cutoff wall required)	1766+00	1674+00	9,200	-	-
		60ft wide canal (landside, next to levee)	Left in place (cutoff wall required)	1623+00	1610+00	1,300	-	-
		45ft wide canal (landside, within 500ft distance from LS toe)	Left in place (cutoff wall required)	1560+00	1540+00	2,000	-	-
		45ft wide canal (landside, within 500ft distance from LS toe)	Left in place (cutoff wall required)	1524+00	1430+00	9,400	-	-
	S5C	15ft-30ft wide ditch (landside, next to levee)	Filled	1430+00	1375+00	5,500	-	-
		Swimming pool (landside, within 500ft distance from LS toe)	Left in place (cutoff wall required)	1348+00	-	-	-	-
	S5D = S4-East	Multiple swimming pools (landside, within 500ft distance from LS toe)	Left in place (cutoff wall required)	992+00	985+00	-	-	-
		Multiple swimming pools (landside, within 500ft distance from LS toe)	Left in place (cutoff wall required)	874+00	820+00	-	-	-
	S7D	Swimming pool (landside, within 500ft distance from LS toe)	Left in place (cutoff wall required)	746+00	-	-	-	-
		Swimming pool (landside, within 500ft distance from LS toe)	Left in place (cutoff wall required)	665+00	-	-	-	-
		140ftx140ft pump station pond (landside, within 500ft distance from LS toe)	Left in place (cutoff wall required)	648+00	-	-	-	
	S7E-Upp							
	S7E-Mid							
	S7E-Low							
	S7F-Upp	100ftx100ft pump station pond (landside, within 500ft distance from LS toe)	Left in place (cutoff wall required)	410+00	-	-	-	-
		20ft wide canal (landside, next to the levee)	Relocated (500ft away)	299+00	280+00	1,900	-	-
		30ft-35ft wide canal (landside, within 500ft distance from LS toe)	Filled	280+00	-	500	-	-
		10ft wide canal (landside, next to levee)	Relocated (500ft away)	280+00	215+00	6,500	2	-
	S7F-Mid							
	S7F-Low	15ft wide ditch (landside, next to levee)	Filled	47+00	10+00	3,700	-	-
SBEL	S7G	30ft-35ft wide ditch (landside, next to levee)	Relocated (500ft away)	96+00	400+00	30,400	5	1
		30ft wide ditch (landside, within 500ft distance from LS toe)	Filled	136+00	-	500	-	-
	S7H	30ft-35ft wide ditch (landside, next to levee)	Relocated (500ft away)	400+00	490+00	9,000	-	-
	S7I	30ft-35ft wide ditch (landside, next to levee)	Relocated (500ft away)	490+00	920+00	43,000	6	-
		170ftx170ft pump station pond (landside, within 500ft distance from LS toe)	Left in place (cutoff wall required)	78+00	-	-	-	-
WCEL	S7J	25ft wide ditch (landside, next to levee)	Relocated (500ft away)	25+00	230+00	20,500	5	2

TYP 9	Not enough information
& TYP 12	Assume an additional 5% of utility cost for all reaches except reach S5D and S4-East Assume an additonal 7% of utility cost for reach S5D and S4-East (urban levees)

TYP 10	Handled by RE

APPENDIX A

YUBA CITY RING LEVEE

FIELD TRIP SUMMARY

The current quantity and cost estimates for utility relocations for construction of the J and ring levees around Yuba City were prepared using aerial photography and an assumed percentage of the total construction first cost. A site visit was conducted on April 6th, 2012 by representative of Cost Engineering, Geotechnical Branch and Civil Design to field check relocations and potential levee alignments. The primary objective of the field trip was to visually identify any potential major utility relocation. The secondary objective was to determine if any major revisions of the proposed levee alignments should be made to refine the preliminary design. Because of limited access, the assessments were made mainly at nodes where the proposed levee alignments cross the public roads whereas the assessments along the proposed levee segments could only be made where visual projection from public roads/accesses permitted. The field trip revealed multiple overhead electrical lines (including some major transmission lines) and underground utility conduits (including telephone, fiber optic, water and gas lines) crossing the proposed levee alignments. It also appeared that many agricultural wells and risers are within the vicinity of the proposed levees' footprint. The levee alignments appeared to have been reasonably sited. Below is a list of potential relocations identified during the site visits.

1. Overhead electrical line: 31 total (27 distribution lines, 4 transmission lines)
2. Agricultural structure: 4 total (2 towers, 1 agriculture pump & riser, 1 agriculture well & riser)
3. Underground telephone conduit: 7 total
4. Underground fiber optic conduit: 3 total
5. Underground water pipeline: 4 total
6. Underground gas pipeline: 5 total
7. Construction site (RE related): 1 on-going construction site

For the estimating purposes, the followings show breakdown estimate per increment/reach:

- **Increment S4-south (= S6-south)**

1. Overhead electrical line: 12 distribution lines
2. Agricultural structure: 3 total (1 towers, 1 agriculture pump & riser, 1 agriculture well & riser)
3. Underground telephone conduit: 1 total
4. Underground fiber optic conduit: 0 total
5. Underground water pipeline: 0 total
6. Underground gas pipeline: 0 total
7. Construction site (RE related): 1 on-going construction site

- **Increment S4-west (= S6-west)**

1. Overhead electrical line: 5 total (4 distribution lines, 1 transmission lines)
2. Agricultural structure: 0 total
3. Underground telephone conduit: 4 total
4. Underground fiber optic conduit: 1 total
5. Underground water pipeline: 2 total
6. Underground gas pipeline: 3 total
7. Construction site (RE related): 0 on-going construction site

- **Increment S4-north**

1. Overhead electrical line: 14 total (11 distribution lines, 3 transmission lines)
2. Agricultural structure: 1 towers
3. Underground telephone conduit: 2 total
4. Underground fiber optic conduit: 2 total
5. Underground water pipeline: 2 total
6. Underground gas pipeline: 2 total
7. Construction site (RE related): 0 on-going construction sites

Appendix G – Content of Engineering Appendix to Feasibility Report
Revised Date: 2013-03-28

APPENDIX G
COST ENGINEERING

1. BASIS OF ESTIMATE

COST ESTIMATE FOR DRAFT ALTERNATIVE ARRAY

Cost estimates were developed to compare the draft array of alternatives presented in the Feasibility Study Report. These cost estimates were utilized to select the final array of alternatives and were based on a level 4 per requirement of ER 110-2-1302. In developing the reconnaissance level cost estimates of the various measures and alternatives (combined measures) for the Sutter Basin project, the Cost Engineering team utilized a methodology wherein costs for levee improvements or new levees (sans relocations) were developed using a parametric spreadsheet based on typical cross sections for differing types of levee improvements. Costs for relocations and construction other than that directly related to the levee were compiled based on either 1) historical costs - past levee projects in the vicinity of Sacramento, 2) estimating software MII (MCACES, 2nd Generation) or PACES, or 3) based on a percentage of construction costs. In lieu of the time constraints of the 24-month fast-track pilot study schedule, these methods were used for preparing costs for the purpose of selecting the final array of alternatives. Refer to Attachment A for further detail on the background and approach to developing cost estimates for the draft array of alternatives.

FEASIBILITY COST ESTIMATES FOR FINAL ALTERNATIVE ARRAY

The baseline feasibility cost estimates for the final array of alternatives (SB-1, SB-7 & SB-8) were developed using the design drawings provided by Civil Design. The quantities take-off calculations were provided by the Sacramento District's Civil Design section to produce the feasibility estimates. There are 41 Reaches spanning approximately 40 miles of levee. The breakdown of the alternatives by reach is further described in paragraph 2. Most of the geotechnical levee repair for the alternatives is to be accomplished with a soil-bentonite slurry wall constructed in the centerline of the levee. There are locations where jet grout, seepage berm or relief wells are also utilized but they are small in magnitude relative to the SB slurry wall. Of the 41 Reaches, there are several Reaches where no levee work is proposed (Reach 14, 15, 29, and 39).

Due to the large scope, the project is broken into construction contracts. To facilitate comparison to the local sponsor Early Implementation Project (EIP), similar contract reaches were utilized. These contracts have no impact on the total project cost. Based on the anticipated yearly funding availability, the reaches were combined in more manageable contracts, totaling approximately $40 million per contract per year for the feasibility study. Refer to tables in paragraph 5 for breakdown of contracts by reach.

2. PROJECT SCOPE/DESCRIPTION

There are three final Alternatives (SB-1, SB-7 & SB-8) to be evaluated for selection of the Tentatively Selected Plan (TSP). Alternative SB-1 is the No Action plan, which is to do nothing; hence a cost estimate was not created. It is assumed that Alternative SB-1 has no federal cost.

Alternative SB-7 is to Fix-in-Place the Feather River West Levee from the Sunset Weir to Laurel Avenue. The Alternative SB-7 project footprint extends from FRWL Reach 2 through 21. Alternative SB-8 is to Fix-in-Place the Feather River West Levee from Thermalito Afterbay to Laurel Avenue. The SB-8 project footprint extends from FRWL Reach 2 through 41. Alternative SB-8 is an incremental addition to Alternative SB-7 and all elements in Alternative SB-7 exist in Alternative SB-8.

Alternative SB-8 is almost equivalent to the Feather River West Levee Project (FRWLP) with the exception of Reach 6. At Reach 6, the Sponsor has constructed the Star Bend Setback Levee. However, during plan formulation the PDT proposed to have Reach 6 as a Fix-In-Place levee in lieu of Setback Levee because it is more cost effective. The Sponsor is seeking credit for work at this location. An estimate for the Star Bend Setback levee was created for cost comparison.

The designs for Alternatives SB-7 and SB-8 are similar in terms of levee remedial methods needed to reduce flood risk to the Sutter Basin. The vast majority of levee remediation is to reduce seepage by constructing a soil-bentonite slurry cutoff wall through the centerline of the levee and rebuild the levee to pre-project geometry. At some locations, seepage berms, relief wells, deep-soil-mixing, jet grout cutoff walls, canal relocations, and slight levee relocations to provide O&M access roads are included but they are minor relative to the soil-bentonite cutoff wall construction. Detail of the design remedial methods can be found in the Civil Design Appendix.

Along the FRWL, there are abandoned utilities that need to be removed. Active utilities such as pressure pipes, irrigation pipes, drainage pipes, electrical, sewer, gas, cable and water lines are to be removed and replaced in order to construct the soil-bentonite cutoff wall. Temporary utilities service is to be provided during the service outages. Roads on the levee crowns that must be removed in order to demolish or relocate utilities will be replaced.

3. MII COST ESTIMATE (SEE ATTACHED) – NOTES & ASSUMPTIONS

The MII estimate used the QTO's provided by Civil Design. An estimate on the construction contracts and years for Alternatives SB-7 and SB-8 is presented below in paragraph 5.

MCACES PROGRAM & LIBRARIES

The program and libraries used for the MCACES cost estimate are as follows:

a. MII version 4.1 Build 4

b. 2010 Cost Book

c. 2011 EP1110-1-8 Equipment Library for Region VII.

OVERTIME
Overtime is included in the estimate. Assumption is 10 hour workdays, 6 days per week.

ACQUISITION PLAN
Construction contracts are assumed to be Invitation For Bid (IFB), Competitive, Unrestricted Full and Open Competition and all businesses may respond.

CONTRACTING PLAN
The prime contractor is expected to be an earthwork contractor responsible for site work, borrow site excavation, levee degradation, slurry wall construction, and levee embankment reconstruction. The utilities penetration relocation is expected to be done by a specialty subcontractor. Material hauling, hydroseeding, jet grouting, asphalt pavement, and other miscellaneous work are expected to be performed by subcontractors.

SITE ACCESS
The project footprint follows the existing levee along the west bank of the Feather River, northernmost from Thermalito Afterbay and extending southernmost to near the Sutter Bypass and Feather River confluence. The levee is assumed to be maintained by local Reclamation Districts (RD) and it is expected that the levee is accessible from the landside. Staging areas or stockpile areas are constructed every 2,500 lineal feet along or near the levee landside /waterside toes. Stripped topsoil material, aggregate base, and levee degrade material can be readily stockpiled in the staging areas. Haul routes for import/export material is expected to be on existing roads and highways (no barge transport). No new roadway for site access is expected to be constructed.

BORROW/DISPOSAL AREAS
Borrow sources identified by the sponsor are incorporated into the estimate. A material balance calculation was performed by SPK's Civil Design and Cost Engineering sections using sponsor QTO's for levee fill materials (Types 1, 2 & Random) available at each borrow site. It was concluded that there is enough material to satisfy the fill demand for Alternatives SB7 and SB8. The suitability of the borrow source/material has been evaluated by the SPK Geotech Section (please refer to Geotechnical Engineering Appendix for detail). Non-hazardous unsuitable fill material is assumed to be used to backfill the borrow pits. Other construction waste is assumed to be disposed of off-site in accordance with local, state, and federal regulations. HTRW waste is assumed to be absent from the project. Construction waste can be safely disposed of within a 30 mile radius of the site.

CONSTRUCTION METHODOLGY
The construction methodologies for the soil-bentonite slurry wall excavation and placement are considered to be standard, except for deep walls (greater than 85 feet). Below this depth a conventional long reach hydraulic excavator cannot be used. The method provided in the cost estimate opts for the contractor to utilize a deep-soil-mixing (DSM) method for a design depth of

cutoff wall greater than 85 feet.

CONSTRUCTION WORK WINDOWS

Due to environmental and wildlife concerns (wildlife habitat, migratory season, mating season etc.) it is assumed that a normal construction season would typically span from the month of May through October. Typically, USACE and local flood agencies want the levee to be reconstructed by October due to the beginning of the storm season. This is a flood safety measure. Depending on local jurisdiction and permitting weather, construction tasks such as hydroseeding, asphalt pavement repair of levee crown, and associated work that does not undermine the structural integrity of the levee during a storm event may be permissible beyond October. The irrigation canal that runs parallel to the levee landside toe is operational from April through February. The construction window for work in the canal is limited from February through April. One approach for working around this limitation is to obtain an encroachment permit for a variance to work outside the normal construction season prior to working in the canal. Another approach is to install sheet pile cutoff walls to insure that the work within the levee does not lead to excessive seepage or possible failure of the canal bank. This second approach does not require a variance. For the purposes of the feasibility report, the estimate assumes installation of a sheet pile cutoff wall. Depending on the scope of work and pipe crossing type, each approach is site specific and will be more closely dealt with on a case by case basis in the PED phase.

UNIQUE TECHNIQUES OF CONSTRUCTION

In close proximity to existing bridge abutments, underground utilities, or railroad tracks, a jet grout cutoff wall is to be constructed in lieu of the slurry cutoff wall.

EQUIPMENT AND LABOR AVAILABILITY AND DISTANCE TRAVELED

The project is in Yuba City, an urban city environment and equipment & labor is readily available within a 100 mile radius of the site. No labor shortage is anticipated.

ENVIRONMENTAL CONCERNS

Environmental protection requires consideration of air, water, and land, and involves noise management, solid-waste management and management of other pollutants. In order to prevent or provide for abatement and control of any environmental pollution arising from construction, the Prime Contractor and Subcontractors in the performance of the contract shall comply with all applicable Federal, State, and local laws, as well as regulations concerning environmental pollution control and abatement. The Contractor shall use best management practices at all times to minimize the potential for environmental impacts.

LABOR RATES

This estimate meets the Davis Bacon wage rates for Davis Bacon Wage Determination for the State of California, General Decision Number: CA1220009 08/03/2012 CA9.

EQUIPMENT RATES

Equipment rates were obtained from quotes or verbal/telephone conversations and the MII 2011 EP1110-1-8 Equipment Library for Region VII.

MATERIAL COST
Material prices are obtained from vendor quotes, supply catalogs, previous estimates and the MII Cost Book.

SALES TAX
California State Sales tax is applied at 8.00%.

OMRR&R
The proposed project reaches of Alternatives SB-7 and SB-8 are currently maintained as part of the Federal Sacramento River Flood Control Project. The OMRR&R for the proposed project would be similar as the existing project. Therefore, no OMRR&R cost are included in the estimate. A qualitative analysis of the OMRR&R costs was performed to validate this assumption. Both alternatives are comprised almost entirely of installation of a soil-bentonite cutoff wall within the structural section of the levee. The levee will be reconstructed to existing pre-project geometry and meet USACE standards. The slurry wall will reduce the short term maintenance cost due to a reduction in seepage. The reconstruction of the upper half of the levee (side slopes, vegetation removal, grass re-establishment, and crown road replacement) will also reduce the short term maintenance cost. With the installation of the slurry wall, many of the existing relief wells can be decommissioned or converted to other functions and this would reduce short term maintenance costs. The Levee Safety requirements for typical levee cross-sections (side slopes, crown and O&M road widths, etc.) will somewhat increase the current maintenance costs due to a larger footprint of vegetation management. The replacement of utility and drainage pipe crossings would reduce maintenance costs in the short term. Overall, the short term OMRR&R will decrease. However, in long term the OMRR&R cost is about the same because the commitments remain unchanged.

LIFE CYCLE COST
A life cycle cost estimate was not performed for the study.

4. CONTRACTOR MARKUPS

Prime Contractor's Markups – Below is the breakdown of the Prime CTR markups.

Prime Contractor	Own Work	Sub Work
JOOH	10.00%	10.00%
HOOH	10.00%	10.00%
Profit	9.00%	5.00%
Bond	1.50%	0.00%

Subcontractors' Markups – Below is the breakdown of the general subcontractors' markups.

Piping/Relocation	Own Work

Jet Grout	Own Work

Paving	Own Work

HOOH	12.00%
Profit	10.00%

HOOH	11.00%
Profit	8.00%

HOOH	8.00%
Profit	8.00%

The contractor markups presented in the tables above are representative of past civil works estimates performed in the Sacramento region. Depending on the bidding environment and availability of work in the region, the contractor markups can be higher or lower but the markups are expected be near those shown above. It is assumed that the subcontractors will perform all of their own work and will not subcontract any portion of it.

In addition to the contractor markups, a direct cost markup for Small Tools is estimated at 2.00% of Labor costs.

5. CONSTRUCTION SCHEDULE (SEE ATTACHED)

Alternative SB-7 is expected to consist of five (5) construction contracts. Alternative SB-8 would consist of seven (7) construction contracts. With the exception of the Star Bend FIP contract, each contract is assumed to be completed in one construction season. Star Bend FIP is a relatively small contract and it is assumed it can be constructed concurrently in the same year with another contract. If funding permits, multiple contracts can be awarded in the same year. An approximation on the construction contracts and year(s) of construction is presented below. The schedule assumes the project gets authorized and appropriated through the construction window. This projection assumes that there is no funding shortage to implement the contract(s) in a given year.

SB-7			
CONTRACT		**FRWLP Reaches**	Year for Construction
A		2–5	2020-2021
STAR BEND FIP		6	2019-2020
B		7–12	2019-2020
C	C1	13-18	2017-2018
	C2	19-21	2018-2019

SB-8			
CONTRACT		**FRWLP Reaches**	Year for Construction
A		2–5	2022-2023
STAR BEND FIP		6	2021-2022
B		7–12	2021-2022
C	C1	13-18	2017-2018
	C2	19-25	2018-2019
D	D1	26-33	2019-2020
	D2	34-41	2020-2021

6. COST AND SCHEDULE RISK ANALYSIS (SEE ATTACHED)

The scope of the risk analysis was to calculate and present the cost and schedule contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110- 2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2- 573, Construction Cost Estimating Guide for Civil Works.

7. TOTAL PROJECT COSTS (SEE ATTACHED)

REAL ESTATE (01 Account)
The Real Estate cost estimate (Lands & Damages, Administrative cost and etc.) is performed by the SPK Real Estate Division and provided to the Cost Engineering section. It is understood that RE Division included its own contingencies (50%) in the RE estimate due to their knowledge and field of expertise (please refer to the Real Estate Appendix for more detail). The contingency provided by RE Division is independent of that derived from the Cost and Schedule Risk Analysis.

ENVIRONMENTAL MITIGATION (06 Account)
The Environmental Mitigation cost estimate is performed by SPK Environmental Planning and provided to Cost Engineering. It is understood that Environmental Planning included its own contingencies (20%) in the Environmental Mitigation estimate due to their experience and field of expertise. Environmental Mitigation includes costs for Riparian Forest, Oak Woodlands, Elderberry, Giant Garter Snake, Wetlands, Air Quality, and ETL Compliance (please refer to the Environmental Planning Appendix for more detail). Environmental Planning also provided costs for tree removal. Since this is a construction cost the contingency applied to this task will be that derived from the Cost and Schedule Risk Analysis.

CULTURAL RESOURCES (18 Account)
The Cultural Resources cost is estimated at one percent of the federal cost share.

PLANNING, ENGINEERING AND DESIGN (30 Account)
The cost for Planning, Engineering and Design (PED) is estimated at 18% of Construction Costs. This estimate has been used in recent years by the Sacramento District and is considered fair and reasonable.

CONSTRUCTION MANAGEMENT (31 Account)
The cost for Construction Management (CM) is estimated at 8.5% of Construction Costs. This estimate has been used in recent years by the Sacramento District and is considered fair and reasonable.

SUTTER PILOT STUDY, CALIFORNIA

LEVEE REPAIR ALTERNATIVES AND PARAMETRIC COST ESTIMATES

Contract No. W91238-10-A-0015, Call No. 0004

April 2012

Prepared for:

U.S. Army Corps of Engineers
Sacramento District
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Acronyms and Abbreviations

AACE	Association for the Advancement of Cost Engineering - International
DWR	Department of Water Resources
CVFPB	Central Valley Flood Protection Board
H:V	horizontal to vertical ratio
URS	URS Group, Inc.
USACE	United States Army Corps of Engineers

1.0 INTRODUCTION

1.1 Background and Scope

This report documents the parametric cost estimating services provided by URS Group, Inc. (URS) relative to the Sutter Pilot Study, California Project. URS provided these services as a subcontractor to Cumming Clarke under their Contract with the United States Army Corps of Engineers (USACE), No. W91238-10-A-0015, Call No. 0004.

Briefly, the scope of work included the following services:

- Attending a kickoff meeting with the USACE in Sacramento.
- Meeting with USACE civil and geotechnical engineers to obtain additional levee repair elements to be considered for the Sutter Pilot Study.
- Meeting with USACE cost estimators to agree upon the applicable unit pricing to be used to prepare cost estimates.
- Attending a Decision Point 2 meeting.
- Preparing up to 10 additional cost estimating templates for the repair elements to be included in the MII Toolbox. These templates can be used to systematically estimate the costs for levee repair measures composed of one or more elements identified by USACE.
- Prepare draft and final reports describing the work and presenting cost estimating results and supporting documentation.

URS prepared cost estimates using the MII templates adapted to the project that include specific details for the levee repair elements identified by the USACE.

1.2 Terminology

The following terminology is used in this report relative to levee repair options and cost estimating:

Element: An element is a discrete measure that can be selected and applied to repair an assessed levee deficiency. For example, a soil-bentonite slurry cutoff wall, including all associated construction activities, is an element that can be selected to repair underseepage deficiencies. Section 2.0 describes the elements in the MII Toolbox used for the Sutter Pilot Study.

Management Measure: An over-all approach to repairing deficiencies in a geographic area. For example, constructing a ring levee system at Yuba City, constructing a setback levee at Star Bend, fixing-in-place Feather River levees, and other repairs needed for a complete repair alternative.

Repair Measure: A repair measure is a selection of one or more elements that repair all of the deficiencies assessed for a levee segment or reach. For example, a slurry wall element and a levee widening element could be selected as a measure to repair underseepage and geometry deficiencies. The repair cost for the measure would be the sum of the costs for the selected elements comprising the measure.

Range Estimates: Additional estimates that could be prepared for a repair measure in which key parameters (like cutoff wall depth or crest width) are varied for the elements to evaluate how parameter variations might affect element cost and repair measure cost.

1.3 Quality Assurance

All of the cost estimates provided in this report were reviewed and checked in accordance with URS' Quality Control/Quality Assurance procedures. An independent technical review of the report was also performed by a qualified, independent senior engineer not directly associated with the estimating work or report preparation.

2.0 SELECTION OF MII TOOLBOX REPAIR ELEMENTS

URS developed templates to uniformly and systematically perform parametric cost estimating for Urban and Non-Urban Levee Evaluation Projects for the California Department of Water Resources (DWR), Division of Flood Management. The templates included 32 standardized levee repair elements that address seepage, instability, erosion, and geometry/freeboard deficiencies. USACE selected 9 element templates out of 32 available and URS customized the 9 as directed by USACE to meet the needs of the Sutter Pilot Study. Table 1 lists the nine selected element templates in the MII Toolbox.

Table 1. Element Templates Selected for the Sutter Pilot Study MII Toolbox

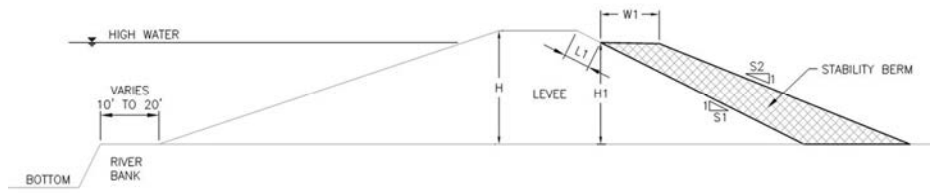
Element Template	Type of Deficiency Remediated
1. Stability Berm	Landside Slope Instability
2. Stability Berm with Relief Wells	Landside Slope Instability, Underseepage
3. Seepage Berm	Underseepage
4. Gravel Stability Berm	Through Seepage, Landside Slope Instability
5. Waterside Soil-Bentonite Slurry Cutoff Wall	Through Seepage, Underseepage, Slope Instability
6. Centerline Soil-Bentonite Cutoff Wall	Through Seepage, Underseepage, Seepage-Related Landside Slope Instability
7. New Levee	Through Seepage, Landside Slope Instability, Geometry
8. New Levee with Centerline Soil-Bentonite Slurry Cutoff Wall	Through Seepage, Underseepage, Landside Slope Instability, Geometry
9. Levee Crest Widening	Geometry

Each of the repair elements listed in Table 1 is described in more detail in Section 3.0.

3.0 DESCRIPTION OF MII TOOLBOX REPAIR ELEMENTS

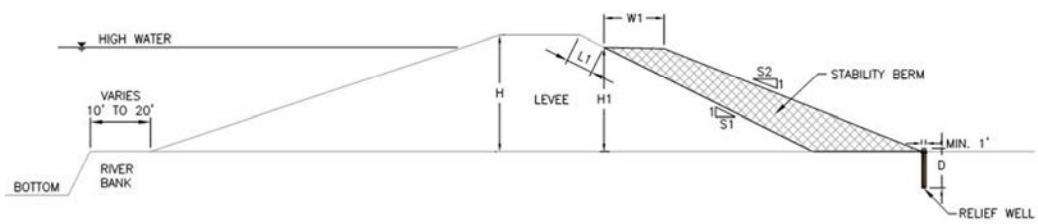
The nine standard repair element templates in the MII Toolbox were developed as building blocks that can be applied separately or in combinations along a levee segment or reach to: (1) provide a complete repair measure for levees with assessed deficiencies that are to be fixed-in-place, or (2) provide a repair measure involving new setback or ring levees. Appendix A provides a copy of the MII Toolbox. Each of the nine repair elements in the Toolbox is briefly described in the following sections. Note that the copy of the toolbox in Appendix A is a sample, generic copy provided for information only, and any data that may appear in this copy is not related to any of the project cost estimates presented in Section 8.0 and Appendix C.

3.1 Stability Berm Element



Typical details for the stability berm element are shown above. Letter dimensions are those typically required as input for the template (see stability berm template in Appendix A). The stability berm element can be used to repair landside instability. The crest width of the berm typically is set at 15 feet, but a larger or smaller width can be entered on the template to suite project requirements. The berm base width depends upon the landside slopes of the existing levee and the berm, and is calculated automatically within the template programming along with the earthwork volumes and other construction quantities needed for estimating.

3.2 Stability Berm with Relief Wells Element

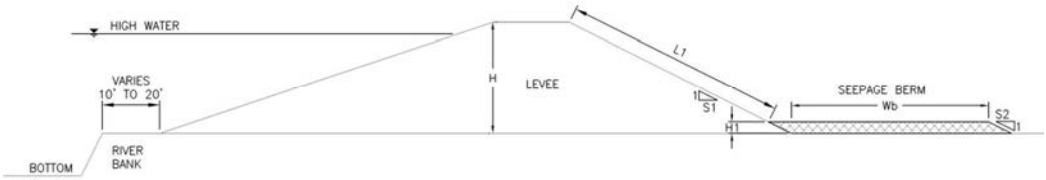


Typical details for the stability berm with relief wells element are shown above. Letter dimensions are those typically required as input for the template (see stability berm with relief wells template in Appendix A). The stability berm with relief wells element can be used to repair landside instability and underseepage. The crest width of the berm (W1) typically is set at 15 feet, but a larger or smaller width can be entered on the template to suite project requirements. The berm base width depends upon the landside slope of the existing levee and the berm and is calculated automatically within the template programming along with the earthwork volumes and other construction quantities needed for estimating.

The depth of the relief well (D) is also an input parameter required on the template. For estimating, the default spacing between wells on the template is set to 75 feet measured

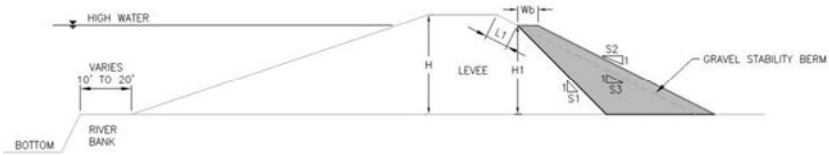
along the landside toe. This spacing can be varied but a simple change to the template programming would be required.

3.3 Seepage Berm Element



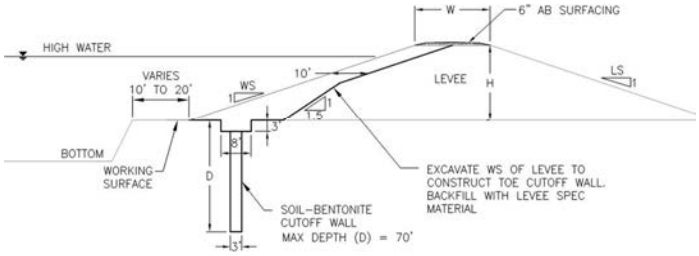
Typical details for the seepage berm element are shown above. Letter dimensions are those typically required as input for the template (see seepage berm template in Appendix A). The seepage berm can be used to remediate underseepage. The thickness of the berm (H1) and the width of the berm (W_b) are required input parameters. Earthwork and other quantities needed for estimating are calculated automatically within the template programming.

3.4 Gravel Stability Berm Element



Typical details for the gravel stability berm element are shown above. Letter dimensions are those typically required as input for the template (see gravel stability berm template in Appendix A). The gravel stability berm can be used to remediate through seepage and landside slope instability. The crest of the berm can selected by the user, but a minimum width of 8 feet should be assumed to facilitate placement and compaction of the fill material by construction equipment. The berm base width depends upon the slope of the existing levee and the berm and is calculated automatically within the template programming along with the excavation, fill, and other quantities needed for estimating.

3.5 Waterside Soil-Bentonite Slurry Cutoff Wall Element

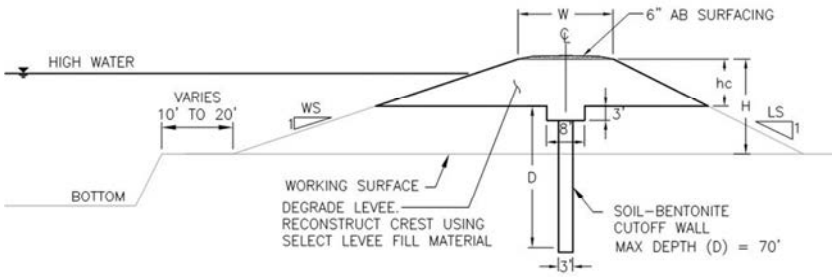


Typical remediation details for the waterside soil-bentonite slurry cutoff wall element are shown above. Letter dimensions are those typically required as input for the template (see waterside soil-bentonite slurry cutoff wall template in Appendix A). The waterside soil-

bentonite slurry cutoff wall can be used to remediate underseepage for a levee and improve the waterside slope if needed.

This template also allows the user to enter an estimate of the percentage of the degrade excavation material that could be stockpiled and reused to reconstruct the levee following slurry wall construction. Reusable material is stockpiled and replaced, and the quantity of imported material required to reconstruct the levee is reduced by the reusable material quantity. The default value for reusable material is zero percent.

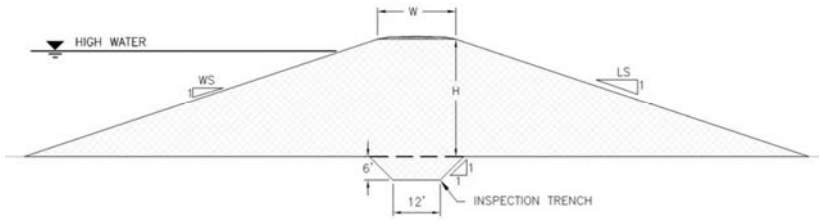
3.6 Centerline Soil-Bentonite Slurry Cutoff Wall Element



Typical remediation details for the centerline soil-bentonite slurry cutoff wall element are shown above. Letter dimensions are those typically required as input for the template (see centerline soil-bentonite slurry wall template in Appendix A). These cutoff walls can be used to remediate underseepage, and through seepage. The levee height (H), degrade amount (h_c), and cutoff wall depth (D) are selected by the user and excavation, backfill, wall construction, and other quantities required for estimating are calculated within the template programming.

This template also allows the user to enter an estimate of the percentage of the degrade excavation material that could be stockpiled and reused to reconstruct the levee following slurry wall construction. Reusable material is stockpiled and replaced, and the quantity of imported material required to reconstruct the levee is reduced by the reusable material quantity. The default value for reusable material is zero percent.

3.7 New Levee Element

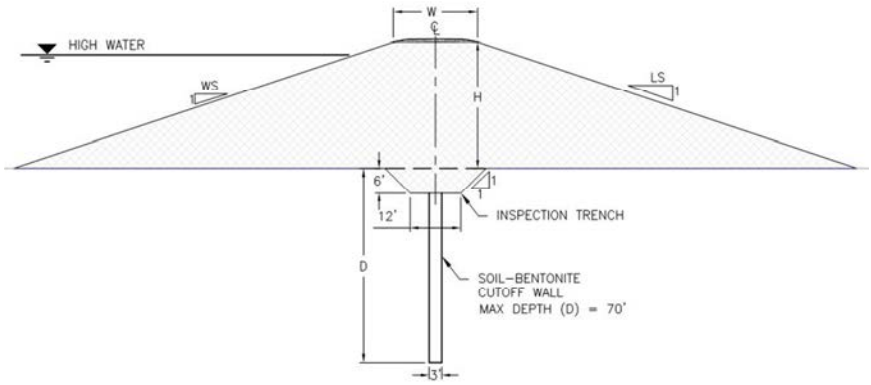


Typical remediation details for the new levee element are shown above. This element could be used as a setback levee or a ring levee. Letter dimensions are those typically required as input for the template (see the new levee template in Appendix A). The template includes an inspection trench in the foundation extending along the full length of the new levee. Finished slopes are set at 3 horizontal to 1 vertical (3H:1V) on both sides by default. These slopes can

be adjusted if needed. The levee height and crest width are selected by the user, and excavation, backfill, and other quantities required for estimating are calculated within the template programming.

This template also allows the user to enter an estimate of the percentage of material from the exploration trench that could be stockpiled and reused as backfill or levee fill. The default value for reusable material is zero percent. The template includes a 12-foot-wide aggregate base crest road and asphalt concrete surfacing can be added if needed over the aggregate base.

3.8 New Levee with Centerline Soil-Bentonite Cutoff Wall Element

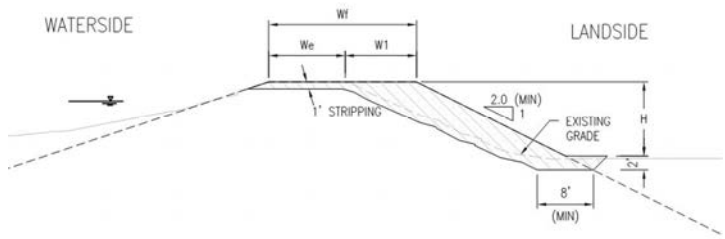


Typical remediation details for the new levee with centerline soil-bentonite cutoff wall element are shown above. Levee details are the same as those described for the New Levee in Section 3.7. Letter dimensions are those typically required as input for the template (see the new levee with centerline soil-bentonite cutoff wall template in Appendix A).

The template includes an inspection trench in the foundation under the levee. The slurry wall is installed from the bottom of the inspection trench down into an impermeable layer. While not specifically stated on the template, the wall depth for this element should not exceed 70 feet, which is the current practical limit for conventional slurry wall construction using long-reach excavators. For deeper cutoff walls, the template would be similar, but costs for other cutoff wall installation methods (such as deep soil mixing) would be needed for estimating.

By default, finished slopes are set at 3H:1V on both sides. These slopes can be adjusted if needed. The levee height (H), crest width (W) and cutoff wall depth (D) are selected by the user, and excavation, backfill, cutoff wall, and other quantities required for estimating are calculated within the template programming. The template includes a 12-foot-wide aggregate base crest road and asphalt concrete surfacing can be added if needed over the aggregate base.

3.9 Levee Crest Widening Element



Typical remediation details for the levee crest widening element are shown above. Letter dimensions are those typically required as input for the template (see the levee crest widening template in Appendix A). Widening is accomplished by filling on the landside of the levee. The fill detail includes an 8-foot wide toe key that should also prevent having to place sliver fills on the existing slope. If W1 is less than 4 feet, the finished landside slope can be adjusted to fit an 8-foot toe key base.

The levee height (H), existing and desired crest widths (We, W1, Wf), and finished landside slope (S) are selected by the user, and excavation, backfill, and other quantities required for estimating are calculated within the template programming.

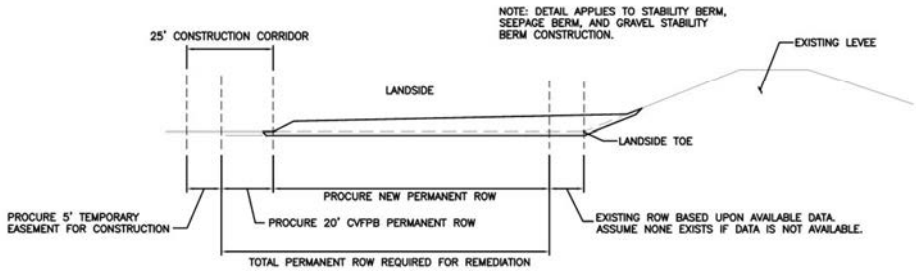
3.10 Executing the MII Toolbox

The MII Toolbox is a program-driven Microsoft Excel spreadsheet that calculates costs for each of the nine remediation templates based upon input information provided by the user. The program was developed using Microsoft Excel 2010. The MII Toolbox may not run correctly (if at all) on prior versions of Excel. Passwords are not required for the user to input data and prepare cost estimates. However, passwords are required to make any changes to the template or template programming.

4.0 ALLOWANCES AND CONTINGENCY

4.1 Right-of-Way Allowance and Cost

The nine element templates include provisions to procure new right of way or temporary easements for each repair element. Typical procurement limits for a seepage berm are shown below. Details would be similar for other elements.



Procurement includes the following components:

- Procuring the strip of land needed for new construction (base width of berms, base width of new levees, etc.).
- Procuring an additional 25-foot-wide strip of land on the landside as a construction corridor. Twenty feet of this corridor provides the Central Valley Flood Protection Board (CVFPB) permanent easement. The remaining 5 feet would be a temporary construction easement that, when combined with the CVFPB easement, provide a 25-foot-wide haul, stockpile, and access route along the landside of the work.
- Procuring an additional 15 feet of permanent easement on the waterside of new levees.

For fix-in-place repair measures, an easement is likely present along existing levees. However, due to time constraints for the current pilot study, it was not possible to research existing easements. Therefore, for the cost estimates provided in this report, it is assumed there are no existing easements. Researching existing easements and reducing the amount of new property acquisitions required by the amount of existing easements could be considered in future phases of the work. Existing easement widths can be entered on the various element templates in the future, but the current default value is set to zero.

Real estate costs for procuring permanent right-of-way depend upon land use. Table 2 provides the unit costs for land provided by USACE that are in the MII Toolbox. Cost is based upon the land use classification.

Table 2. Land Classifications and Procurement Costs

Land Classification	Procurement Cost (Per Acre)
1. Agricultural	$8,000
2. Orchard	$20,000
3. Industrial	$392,000
4. Residential	$260,000

4.2 Mobilization and Demobilization

Each element template includes an allowance of 5 percent of the direct construction cost to cover mobilization and demobilization. Land acquisition and environmental mitigation costs are not included in this calculation.

4.3 Unallocated Items

Each element template includes an allowance of 10 percent of the direct construction cost to cover miscellaneous direct costs not included with other line items in the estimate. These costs might include Storm Water Pollution Prevention Plan implementation, silt fencing, fencing and gates, developing staging and office areas, site maintenance, and the like. This percentage can be adjusted if necessary in the rate table.

4.4 Contingencies

Construction Contingency: Each element template includes a contingency of 30 percent applied to the direct construction cost, including mobilization and demobilization.

Land Acquisition Contingency: Each element template requiring temporary or permanent land acquisition includes a 35 percent allowance on the land cost comprised of 25 percent for contingency and 10 percent for severance.

4.5 Environmental Mitigation

Each element template includes a factor to estimate environmental mitigation. This factor can be selected to be either 25 percent or 35 percent of the construction cost (including mobilization and demobilization and construction contingency). Any projects involving wetlands, waterside wet work, or listed and endangered species should use the higher percentage.

4.6 Other Owner Costs

Other owner costs will be included on the USACE summary cost sheets for the project. These costs will include engineering and design, engineering support during construction, construction management, site inspections during construction, and escalation. Even though these costs are listed on the various templates, they are assigned a zero value for the estimates provided in this report.

5.0 COST ESTIMATE ACCURACY

The order-of-magnitude cost estimates developed by the element templates and presented in this report are Class 4 estimates as defined by the Association for Advancement of Cost Engineering International (AACE) in Report No. 18R-97, Cost Estimate Classification System as Applied in Engineering, Procurement and Construction for the Process Industries (AACE, 2011).

Class 4 estimates are based upon limited project definition and are suitable for feasibility studies and evaluations similar to this pilot study project where site data and geotechnical analyses are limited.

6.0 UNIT RATES FOR ESTIMATING

6.1 Percentage Factors and Unit Rates

Table 3 summarizes the key percentage factors and unit rates included in the rate table that are used for the estimates included in this report.

Table 3. Unit Rates for Estimating in MII Toolbox

Cost Item	Percent Allowance	Unit	Unit Price ($)
Percent Factors			
Escalation	0	-	-
Contingency on Direct Construction Costs	30	-	-
Contingency on ROW and Temporary Easement Costs	35	-	-
Legal/Land Acquisition	5	-	-
Design and Engineering	0	-	-
Engineering During Construction	0	-	-
Construction Management/Site Inspection	0	-	-
Mobilization and Demobilization	5	-	-
Environmental Mitigation, Average 1	25	-	-
Environmental Mitigation, Average 2	35	-	-
Unit Rates			
Permanent Right Of Way, Agricultural	-	Acre	8,000.00
Permanent Right Of Way, Orchard	-	Acre	20,000.00
Permanent Right Of Way, Industrial/Commercial	-	Acre	392,000.00
Permanent Right Of Way, Residential	-	Acre	260,000.00
Temporary Easement	-	Acre	5,000.00
Clearing and Grubbing	-	Acre	5,000.00
Stripping	-	Acre	3,000.00
Excavation	-	CY	5.00
Stockpile/Reuse Suitable Material	-	CY	4.00
Unsuitable Material Disposal	-	CY	15.00
Foundation Preparation	-	SY	5.00
Select Levee Fill	-	CY	43.50
Gravel Berm Fill	-	CY	50.00
Berm Fill		CY	10.00
Aggregate Base	-	Ton	37.50
Asphalt Concrete Paving	-	SY	12.00
Hydroseeding	-	Acre	3,750.00
Rock Slope Protection	-	Ton	40.00
Drain Rock, Filter Layer, Geotextile (Drain Layers)	-	CY	60.00
Soil-Bentonite Slurry Wall, to 40’ Deep/Greater than 40’	-	SF	10.00/12.50

The percentage factors and unit rates, which are used on the various element cost estimating templates in the MII Toolbox, are stored in a unit rate table that is linked to the toolbox. The unit rate table from the Non-Urban Levee Remediation Project was the initial source of data for the MII Toolbox unit rate table. USACE reviewed these rates and URS incorporated their suggested updates and revisions into the rate table.

Note that some of the percentage factors for items in Table 3 are set to zero at the request of USACE. USACE will incorporate appropriate costs for these items, and other cost items not included in the URS scope of work, in the summary project estimates that they will prepare.

6.2 Basis for Unit Rates

The unit rates are considered to be mid-2010 values and do not reflect the lower than normal rates seen in bids tendered during the recent economic downturn.

6.3 Applying Percent Factors

The mobilization and demobilization factor is applied to the sum of the direct construction costs (excluding the construction contingency).

The construction contingency listed in Table 3 is applied to the sum of all of the direct construction costs, including mobilization and demobilization to estimate the construction cost shown on each template.

The real estate contingency and severance factor is applied to the sum of the permanent and temporary easement costs shown on each template. The legal/land acquisition factor is applied to the total right-of-way cost (including contingency and severance) to provide an allowance for the appraisal, legal, and documentation costs associated with the land acquisition.

The percentage factors for other cost items are typically applied to the construction cost.

7.0 LEVEE REPAIRS EVALUATED FOR THE SUTTER PILOT STUDY

7.1 Selected Levees

USACE identified approximately 22 Management Measures for the Sutter Pilot Study that involved constructing new setback or ring levees, repairing (fixing-in-place) existing levees, and other possible actions. Of these, 13 involved new levee or fix-in-place levee options for which costs can be estimated using MII Toolbox templates. Table 4 identifies these 13 Management Measures. URS prepared cost estimates for these Management Measures using the toolbox and the estimates are discussed in Section 8.0.

Table 4. Management Measures Estimated by URS

No.	USACE Designation	Management Measure Description
1.	S1	Biggs Ring Levee
2.	S2	Gridley Ring Levee
3.	S3	Live Oak Ring Levee
4.	S4	Yuba City Ring Levee
5.	S5	Feather River West Levee, Fix-in-Place, Thermalito to Shanghai Bend
6.	S6	Southern Portion of J-Levee
7.	S7	Feather River West Levee, Fix-in-Place, Shanghai Bend to Sutter Bypass, including Wadsworth Canal East Levee and Sutter Bypass East Levee
8.	S8	Butte Bypass
9.	S9	Sutter Bypass Setback Levee
10.	S10	Northern Feather River Setback Levee
11.	S11	Sutter Bypass and Feather River Confluence Setback Levee
12.	S12	Star Bend Setback Levee
13.	S24	New Gilsizer Cross Levee with Flap Gates

The extent of each of the projects is shown in Figure 1 through Figure 4.

7.2 Levee Repair Measures

Table 5 lists the levee repair measure elements selected by USACE for each of the 13 levees Management Measures included in Table 4. Appendix B includes Levee Remediation Measure Worksheets for the repair measure elements. These worksheets provide the input data needed for cost estimating using the MII Toolbox, including elements selected to form the repair measure, the length of the element, the input parameters required to estimate costs using the toolbox templates for each element, and the land classifications that exist along the repair element length.

Table 5. USACE Repair Measures and Elements

USACE Designation	Management Measure	Total Length (Feet)	Repair Elements	Element Length (Feet)
S1	Biggs Ring Levee	21,648	New Levee New Levee with SB Cutoff Wall	16,236 5,412
S2	Gridley Ring Levee	32,736	New Levee New Levee with SB Cutoff Wall	24,552 8,184
S3	Live Oak Ring Levee	33,792	New Levee New Levee with SB Cutoff Wall	25,344 8,448
S4	Yuba City Ring Levee			
	East Side (River) (Fix-in-Place)	33,600	Levee Crest Widening Only Centerline SB Cutoff Wall and Levee Crest Widening	16,800 16,800
	E-W Levee, North Side	23,460	New Levee New Levee with SB Cutoff Wall	11,730 11,730
	N-S Levee, West Side	20,600	New Levee New Levee with SB Cutoff Wall	15,450 5,150
	E-W Levee, South Side	2,7410	New Levee New Levee with SB Cutoff Wall	13,705 13,705
S5	Fix-in-Place, Feather River West Levee, Thermalito to Shanghai Bend			
	Reach 1	53,328	Gravel Stability Berm Centerline SB Cutoff Wall	13,332 53,328
	Reach 2	39,072	Gravel Stability Berm Centerline SB Cutoff Wall	29,304 29,304
	Reach 3	30,624	Gravel Stability Berm and Levee Crest Widening Centerline SB Cutoff Wall and Levee Crest Widening	7,656 22,968
	Reach 4	31,152	Gravel Stability Berm and Levee Crest Widening Centerline SB Cutoff Wall and Levee Crest Widening Levee Crest Widening Only	3,115 15,576 12,461

Table 5. USACE Repair Measures and Elements

USACE Designation	Management Measure	Total Length (Feet)	Repair Elements	Element Length (Feet)
S6	Southern Portion of J-Levee			
	South Side	27,410	New Levee New Levee with SB Cutoff Wall	13,705 13,705
	West Side - Lower	20,600	New Levee New Levee with SB Cutoff Wall	15,450 5,150
	West Side - Upper	6,400	New Levee New Levee with SB Cutoff Wall	4,800 1,600
S8	Butte Bypass	101,376	New Levee New Levee with SB Cutoff Wall	25,344 76,032
S9	Sutter Bypass Setback Levee			
	Reach 1 (Same as S7, Reach 4)	40,128	New Levee with SB Cutoff Wall	40,128
	Reach 2 (Same as S7, Reach 5)	9,504	New Levee with SB Cutoff Wall	9,504
	Reach 3 (Same as S7, Reach 6)	42,768	New Levee with SB Cutoff Wall	42,768
S10	Northern Feather River Setback Levee	27,984	New Levee with SB Cutoff Wall	27,984
S11	Sutter Bypass and Feather River Confluence Setback Levee	11,088	New Levee New Levee with SB Cutoff Wall	5,544 5,544
S12	Star Bend Setback Levee	4,224	Centerline SB Cutoff Wall New Levee with SB Cutoff Wall	1,056 3,168
S24	New Gilsizer Cross Levee with Flap Gates	32,000	New Levee New Levee with SB Cutoff Wall	11,200 20,800

8.0 COST ESTIMATES

Based upon the selected levee repair measures and repair elements described in Section 7.0, URS applied the MII Toolbox to prepare remediation cost estimates for each of the 13 Management Measures. Table 6 provides a summary of the cost estimates.

Table 6. Summary of Cost Estimates

USACE Designation	Management Measure Description	Cost ($)
S1	Biggs Ring Levee	34,237,000
S2	Gridley Ring Levee	71,573,000
S3	Live Oak Ring Levee	61,818,000
S4	Yuba City Ring Levee	
	East Side (River)	93,399,000
	North Side	46,996,000
	West Side	37,614,000
	South Side	92,999,000
		271,008,000
S5	Fix-in-Place, Feather River West Levee, Thermalito to Shanghai Bend	
	Reach 1	148,672,000
	Reach 2	83,591,000
	Reach 3	88,328,000
	Reach 4	90,766,000
		411,357,000
S6	Southern Portion of J-Levee	
	South Side	91,548,000
	West Side - Lower	36,770,000
	West Side - Upper	11,424,000
		139,742,000
S7	Fix-in-Place, Feather River West Levee, Shanghai Bend to Sutter Bypass, including Wadsworth Canal East Levee and Sutter Bypass East Levee	
	Reach 1	60,097,000
	Reach 2	60,268,000
	Reach 3	149,579,000
	Reach 4	99,269,000
	Reach 5	23,821,000
	Reach 6	84,235,000
	Reach 7	32,111,000
		509,380,000
S8	Butte Bypass	261,697,000
S9	Sutter Bypass Setback Levee	
	Reach 1 (Same as S7, Reach 4)	301,793,000
	Reach 2 (Same as S7, Reach 5)	60,172,000
	Reach 3 (Same as S7, Reach 6)	270,776,000
		632,741,000
S10	Northern Feather River Setback Levee	210,796,000
S11	Sutter Bypass and Feather River Confluence Setback Levee	79,756,000
S12	Star Bend Setback Levee	33,771,000
S24	New Gilsizer Cross Levee with Flap Gates	216,095,000

Appendix C provides the estimate backup. Each estimate begins with a summary cover page followed by the individual estimate templates for each repair measure. Note in Table 6 and Appendix C that multiple estimates are provided for many of the Management Measures in the project where the levee segment was subdivided into subreaches and different repair measure was selected for each subreach. The total cost for the Management Measure in these cases would be the sum of all of the subreach cost estimates.

URS understands that USACE will use some of the structure repair measure cost information provided on the estimates in Appendix C to compile and finalize comprehensive estimates for each identified project, including special items and other factors not included in the MII Toolbox estimates.

9.0 LIMITATIONS

Estimates provided in this report are Class 4 order of magnitude estimates.

The levee remedial elements and measures described in this report are for USACE planning purposes only and are based upon engineering judgment using limited available geotechnical data. Other remedial measures could be identified and selected for design after additional geotechnical and geological data are collected and detailed, levee-specific analyses are completed.

URS makes no warranty, express or implied, that actual encountered site and subsurface conditions will conform exactly to any conditions described in this report. URS' services were performed within the limits prescribed in the contract and by USACE, and with the customary thoroughness and competence of our profession.

This report is for the sole use of USACE. It may not be appropriate to satisfy the needs of others, or other levee remediation planning projects. Any use or re-use of any portion of this report by any entity other than DWR is at the sole risk of that user.

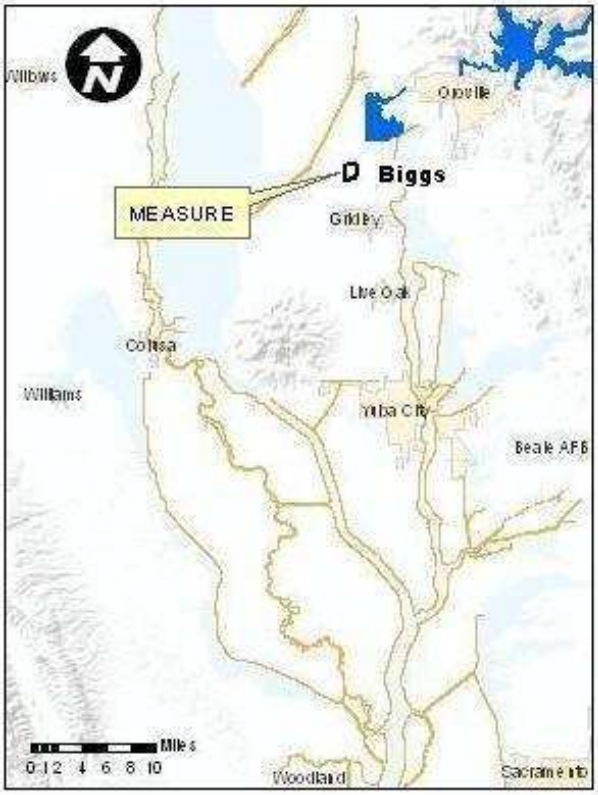
10.0 REFERENCES

This bibliography lists all documents and other information sources consulted to date and used to develop this report.

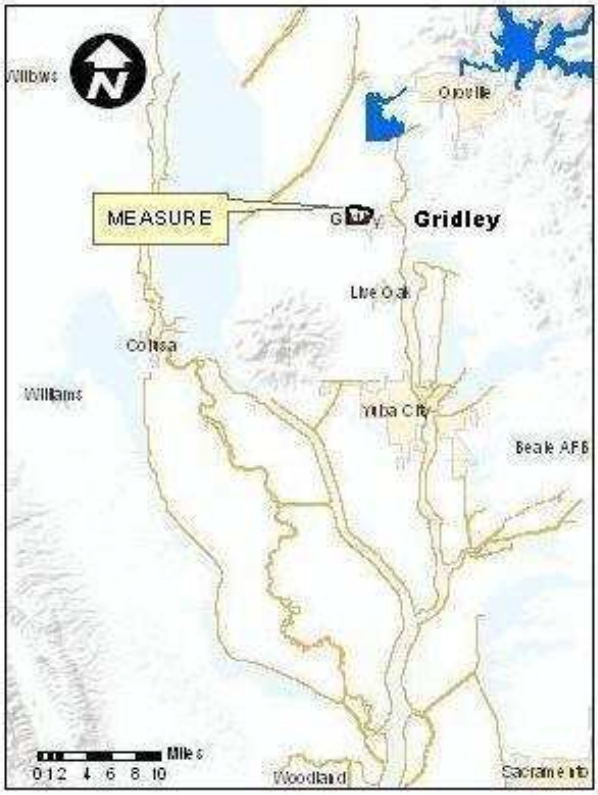
AACE, 2011. *Cost Estimate Classification System As Applied in Engineering, Procurement and Construction for the Process Industries (Report No. 18R-97),* January 15.

FIGURES

SUTTER PILOT STUDY, CALIFORNIA
MANAGEMENT MEASURE LOCATIONS

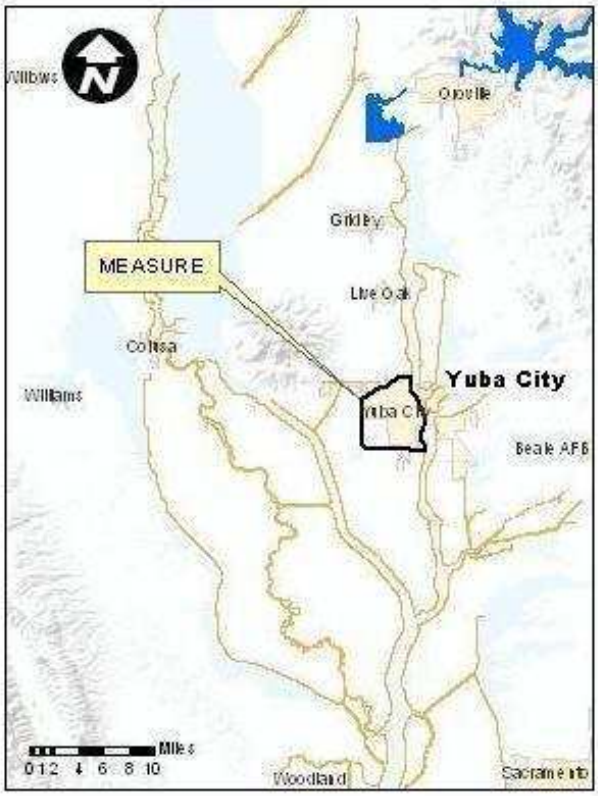


S1 - Biggs Ring Levee



S2 - Gridley Ring Levee

S3 - Live Oak Ring Levee



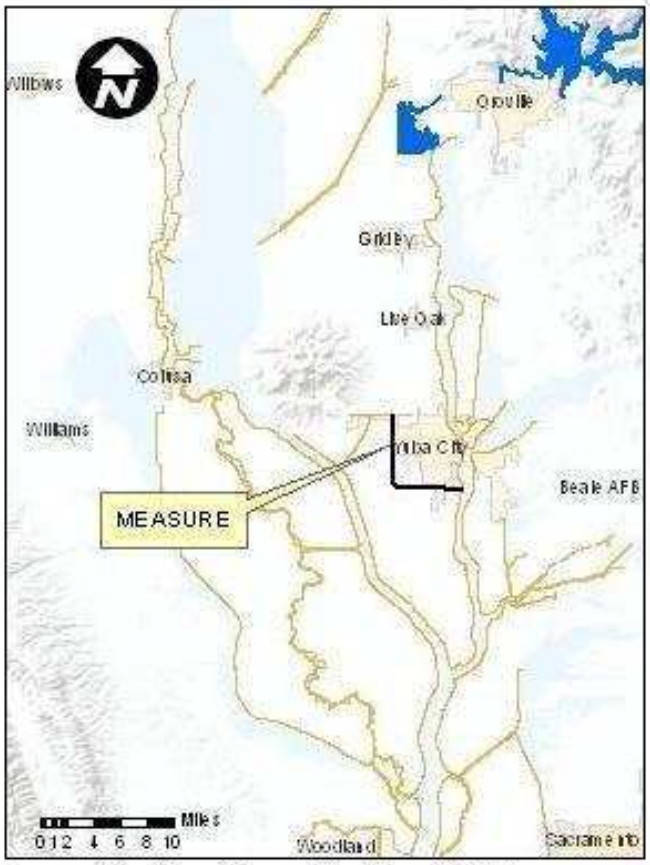
S4- Yuba City Ring Levee

Figures Provided By USACE

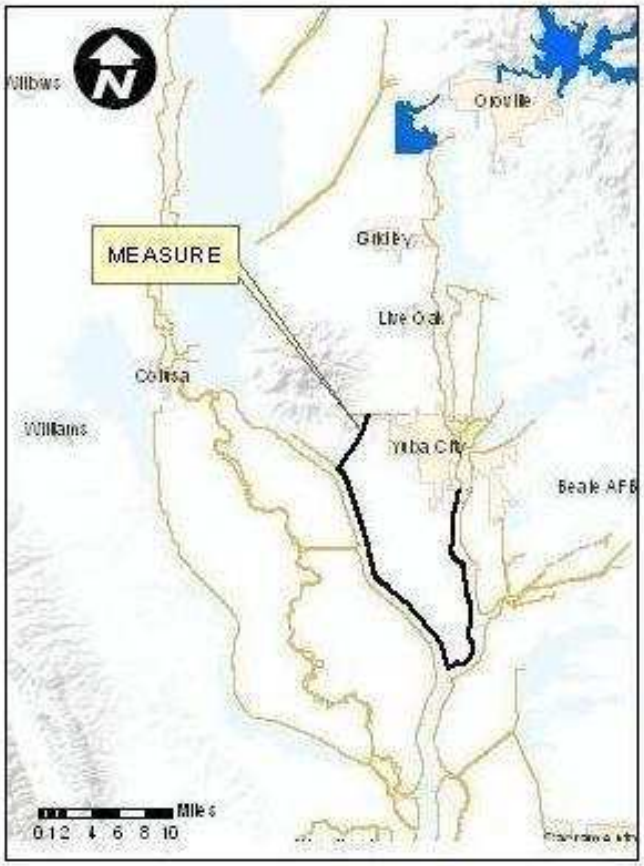
FIGURE 1

SUTTER PILOT STUDY, CALIFORNIA
MANAGEMENT MEASURE LOCATIONS

S5- Feather River West Levee Thermalito To Shanghai Bend



S6 - Southern Portion Of J-Levee



S7 - Feather River West Levee Shanghai Bend To Sutter Bypass

(Plus Wadsworth Canal East Levee and Sutter Bypass East Levee)

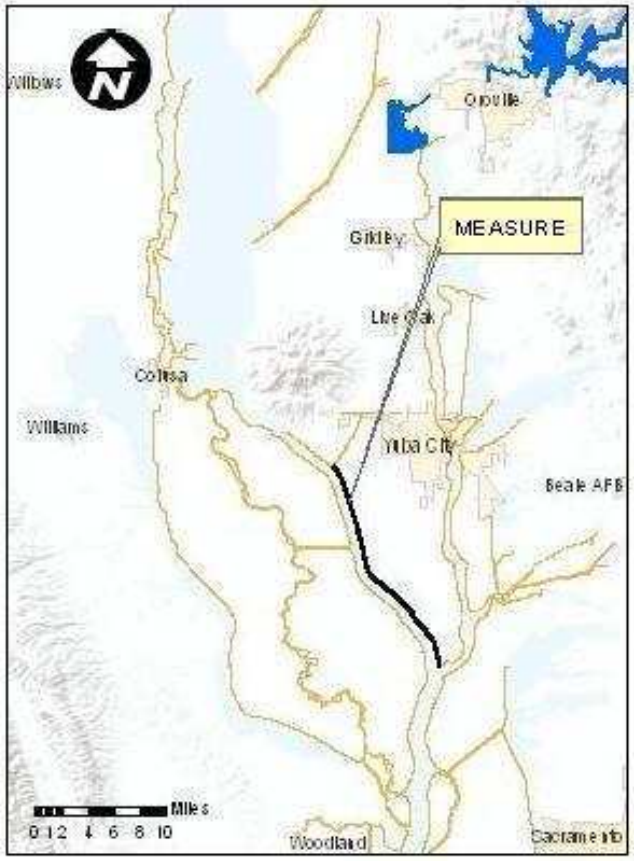
(Later)

S8 - Butte Bypass

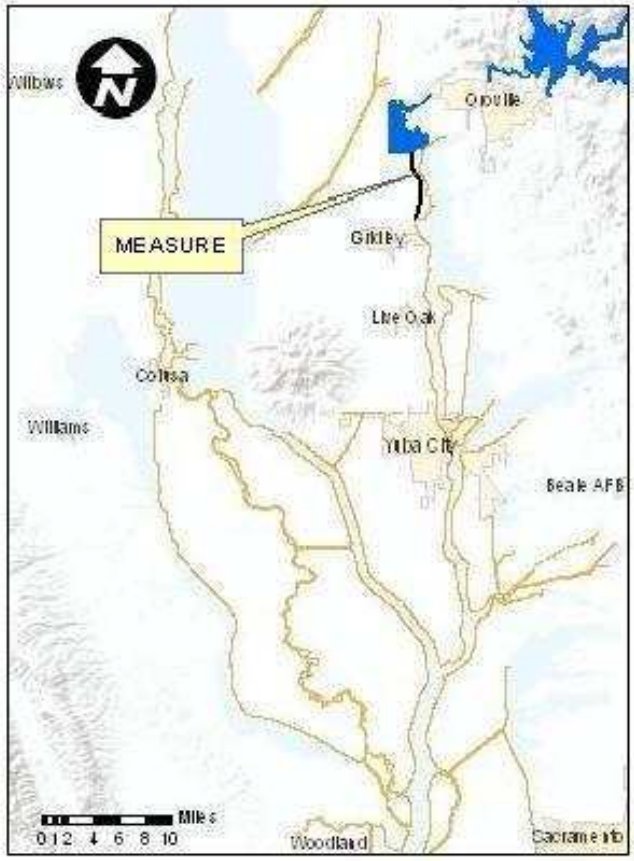
(Figures Provided by USACE)

FIGURE 2

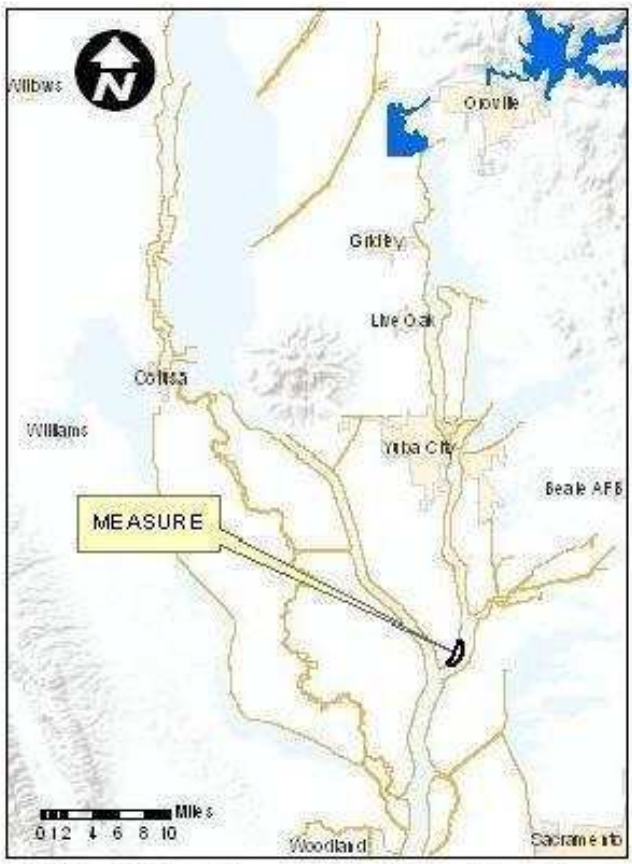
SUTTER PILOT STUDY, CALIFORNIA
MANAGEMENT MEASURE LOCATIONS



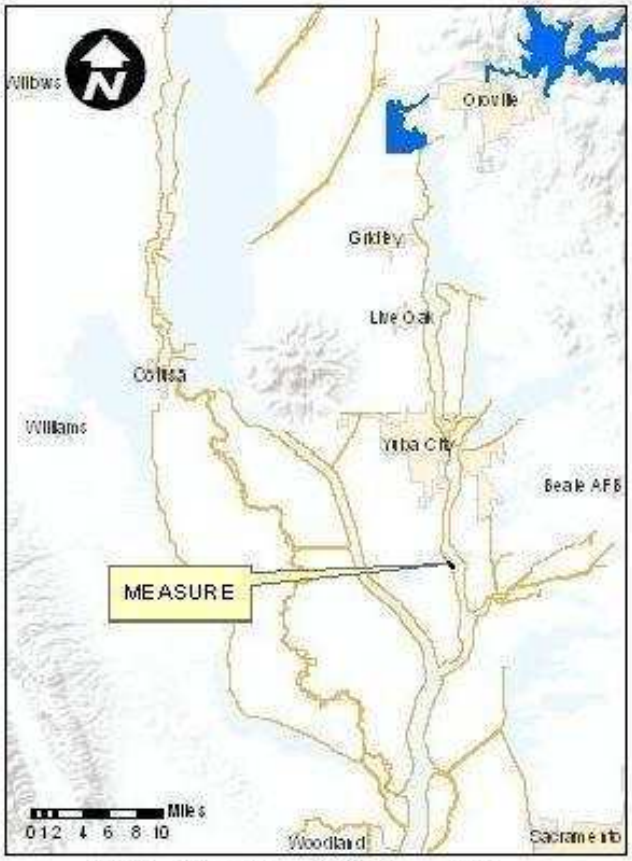
S9 - Sutter Bypass Setback Levee



S10 - Northern Feather River Setback Levee



S11 - Sutter Bypass And Feather River Confluence Setback Levee



S12 - Star Bend Setback Levee

Figures Provided By USACE

FIGURE 3

(Later)

S24 - New Gilsizer Cross Levee

(Figures Provided by USACE)

FIGURE 4

APPENDIX A
MII TOOLBOX

US Army Corps
of Engineers

MII Toolbox - Levees

Version 2010 Build 1

1. Fill in the site information form. Site Information

2. Select repair alternatives and input required data. Alternatives

3. Print cost estimate. Preview All

Project Site Information Entry Form

Project No:		
*Title:	SUTTER BASIN PILOT STUDY	
*Measure ID:	ID	Measures
Series:		
*Estimated By:		
*Date:		
*Price Basis:	2010	
*Escalation to:	2011	
* Total Segment Length		FT
Stationing		
Name		
*Study Area		
Levee Mile		
River Mile		
*Agency		
*Unit		

* Required

SUTTER BASIN PILOT STUDY

ESTIMATED BY:

DATE:

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: ID
SERIES:
TOTAL SEGMENT LENGTH (FT):

ID - Measures

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
							$ -

LS-TB-SB **Stability Berm**
LOCATION: ID - Measures

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 6.78	5% of sum Items 2 to 6, 9, and 11
2	02230	CLEARING AND GRUBBING	0.0018	ACRE	$ 5,000.00	$ 9.18	
3	02230	STRIPPING	0.0014	ACRE	$ 3,000.00	$ 4.20	
4	02300	BERM FILL	8.0000	CY	$ 10.00	$ 80.00	
5	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
6	02925	HYDROSEEDING	0.0016	ACRE	$ 3,750.00	$ 5.85	
9	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
11	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 12.33	Qty (%) x sum of Items 2 to 6 and 9
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 42.71	30% x sum of items above
		CONSTRUCTION COST				$ 185.08	Per Linear Foot

7	01000	PERMANENT RIGHT OF WAY (ROW)	0.0009	ACRE	$ 238,400.00	$ 224.39	
8	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 78.74	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 9.25	
		ROW AND TEMP EASEMENT COST				$ 312.95	
10	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 46.27	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	-	Segment Length (FT)
Repair Length		of Segment Length (enter percent with % sign)

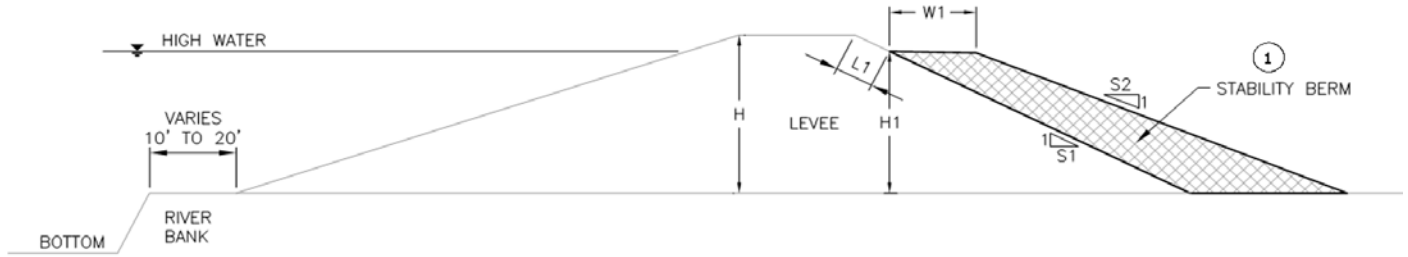
BUDGET AMOUNT	**$ -**	For the Specified Repair Length

Stability Berm

Major Quantity Zone:

(1) Berm Fill

		FT Existing ROW
Levee Geometry:		
H:	15	FT Levee Height
H1:	12	FT
L1:	6.71	FT
S1:	2	:1 Existing Slope
S2:	2.5	:1 Fill Slope
W1:	15	FT Berm Width



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 6, 9, and 11
2	02230	CLEARING AND GRUBBING	80	1	80	SF	Top of levee slope down to toe of
			Length	Length	0.00184	ACRE	berm + ROW + temporary easement
3	02230	STRIPPING	61	1	61	SF	Top of berm slope down to toe of
			Length	Length	0.00140	ACRE	berm + easement road width
4	02300	BERM FILL	216	1	216	CF	Zone 1
			Area	Length	8.00000	CY	
5	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
6	02925	HYDROSEEDING	68	1	68	SF	Top of levee slope down to disturbed area
			Length	Length	0.00156	ACRE	
7	01000	PERMANENT RIGHT OF WAY (ROW)	41	1	41	SF	Toe widening: berm width + ROW
			Length	Length	0.00094	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
8	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	for construction beyond CVFPB ROW
9	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table	Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

LS-TB-TW **Stability Berm with Relief Well**
LOCATION: ID - Measures

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 10.90	5% of sum Items 2 to 7, 10, and 12
2	02230	CLEARING AND GRUBBING	0.0018	ACRE	$ 5,000.00	$ 9.18	
3	02230	STRIPPING	0.0014	ACRE	$ 3,000.00	$ 4.20	
4	02300	BERM FILL	8.0000	CY	$ 10.00	$ 80.00	
5	02600	RELIEF WELL	0.3333	FT	$ 225.00	$ 75.00	
6	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
7	02925	HYDROSEEDING	0.0016	ACRE	$ 3,750.00	$ 5.85	
10	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
12	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 19.83	Qty (%) x sum of Items 2 to 7 and 10
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 68.70	30% x sum of items above
		CONSTRUCTION COST				$ 297.70	Per Linear Foot

8	01000	PERMANENT RIGHT OF WAY (ROW)	0.0009	ACRE	$ 238,400.00	$ 224.39	
9	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 78.74	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 14.88	
		ROW AND TEMP EASEMENT COST				$ 318.59	
11	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 74.42	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	-	Segment Length (FT)
Repair Length		of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ -**	For the Specified Repair Length

Stability Berm with Relief Well

Major Quantity Zone:

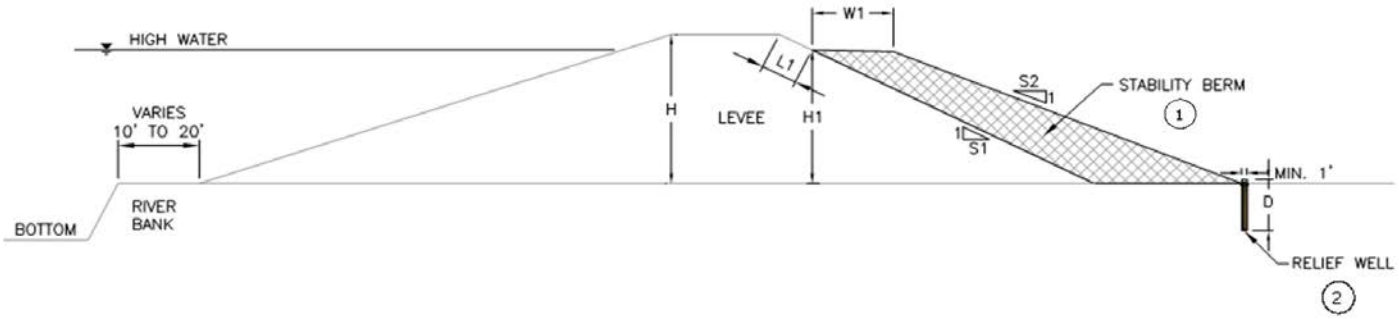
1 Berm Fill

2 Relief Well

		FT Existing ROW

Levee Geometry:

H:	15	FT Levee Height
H1:	12	FT
D	25	FT Relief Well Depth
L1:	6.71	FT
S1:	2	:1 Existing Slope
S2:	2.5	:1 Fill Slope
W1:	15	FT Berm Width



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 7, 10, and 12
2	02230	CLEARING AND GRUBBING	80	1	80	SF	Top of levee slope down to toe of
			Length	Length	0.00184	ACRE	berm + ROW + temporary easement
3	02230	STRIPPING	61	1	61	SF	Top of berm slope down to toe of
			Length	Length	0.00140	ACRE	berm + easement road width
4	02300	BERM FILL	216	1	216	CF	Zone 1
			Area	Length	8.00000	CY	
5	02600	RELIEF WELL	25	0.01333	0.33333		Zone 2: depth (FT) x quantity of wells
			Depth	No. of Wells	0.33333	FT	No. of well for 1 LF = 1 well / 75' spacing
6	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
7	02925	HYDROSEEDING	68	1	68	SF	Top of levee slope down to disturbed area
			Length	Length	0.00156	ACRE	
8	01000	PERMANENT RIGHT OF WAY (ROW)	41	1	41	SF	Toe widening: berm width + ROW
			Length	Length	0.00094	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
9	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
10	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table	Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

LS-TB **Seepage Berm**

LOCATION: ID - Measures

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 5.92	5% of sum Items 2 to 6, 9, and 11
2	02230	CLEARING AND GRUBBING	0.0020	ACRE	$ 5,000.00	$ 10.10	
3	02230	STRIPPING	0.0016	ACRE	$ 3,000.00	$ 4.68	
4	02300	BERM FILL	6.2222	CY	$ 10.00	$ 62.22	
5	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
6	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
9	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
11	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 10.76	Qty (%) x sum of Items 2 to 6 and 9
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 37.28	30% x sum of items above
		CONSTRUCTION COST				$ 161.53	Per Linear Foot

7	01000	PERMANENT RIGHT OF WAY (ROW)	0.0017	ACRE	$ 238,400.00	$ 415.94	
8	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 145.78	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 8.08	
		ROW AND TEMP EASEMENT COST				$ 570.37	
10	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 40.38	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	-	Segment Length (FT)
Repair Length		of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ -**	For the Specified Repair Length

Seepage Berm

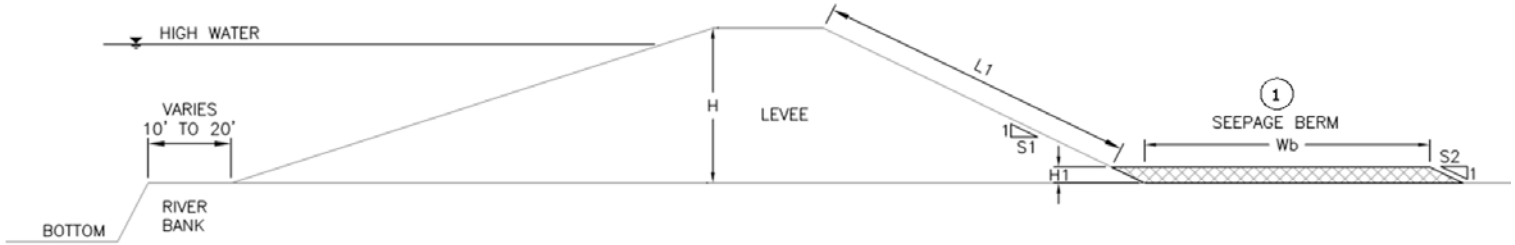
Major Quantity Zone:

(1) Toe Blanket Fill

		FT Existing ROW

Levee Geometry:

H:	15	FT Levee Height
H1:	3	FT
L1:	26.83	FT
S1:	2	:1 Existing Slope
S2:	2	:1 Fill Slope
Wb:	50	FT Berm Width



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 6, 9, and 11
2	02230	CLEARING AND GRUBBING	88	1	88	SF	Berm widening + ROW + temporary
			Length	Length	0.00202	ACRE	easement
3	02230	STRIPPING	68	1	68	SF	Berm widening + 12' AB easement road
			Length	Length	0.00156	ACRE	
4	02300	BERM FILL	168	1	168	CF	Zone 1
			Area	Length	6.22222	CY	
5	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
6	02925	HYDROSEEDING	76	1	76	SF	Berm widening + 13' ROW
			Length	Length	0.00174	ACRE	
7	01000	PERMANENT RIGHT OF WAY (ROW)	76	1	76	SF	Toe widening: berm width + ROW
			Length	Length	0.00174	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
8	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
9	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table		Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

LS-TB **Gravel Stability Berm**

LOCATION: ID - Measures

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 17.56	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	0.0015	ACRE	$ 5,000.00	$ 7.46	
3	02300	EXCAVATION	2.6667	CY	$ 5.00	$ 13.33	
4	02230	STRIPPING	0.0011	ACRE	$ 3,000.00	$ 3.17	
5	02370	GRAVEL BERM FILL	5.3333	CY	$ 50.00	$ 266.67	
6	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
7	02925	HYDROSEEDING	0.0012	ACRE	$ 3,750.00	$ 4.56	
10	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
11	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 31.92	Qty (%) x sum of Items 2 to 7 and10
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 110.61	30% x sum of items above
		CONSTRUCTION COST				$ 479.31	Per Linear Foot

8	01000	PERMANENT RIGHT OF WAY (ROW)	0.0006	ACRE	$ 238,400.00	$ 142.30	
9	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 50.00	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 23.97	
		ROW AND TEMP EASEMENT COST				$ 216.84	
10	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 119.83	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

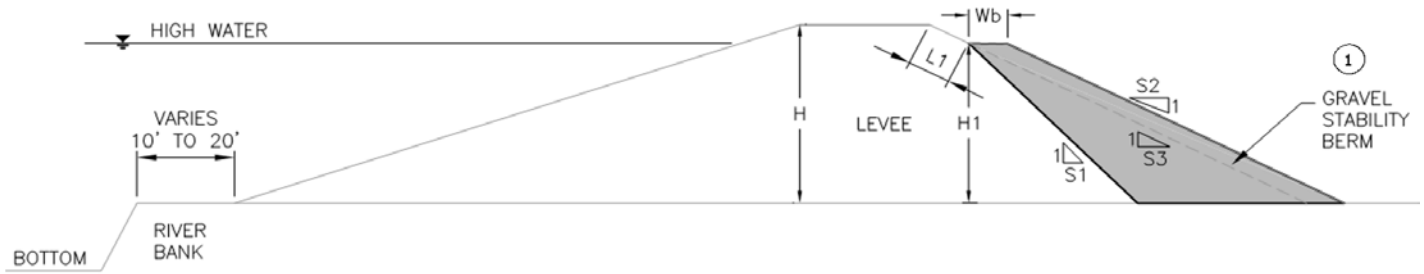
	-	Segment Length (FT)
Repair Length		of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ -**	For the Specified Repair Length

Gravel Stability Berm

Major Quantity Zone:

(1) Gravel Berm Fill



		FT Existing ROW

Levee Geometry:

H:	15	FT Levee Height
H1:	12	FT
L1:	6.71	FT
S1:	1	:1 Cut Slope
S2:	2	:1 Fill Slope
S3:	2	:1 Existing Slope (S2=>S3 Only)
Wb:	6	FT Berm Width

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	65	1	65	SF	Top of levee slope down to toe of
			Length	Length	0.00149	ACRE	berm + ROW + temporary easement
3	02300	EXCAVATION	72	1	72	CF	Material cut from S3 to S1
			Area	Length	2.66667	CY	
4	02230	STRIPPING	46	1	46	SF	Top of berm slope down to toe of
			Length	Length	0.00106	ACRE	berm + 12' AB easement road
5	02370	GRAVEL BERM FILL	144	1	144	CF	Zone 1
			Area	Length	5.33333	CY	
6	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
7	02925	HYDROSEEDING	53	1	53	SF	Top of levee slope down, disturbed area,
			Length	Length	0.00122	ACRE	and new slopes
8	01000	PERMANENT RIGHT OF WAY (ROW)	26	1	26	SF	Toe widening: Berm width + ROW
			Length	Length	0.00060	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
9	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
10	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table		Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

WS-SW-WSB **Waterside Soil-Bentonite Slurry Wall**
LOCATION: ID - Measures

Item No.	Spec No	Description	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 115.90	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.51	
3	02300	EXCAVATION	25.7778	CY	$ 5.00	$ 128.89	
4	02300	SELECT LEVEE FILL	24.1111	CY	$ 43.50	$ 1,048.83	
5	02300	UNSUITABLE MATERIAL DISPOSAL	24.1111	CY	$ 15.00	$ 361.67	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.5778	CY	$ 4.00	$ 10.31	
7	02260	SOIL-BENTONITE SLURRY WALL	40.0000	SF	$ 12.50	$ 500.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0018	ACRE	$ 3,750.00	$ 6.63	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 210.73	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 730.17	30% x sum of items above
		CONSTRUCTION COST				$ 3,164.09	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.000459	ACRE	$ 238,400.00	$ 109.46	
11	01500	TEMPORARY EASEMENT	0.000115	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 38.51	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 158.20	
		ROW AND TEMP EASEMENT COST				$ 306.75	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 791.02	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	-	Segment Length (FT)
Repair Length		of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ -**	For the Specified Repair Length

Waterside Soil-Bentonite Slurry Wall

Major Quantity Zone:

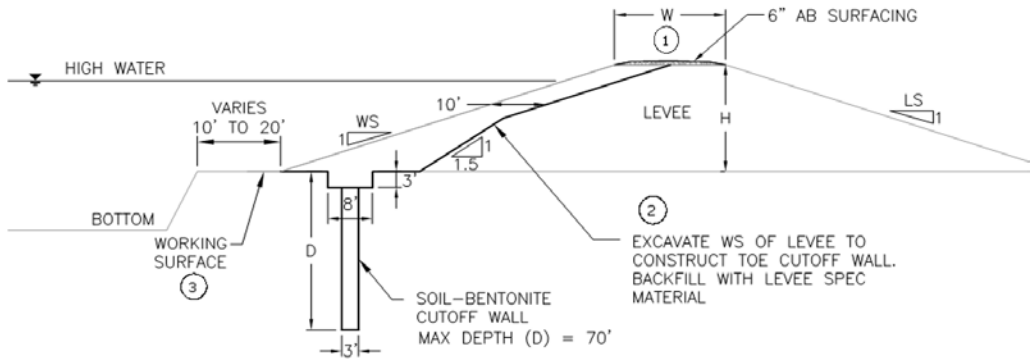
(1) Levee road - cut and fill area

(2) Select Levee Fill (3) SB Cutoff Wall

		FT Existing ROW

Levee Geometry:

H:	20	FT
W:	20	FT
D:	40	FT Cutoff Wall Depth from Working Surface*
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	10%	% of Reusable Material



Working Surface* = 40 ft Minimum

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	109	1	109	SF	Levee crest width, WS slope length, and
			Length	Length	0.00250	ACRE	ROW
3	02300	EXCAVATION	696	1	696	CF	Zone 2
			Area	Length	25.77778	CY	
4	02300	SELECT LEVEE FILL	651	1	651	CF	Zone 2
			Area	Length	24.11111	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	651	1	651	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	24.11111	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	69.6	CF	Reusable Material
			Area	Length	2.57778	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	40	1			
			Depth	Length	40.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	77	1	77	SF	Top of levee slope down to disturbed area
			Length	Length	0.00177	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent right of way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SW-SCBCW- **Centerline Soil-Bentonite**

LOCATION: ID - Measures

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 103.61	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0028	ACRE	$ 5,000.00	$ 14.00	
3	02300	LEVEE DEGRADE	16.6667	CY	$ 4.50	$ 75.00	
4	02300	SELECT LEVEE FILL	15.8889	CY	$ 43.50	$ 691.17	
5	02300	UNSUITABLE MATERIAL DISPOSAL	15.8889	CY	$ 15.00	$ 238.33	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	1.6667	CY	$ 4.00	$ 6.67	
7	02260	SOIL-BENTONITE SLURRY WALL	65.00	SF	$ 12.50	$ 812.50	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0021	ACRE	$ 3,750.00	$ 7.75	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 188.39	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 652.76	30% x sum of items above
		CONSTRUCTION COST				$ 2,828.62	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0005	ACRE	$ 238,400.00	$ 109.46	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 38.51	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 141.43	
		ROW AND TEMP EASEMENT COST				$ 289.97	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 707.15	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	-	Segment Length (FT)
Repair Length		of Segment Length (enter percent with % sign)

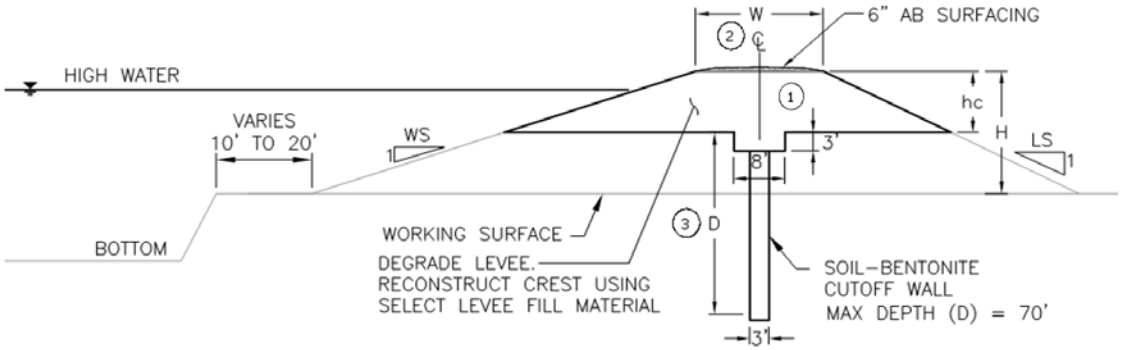
BUDGET AMOUNT	**$ -**	For the Specified Repair Length

Centerline Soil-Bentonite

Major Quantity Zone:

(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall



		FT Existing ROW

Levee Geometry:

H:	20	FT
W:	20	FT
hc:	10	FT Levee Degrade from Crest to Working Surface
D:	65	FT Cutoff Wall Depth from Working Surface
WS:	3	:1 (Waterside Slope)
LS:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	10%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	122	1	122	SF	LS slope length + temporary easement +
			Length	Length	0.00280	ACRE	ROW + W + 1/2 of WS slope length
3	02300	LEVEE DEGRADE	450	1	450	CF	Zone 2
			Area	Length	16.66667	CY	
4	02300	SELECT LEVEE FILL	429	1	429	CF	Zone 2
			Area	Length	15.88889	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	429	1	429	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	15.88889	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	45	1	45	CF	Zone 2 reusable material
			Area	Length	1.66667	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	65	1			
			Depth	Length	65.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	90	1	90	SF	Top of levee down to disturbed area
			Length	Length	0.00207	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent Right of Way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

LS-SL **New Levee**
LOCATION: ID - Measures

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 87.70	5% of sum Items 2 to 9 and 13 to 16
2	02230	CLEARING AND GRUBBING	0.0032	ACRE	$ 5,000.00	$ 15.84	
3	02230	STRIPPING	0.0025	ACRE	$ 3,000.00	$ 7.58	
4	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
5	02300	FOUNDATION PREPARATION	10.8889	SY	$ 5.00	$ 54.44	
6	02300	SELECT LEVEE FILL	32.0370	CY	$ 43.50	$ 1,393.61	
7	02300	UNSUITABLE MATERIAL DISPOSAL	3.5926	CY	$ 15.00	$ 53.89	
8	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0024	ACRE	$ 3,750.00	$ 9.13	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 159.46	Qty (%) x sum Items 2 to 9 and 14 to 16
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	0.4074	CY	$ 4.00	$ 1.63	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 552.51	30% x sum of items above
		CONSTRUCTION COST				$ 2,394.23	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0031	ACRE	$ 238,400.00	$ 727.90	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 254.96	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 119.71	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 1,103.15	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 598.56	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

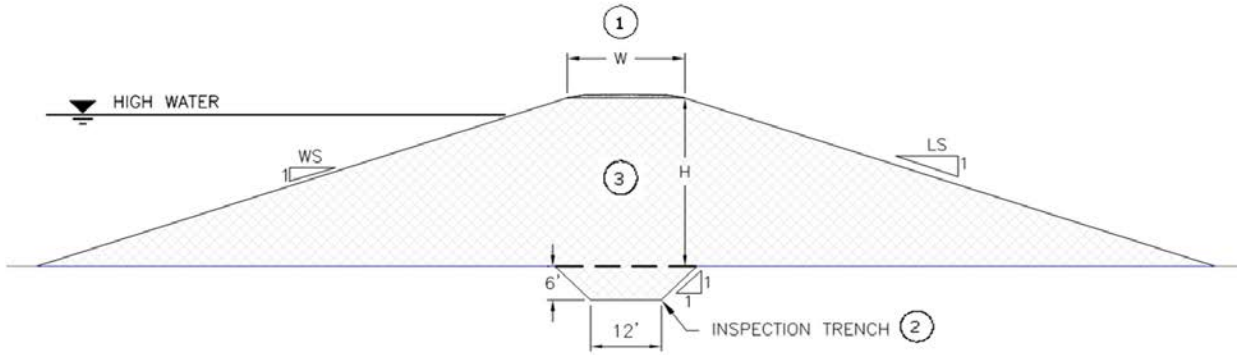
	-	Segment Length (FT)
Repair Length		of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ -**	For the Specified Repair Length

New Levee

Major Quantity Zone:

1. Levee Road - AB fill area
2. Inspection or cutoff trench - cut and fill area
3. Select Levee Fill - fill area



		FT Existing ROW

Levee Geometry:

H:	13	FT Levee Height
W:	20	FT
W_{AC}:		FT Asphalt Concrete Paving Width
W S:	3	:1 Waterside Slope
L S:	3	:1 Landside Slope
RM:	10%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	138	1	138	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00317	ACRE	5' temporary easement
3	02230	STRIPPING	110	1	110	SF	Levee footprint + 12' AB easement road
			Length	Length	0.00253	ACRE	
4	02300	EXCAVATION	108	1	108	CF	Zone 2
			Area	Length	4.00000	CY	
8	02300	FOUNDATION PREPARATION	98	1	98	SF	Levee footprint
			Length	Length	10.88889	SY	
6	02300	SELECT LEVEE FILL	865	1	865	CF	Zone 3
			Area	Length	32.03704	CY	
7	02300	UNSUITABLE MATERIAL DISPOSAL	97	1	97	CF	Zone 2 unsuitable material
			Area	Length	3.59259	CY	
8	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON to CY
9	02925	HYDROSEEDING	106	1	106	SF	Top of levee slope down to disturbed area
			Length	Length	0.00243	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	133	1	133	SF	Same footprint as the replaced levee
			Length	Length	0.00305	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	11	1	11	CF	Zone 2 reusable material
			Area	Length	0.40741	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**

LOCATION: ID - Measures

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 107.71	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0032	ACRE	$ 5,000.00	$ 15.84	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0025	ACRE	$ 3,000.00	$ 7.58	
5	02300	FOUNDATION PREPARATION	10.8889	SY	$ 5.00	$ 54.44	
6	02300	SELECT LEVEE FILL	32.0370	CY	$ 43.50	$ 1,393.61	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0024	ACRE	$ 3,750.00	$ 9.13	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 195.84	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	4.5185	CY	$ 15.00	$ 67.78	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	0.4000	CY	$ 4.00	$ 1.60	
						-	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 678.59	30% x sum of items above
		CONSTRUCTION COST				$ 2,940.57	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0031	ACRE	$ 238,400.00	$ 727.90	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 254.96	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 147.03	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 1,130.46	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 735.14	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	-	Segment Length (FT)
Repair Length		of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ -**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

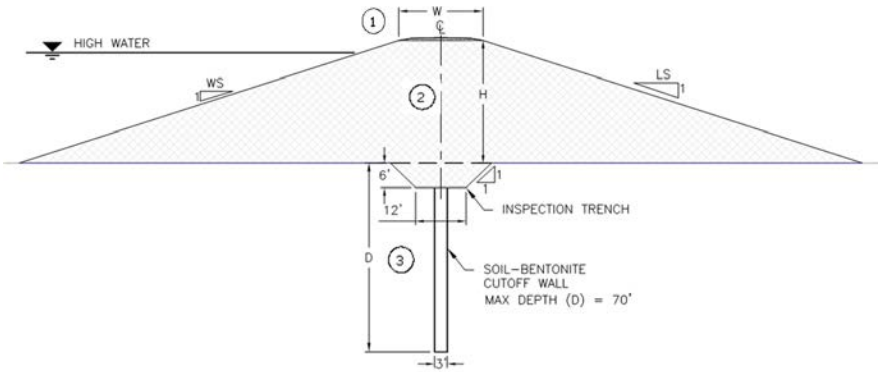
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	13	FT
W:	20	FT
RM:	10%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	138	1	138	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00317	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	110	1	110	SF	Levee footprint
			Length	Length	0.00253	ACRE	
5	02300	FOUNDATION PREPARATION	98	1	98	SF	Levee footprint
			Length	Length	10.88889	SY	
6	02300	SELECT LEVEE FILL	865	1	865	CF	Zone 2
			Area	Length	32.03704	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	106	1	106	SF	Top of levee slope down to disturbed area
			Length	Length	0.00243	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	133	1	133	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00305	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	122	1	122	CF	Unsuitable material from excavation
			Area	Length	4.51852	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	11	1	10.8	CF	Reusable material from excavation
			Area	Length	0.40000	CY	Haul to stockpile for reuse

Legend:

Input cell (Variables) — Linked to estimate table — Formula cell

S1: 2 Levee geometry input (Fixed)

100 Length — Cross-section length, area, depth, or width calculation cell

LS-TB-LCW **Levee Crest Widening**
LOCATION: ID - Measures

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 17.96	5% of sum Items 2 to 8 and 12 to 15
2	02230	CLEARING AND GRUBBING	0.0013	ACRE	$ 5,000.00	$ 6.54	
3	02230	STRIPPING	0.0012	ACRE	$ 3,000.00	$ 3.65	
4	02300	EXCAVATION	0.2963	CY	$ 5.00	$ 1.48	
5	02300	SELECT LEVEE FILL	6.5287	CY	$ 43.50	$ 284.00	
6	02300	UNSUITABLE MATERIAL DISPOSAL	0.2593	CY	$ 15.00	$ 3.89	
7	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
8	02925	HYDROSEEDING	0.0008	ACRE	$ 3,750.00	$ 2.84	
12	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 32.66	Qty (%) x sum Items 2 to 8 and 13 to 15
13	02720	AGGREGATE BASE EASEMENT ROAD		TON	$ 37.50	$ -	
14	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	0.0370	CY	$ 4.00	$ 0.15	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 113.16	30% x sum of items above
		CONSTRUCTION COST				$ 490.36	Per Linear Foot

9	01000	PERMANENT RIGHT OF WAY (ROW)	0.0002	ACRE	$ 238,400.00	$ 43.78	
10	01500	TEMPORARY EASEMENT		ACRE	$ 5,000.00	$ -	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 15.32	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 24.52	
		ROW AND TEMP EASEMENT COST				$ 83.63	
11	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 122.59	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

-	Segment Length (FT)	
Repair Length		of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ -**	For the Specified Repair Length

Levee Crest Widening

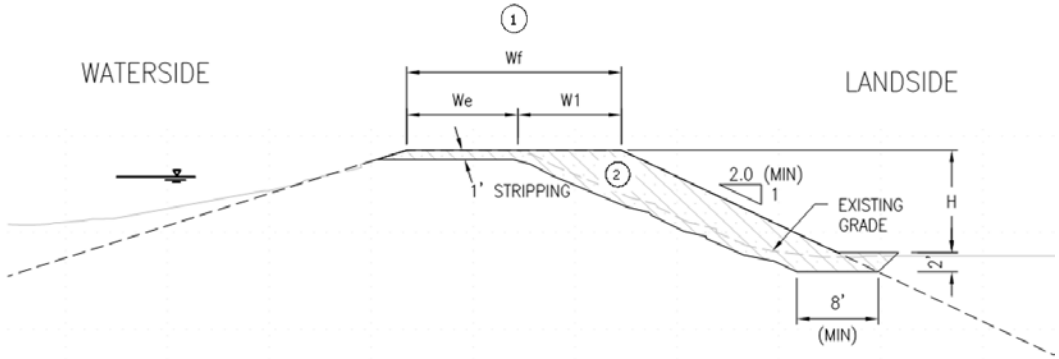
Major Quantity Zone:

(1) Levee Road - fill area (2) Select Levee Fill - fill area

		FT Temporary Easement
		FT ROW
		FT Existing ROW

Levee Geometry:

H	13	FT Crest to Ex Toe Grade
We	16	FT Existing Levee Crest Width
Wf:	20	FT Finished Levee Crest Width
W1:	4	FT (Wf-We)
L S:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	10%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	57	1	57	SF	Levee crest edge down to toe slope +
			Length	Length	0.00131	ACRE	ROW + temporary easement (if needed)
3	02230	STRIPPING	53	1	53	SF	1' deep stripping
			Length	Length	0.00122	ACRE	
4	02300	EXCAVATION	8	1	8	CF	Excavation below 1' deep stripping
			Area	Length	0.29630	CY	
5	02300	SELECT LEVEE FILL	176	1	176	CF	Zone 2
			Area	Length	6.52872	CY	
6	02300	UNSUITABLE MATERIAL DISPOSAL	7	1	7	CF	Unsuitable material from excavation
			Area	Length	0.25926	CY	
7	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: W x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
8	02925	HYDROSEEDING	33	1	33	SF	Top of levee slope down to disturbed area
			Length	Length	0.00076	ACRE	
9	01000	PERMANENT RIGHT OF WAY (ROW)	8	1	8	SF	Landside slope footprint + ROW (if needed)
			Length	Length	0.00018	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
10	01500	TEMPORARY EASEMENT		1		SF	5 feet temporary easement (if needed)
			Length	Length		ACRE	For construction beyond ROW
13	02720	AGGREGATE BASE EASEMENT ROAD		1		CF	12' x 6" AB easement road (If needed)
			Area	Length		TON	1.73 TON/CY(freestanding repair pnly)
14	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	1	1	1	CF	Reusable material from excavation
			Area	Length	0.03704	CY	Haul to stockpile for reuse

Legend:

		Input cell (Variables)		Linked to estimate table	Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

APPENDIX B
LEVEE REMEDIATION WORKSHEETS

S1-A Biggs Ring Levee

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Biggs Ring Levee
ID: S1 a Series
Total Length: 21,648 (feet) 4.1 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

		Located Between				Existing Levee Information				New Levee										Comments
									See Note 1	7 New Levee		8 New Levee With Cutoff Wall								
		Stations		Length		ROW	Levee Height	Crest Width	Reusable Material	Levee Height	Crest Width	Levee Height	Crest Width	CW Depth	Insp Key Depth	ROW Land Use (%)				
	Elements	From	To	(Feet)	%	Width	"H"	"W"	"%"	"H"	"W"	"H"	"W"	"D"	"D1"	"Orch"	"Agr"	"Res"	"Com"	
7	New Levee			16,236	75%	0			65%	7	20					24%	70%	2%	4%	
8	New Levee with CW			5,412	25%	0			65%			7	20	35	6	24%	70%	2%	4%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S2-A Gridley Ring Levee

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Gridley Ring Levee
ID: S2 a Series
Total Length: 32,736 (feet) 6.2 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

		Located Between				Existing Levee Information				New Levee										Comments
									See Note 1	7 New Levee		8 New Levee With Cutoff Wall								
		Stations		Length		ROW	Levee Height	Crest Width	Reusable Material	Levee Height	Crest Width	Levee Height	Crest Width	CW Depth	Insp Key Depth	ROW Land Use (%)				
	Elements	From	To	(Feet)	%	Width	"H"	"W"	"%"	"H"	"W"	"H"	"W"	"D"	"D1"	"Orch"	"Agr"	"Res"	"Com"	
7	New Levee			24,552	75%	0			65%	8	20					22%	34%	21%	23%	
8	New Levee with CW			8,184	25%	0			65%			8	20	35	6	22%	34%	21%	23%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S3-A Live Oak Ring Levee

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Live Oak Ring Levee
ID: S3 a Series
Total Length: 33,792 (feet) 6.4 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

		Located Between				Existing Levee Information				New Levee										Comments
									See Note 1	7 New Levee		8 New Levee With Cutoff Wall								
		Stations		Length		ROW	Levee Height	Crest Width	Reusable Material	Levee Height	Crest Width	Levee Height	Crest Width	CW Depth	Insp Key Depth	ROW Land Use (%)				
	Elements	From	To	(Feet)	%	Width	"H"	"W"	"%"	"H"	"W"	"H"	"W"	"D"	"D1"	"Orch"	"Agr"	"Res"	"Com"	
7	New Levee			25,344	75%	0			65%	8	20					78%	13%	9%	0%	
8	New Levee with CW			8,448	25%	0			65%			8	20	35	6	78%	13%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S4-A Yuba City Ring Levee (Fix-in Place)

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures:	Yuba City Ring Levee			
ID:	S4		a	Series
Total Length:	33,600	(feet)	6.36	(miles)
Name:				
Agency:				
Unit:				
Levee Mile:				
Stationing:		to		

Prepared By: LOB
Date: 10/25/2011

Select Alternative Parameters for Estimating - Seepage and Stability

		Located Between				Existing Levee Information				Fix-in Place 6 Centerline SB		Fix-in Place 9 Crest Widening					Comments
		Stations		Length		ROW	Levee Height	Crest Width	See Note 1 Reusable Material	C Wall Depth	Levee Cut	Geometry Def.	ROW Land Use (%)				
	Elements	From	To	(Feet)	%	Width	"H"	"W"	"%"	"D"	"hc"	"W1"	"Orch"	"Agr"	"Res"	"Com"	
6	Centerline SB			16,800	50%	0	25	15	65%	65	12.5		69%	22%	9%	0%	
9	Levee Crest Widening			33,600	100%	0	25	15	65%			5	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S4-B Yuba City Ring Levee (E-W Levee North)

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures:	Yuba City Ring Levee			
ID:	S4		b	Series
Total Length:	23,460	(feet)	4.44	(miles)
Name:				
Agency:				
Unit:				
Levee Mile:				
Stationing:		to		

Prepared By: LOB
Date: 10/25/2011

Select Alternative Parameters for Estimating - Seepage and Stability

		Located Between				Existing Levee Information				New Levee										Comments
									See Note 1	7 New Levee		8 New Levee With Cutoff Wall								
		Stations		Length		ROW	Levee Height	Crest Width	Reusable Material	Levee Height	Crest Width	Levee Height	Crest Width	CW Depth	Insp Key Depth	ROW Land Use (%)				
	Elements	From	To	(Feet)	%	Width	"H"	"W"	"%"	"H"	"W"	"H"	"W"	"D"	"D1"	"Orch"	"Agr"	"Res"	"Com"	
7	New Levee			11,730	50%	0			65%	8	20					69%	22%	9%	0%	
8	New Levee with CW			11,730	50%	0			65%			8	20	35	6	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S4-C Yuba City Ring Levee (N-S Levee West)

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures:	Yuba City Ring Levee			
ID:	S4		c	Series
Total Length:	20,600	(feet)	3.90	(miles)
Name:				
Agency:				
Unit:				
Levee Mile:				
Stationing:		to		

Prepared By: LOB
Date: 10/25/2011

Select Alternative Parameters for Estimating - Seepage and Stability

		Located Between				Existing Levee Information				New Levee										Comments
									See Note 1	7 New Levee		8 New Levee With Cutoff Wall								
		Stations		Length		ROW	Levee Height	Crest Width	Reusable Material	Levee Height	Crest Width	Levee Height	Crest Width	CW Depth	Insp Key Depth	ROW Land Use (%)				
	Elements	From	To	(Feet)	%	Width	"H"	"W"	"%"	"H"	"W"	"H"	"W"	"D"	"D1"	"Orch"	"Agr"	"Res"	"Com"	
7	New Levee			15,450	75%	0			65%	8	20					69%	22%	9%	0%	
8	New Levee with CW			5,150	25%	0			65%			8	20	35	6	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S4-D Yuba City Ring Levee (E-W Levee South)

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures:	Yuba City Ring Levee			
ID:	S4		d	Series
Total Length:	27,410	(feet)	5.19	(miles)
Name:				
Agency:				
Unit:				
Levee Mile:				
Stationing:		to		

Prepared By: LOB
Date: 10/25/2011

Select Alternative Parameters for Estimating - Seepage and Stability

		Located Between				Existing Levee Information				New Levee										Comments
									See Note 1	7 New Levee		8 New Levee With Cutoff Wall								
		Stations		Length		ROW	Levee Height	Crest Width	Reusable Material	Levee Height	Crest Width	Levee Height	Crest Width	CW Depth	Insp Key Depth	ROW Land Use (%)				
	Elements	From	To	(Feet)	%	Width	"H"	"W"	"%"	"H"	"W"	"H"	"W"	"D"	"D1"	"Orch"	"Agr"	"Res"	"Com"	
7	New Levee			13,705	50%	0			65%	13	20					69%	22%	9%	0%	
8	New Levee with CW			13,705	50%	0			65%			13	20	35	6	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S5-A Feather River (Fix-in-Place)

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend
ID: S5 a Series
Total Length: 53,328 (feet) 10.1 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	Fix-in Place 4 Gravel Stability Berm: Berm Height "H1"	Berm Depth "Wb"	See Note 1 Reusable Material "%"	Fix-in Place 6 Centerline SB: C Wall Depth "D"	Levee Cut "hc"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
4	Gravel Stability Berm			13,332	25%	0	17.5		12	12				69%	22%	9%	0%	
6	Centerline SB			53,328	100%	0	17.5	20			65%	65	8.75	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S5-B Feather River (Fix-in-Place)

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend
ID: S5 b Series
Total Length: 39,072 (feet) 7.4 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	Fix-in Place 4 Gravel Stability Berm: Berm Height "H1"	Berm Depth "Wb"	See Note 1 Reusable Material "%"	Fix-in Place 6 Centerline SB: C Wall Depth "D"	Levee Cut "hc"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
4	Gravel Stability Berm			29,304	75%	0	12.5		8	12				69%	22%	9%	0%	
6	Centerline SB			29,304	75%	0	12.5	20			65%	65	6.25	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S5-C Feather River (Fix-in-Place)

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend
ID: S5 c Series
Total Length: 30,624 (feet) 5.8 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	Fix-in Place 4 Gravel Stability Berm Berm Height "H1"	Berm Depth "Wb"	See Note 1 Reusable Material "%"	Fix-in Place 6 Centerline SB C Wall Depth "D"	Levee Cut "hc"	Fix-in Place 9 Crest Widening Geometry Def. "W1"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
4	Gravel Stability Berm			7,656	25%	0	17.5		12	12	65%				69%	22%	9%	0%	
6	Centerline SB			22,968	75%	0	17.5	16			65%	65	8.75		69%	22%	9%	0%	
9	Levee Crest Widening			30,624	100%	0	17.5	16			65%			4	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S5-D Feather River (Fix-in-Place)

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend
ID: S5 d Series
Total Length: 31,152 (feet) 5.9 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	Fix-in Place 4 Gravel Stability Berm: Berm Height "H1"	Berm Depth "Wb"	See Note 1 Reusable Material "%"	Fix-in Place 6 Centerline SB: C Wall Depth "D"	Levee Cut "hc"	Fix-in Place 9 Crest Widening: Geometry Def. "W1"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
4	Gravel Stability Berm			3,115	10%	0	25.0		17	12	65%				69%	22%	9%	0%	
6	Centerline SB			15,576	50%	0	25.0	15			65%	65	12.5		69%	22%	9%	0%	
9	Levee Crest Widening			31,152	100%	0	25.0	15			65%			5	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S6-A Southern Portion of J-Levee (E-W Levee South)

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Southern Portion of J-Levee
ID: S6 a Series
Total Length: 27,410 (feet) 5.19 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 10/25/2011

Select Alternative Parameters for Estimating - Seepage and Stability

		Located Between				Existing Levee Information				New Levee										Comments
									See Note 1	7 New Levee		8 New Levee With Cutoff Wall								
		Stations		Length		ROW	Levee Height	Crest Width	Reusable Material	Levee Height	Crest Width	Levee Height	Crest Width	CW Depth	Insp Key Depth	ROW Land Use (%)				
	Elements	From	To	(Feet)	%	Width	"H"	"W"	"%"	"H"	"W"	"H"	"W"	"D"	"D1"	"Orch"	"Agr"	"Res"	"Com"	
7	New Levee			13,705	50%	0			65%	13	20					67%	29%	4%	0%	
8	New Levee with CW			13,705	50%	0			65%			13	20	35	6	67%	29%	4%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S6-B Southern Portion of J-Levee (N-S Levee West)

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Southern Portion of J-Levee
ID: S6 b Series
Total Length: 20,600 (feet) 3.90 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 10/25/2011

Select Alternative Parameters for Estimating - Seepage and Stability

		Located Between				Existing Levee Information				New Levee										Comments
									See Note 1	7 New Levee		8 New Levee With Cutoff Wall								
		Stations		Length		ROW	Levee Height	Crest Width	Reusable Material	Levee Height	Crest Width	Levee Height	Crest Width	CW Depth	Insp Key Depth	ROW Land Use (%)				
	Elements	From	To	(Feet)	%	Width	"H"	"W"	"%"	"H"	"W"	"H"	"W"	"D"	"D1"	"Orch"	"Agr"	"Res"	"Com"	
7	New Levee			15,450	75%	0			65%	8	20					67%	29%	4%	0%	
8	New Levee with CW			5,150	25%	0			65%			8	20	35	6	67%	29%	4%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S6-C Southern Portion of J-Levee (N-S Levee West)

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Southern Portion of J-Levee
ID: S6 c Series
Total Length: 6,400 (feet) 1.21 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 10/25/2011

Select Alternative Parameters for Estimating - Seepage and Stability

		Located Between				Existing Levee Information				New Levee										Comments
									See Note 1	7 New Levee		8 New Levee With Cutoff Wall								
		Stations		Length		ROW	Levee Height	Crest Width	Reusable Material	Levee Height	Crest Width	Levee Height	Crest Width	CW Depth	Insp Key Depth	ROW Land Use (%)				
	Elements	From	To	(Feet)	%	Width	"H"	"W"	"%"	"H"	"W"	"H"	"W"	"D"	"D1"	"Orch"	"Agr"	"Res"	"Com"	
7	New Levee			4,800	75%	0			65%	8	20					67%	29%	4%	0%	
8	New Levee with CW			1,600	25%	0			65%			8	20	35	6	67%	29%	4%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S7-D Feather River (Fix-in-Place)-Shanghai Bend

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee
ID: S7 d Series
Total Length: 21,120 (feet) 4 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	Fix-in Place 4 Gravel Stability Berm: Berm Height "H1"	Berm Depth "Wb"	See Note 1 Reusable Material "%"	Fix-in Place 6 Centerline SB: C Wall Depth "D"	Levee Cut "hc"	Fix-in Place 9 Crest Widening: Geometry Def. "W1"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
4	Gravel Stability Berm			2,112	10%	0	25.0		10	12	65%				69%	22%	9%	0%	
6	Centerline SB			10,560	50%	0	25.0	15			65%	65	12.5		69%	22%	9%	0%	
9	Levee Crest Widening			21,120	100%	0	25.0	15			65%			5	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S7-E Feather River (Fix-in-Place)-Shanghai Bend

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee
ID: S7 e Series
Total Length: 19,536 (feet) 3.7 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	Fix-in Place 4 Gravel Stability Berm: Berm Height "H1"	Berm Depth "Wb"	See Note 1 Reusable Material "%"	Fix-in Place 6 Centerline SB: C Wall Depth "D"	Levee Cut "hc"	Fix-in Place 9 Crest Widening: Geometry Def. "W1"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
4	Gravel Stability Berm			1,954	10%	0	22.5		15	12	65%				69%	22%	9%	0%	
6	Centerline SB			14,652	75%	0	22.5	17			65%	65	11.25		69%	22%	9%	0%	
9	Levee Crest Widening			19,536	100%	0	22.5	17			65%			3	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S7-F Feather River (Fix-in-Place)-Shanghai Bend

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee
ID: S7 f Series
Total Length: 41,184 (feet) 7.8 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	Fix-in Place 4 Gravel Stability Berm: Berm Height "H1"	Berm Depth "Wb"	See Note 1 Reusable Material "%"	Fix-in Place 6 Centerline SB: C Wall Depth "D"	Levee Cut "hc"	Fix-in Place 9 Crest Widening: Geometry Def. "W1"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
4	Gravel Stability Berm			4,118	10%	0	22.5		15	12	65%				69%	22%	9%	0%	
6	Centerline SB			30,888	75%	0	22.5	13			65%	65	11.25		69%	22%	9%	0%	
9	Levee Crest Widening			41,184	100%	0	22.5	13			65%			7	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S7-G Feather River (Fix-in-Place)-Shanghai Bend

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee
ID: S7 g Series
Total Length: 40,128 (feet) 7.6 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	Fix-in Place 4 Gravel Stability Berm: Berm Height "H1"	Berm Depth "Wb"	See Note 1 Reusable Material "%"	Fix-in Place 6 Centerline SB: C Wall Depth "D"	Levee Cut "hc"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
4	Gravel Stability Berm			4,013	10%	0	22.5		15	12	65%			69%	22%	9%	0%	
6	Centerline SB			40,128	100%	0	22.5	22			65%	40	11.25	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S7-H Feather River (Fix-in-Place)-Shanghai Bend

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee
ID: S7 h Series
Total Length: 9,504 (feet) 1.8 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	Fix-in Place 4 Gravel Stability Berm: Berm Height "H1"	Berm Depth "Wb"	See Note 1 Reusable Material "%"	Fix-in Place 6 Centerline SB: C Wall Depth "D"	Levee Cut "hc"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
4	Gravel Stability Berm			950	10%	0	20.0		13	12	65%			69%	22%	9%	0%	
6	Centerline SB			9,504	100%	0	20.0	22			65%	50	10	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S7-I Feather River (Fix-in-Place)-Shanghai Bend

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee
ID: S7 i Series
Total Length: 42,768 (feet) 8.1 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	Fix-in Place 4 Gravel Stability Berm: Berm Height "H1"	Berm Depth "Wb"	See Note 1 Reusable Material "%"	Fix-in Place 6 Centerline SB: C Wall Depth "D"	Levee Cut "hc"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
4	Gravel Stability Berm			4,277	10%	0	20.0		13	12	65%			69%	22%	9%	0%	
6	Centerline SB			42,768	100%	0	20.0	22			65%	35	10	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S7-J Feather River (Fix-in-Place)-Shanghai Bend

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee
ID: S7 j Series
Total Length: 24,288 (feet) 4.6 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	Fix-in Place 4 Gravel Stability Berm: Berm Height "H1"	Berm Depth "Wb"	See Note 1 Reusable Material "%"	Fix-in Place 6 Centerline SB: C Wall Depth "D"	Levee Cut "hc"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
4	Gravel Stability Berm			2,429	10%	0	15.0		10	15	65%			69%	22%	9%	0%	
6	Centerline SB			12,144	50%	0	15.0	24			65%	65	7.5	69%	22%	9%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S8-A Butte Bypass

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Butte Bypass
ID: S8 a Series
Total Length: 101,376 (feet) 19.2 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	See Note 1 Reusable Material "%"	New Levee 7 New Levee Levee Height "H"	Crest Width "W"	New Levee 8 New Levee With Cutoff Wall Levee Height "H"	Crest Width "W"	CW Depth "D"	Insp Key Depth "D1"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
7	New Levee			25,344	25%	0			65%	10	20					7%	92%	1%	0%	
8	New Levee with CW			76,032	75%	0			65%			10	20	35	6	7%	92%	1%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S9-G Sutter Bypass Setback Levee

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Sutter Bypass Setback Levee
ID: S9 g Series
Total Length: 40,128 (feet) 7.60 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 10/25/2011

Select Alternative Parameters for Estimating - Seepage and Stability

		Located Between				Existing Levee Information				New Levee								Comments
										8								
									See Note 1	New Levee With Cutoff Wall								
		Stations		Length		ROW	Levee Height	Crest Width	Reusable Material	Levee Height	Crest Width	CW Depth	Insp Key Depth	ROW Land Use (%)				
	Elements	From	To	(Feet)	%	Width	"H"	"W"	"%"	"H"	"W"	"D"	"D1"	"Orch"	"Agr"	"Res"	"Com"	
8	New Levee with CW			40,128	100%	0			65%	22.5	20	35	6	0%	99%	1%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S9-H Sutter Bypass Setback Levee

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Sutter Bypass Setback Levee
ID: S9 h Series
Total Length: 9,504 (feet) 1.80 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 10/25/2011

Select Alternative Parameters for Estimating - Seepage and Stability

		Located Between				Existing Levee Information				New Levee								Comments
										8								
									See Note 1	New Levee With Cutoff Wall								
		Stations		Length		ROW	Levee Height	Crest Width	Reusable Material	Levee Height	Crest Width	CW Depth	Insp Key Depth	ROW Land Use (%)				
	Elements	From	To	(Feet)	%	Width	"H"	"W"	"%"	"H"	"W"	"D"	"D1"	"Orch"	"Agr"	"Res"	"Com"	
8	New Levee with CW			9,504	100%	0			65%	20	20	35	6	0%	99%	1%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S9-I Sutter Bypass Setback Levee

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Sutter Bypass Setback Levee
ID: S9 i Series
Total Length: 42,768 (feet) 8.10 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 10/25/2011

Select Alternative Parameters for Estimating - Seepage and Stability

		Located Between				Existing Levee Information				New Levee								Comments
									See Note 1	8								
										New Levee With Cutoff Wall								
		Stations		Length		ROW	Levee Height	Crest Width	Reusable Material	Levee Height	Crest Width	CW Depth	Insp Key Depth	ROW Land Use (%)				
	Elements	From	To	(Feet)	%	Width	"H"	"W"	"%"	"H"	"W"	"D"	"D1"	"Orch"	"Agr"	"Res"	"Com"	
8	New Levee with CW			42,768	100%	0			65%	20	20	35	6	0%	99%	1%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S10-A Northern Feather River Setback Levee

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Northern Feather River Setback Levee
ID: S10 a Series
Total Length: 27,984 (feet) 5.3 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	See Note 1 Reusable Material "%"	New Levee 8 New Levee With Cutoff Wall Levee Height "H"	Crest Width "W"	CW Depth "D"	Insp Key Depth "D1"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
8	New Levee with CW			27,984	100%	0			65%	20	20	75	6	84%	15%	1%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S11-A Sutter Bypass and Feather River

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Northern Feather River Setback Levee
ID: S11 a Series
Total Length: 11,088 (feet) 2.1 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	See Note 1 Reusable Material "%"	New Levee 7 New Levee Levee Height "H"	Crest Width "W"	New Levee 8 New Levee With Cutoff Wall Levee Height "H"	Crest Width "W"	CW Depth "D"	Insp Key Depth "D1"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
7	New Levee			5,544	50%	0			65%	22.5	20					59%	41%	0%	0%	
8	New Levee with CW			5,544	50%	0			65%			22.5	20	35	6	59%	41%	0%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S12-A Star Bend Setback Levee

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures: Star Bend Setback Levee
ID: S12 a Series
Total Length: 4,224 (feet) 0.8 (miles)
Name:
Agency:
Unit:
Levee Mile:
Stationing: to

Prepared By: LOB
Date: 7/13/2011

Select Alternative Parameters for Estimating - Seepage and Stability

	Elements	Located Between Stations From	To	Length (Feet)	%	Existing ROW Width	Existing Levee Height "H"	Crest Width "W"	See Note 1 Reusable Material "%"	Fix-in Place 6 Centerline SB C Wall Depth "D"	Levee Cut "hc"	New Levee 8 New Levee With Cutoff Wall Levee Height "H"	Crest Width "W"	CW Depth "D"	Insp Key Depth "D1"	ROW Land Use (%) "Orch"	"Agr"	"Res"	"Com"	Comments
6	Centerline SB			1,056	25%	0	20.0	20	65%	70	10					5%	95%	0%	0%	
8	New Levee with CW			3,168	75%	0			65%			25	20	65	6	5%	95%	0%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

S24-A Gilsizer Cross-Levee

Input Table
Selection of Remediation Measures

Segment Identification and Location

Measures:	Gilsizer Cross-Levee			
ID:	S24		a	Series
Total Length:	32,000	(feet)	6.06	(miles)
Name:				
Agency:				
Unit:				
Levee Mile:				
Stationing:		to		

Prepared By: LOB
Date: 10/25/2011

Select Alternative Parameters for Estimating - Seepage and Stability

		Located Between				Existing Levee Information				New Levee										Comments
									See Note 1	7		8								
										New Levee		New Levee With Cutoff Wall								
		Stations		Length		ROW	Levee Height	Crest Width	Reusable Material	Levee Height	Crest Width	Levee Height	Crest Width	CW Depth	Insp Key Depth	ROW Land Use (%)				
	Elements	From	To	(Feet)	%	Width	"H"	"W"	"%"	"H"	"W"	"H"	"W"	"D"	"D1"	"Orch"	"Agr"	"Res"	"Com"	
7	New Levee			11,200	35%	0			65%	21.5	20					70%	30%	0%	0%	
8	New Levee with CW			20,800	65%	0			65%			21.5	20	30	6	70%	30%	0%	0%	

Note 1: Provide the estimated % of levee degrade material that could be reused for levee reconstruction of Waterside SB and Centerline SB

LEGEND:

0 : Pre-loaded formula, no input needed

: No input zone

H: Landside Height of Levee
H1: Height of Berm
W: Crest Width of Levee
Wb: Berm or Toe Blanket Width
D: Cutoff Wall Depth
D1: Inspection Key Depth (Measure 8)
hc: Levee Degrade Height (Default H/2)
TB: Toe Blanket
h1: Freeboard Deficiency

CW: Cutoff Wall
SB: Soil-Bentonite
ROW: Right of Way
"Orch": Orchard
"Agr": Agricultural
"Res": Residential
"Com": Commercial
%: Percent

APPENDIX C

REPAIR MEASURE COST ESTIMATES

Appendix C contains the detailed cost estimates for each of the 13 Management Measures covered by this report. Each estimate includes a summary cover page followed by the cost estimate templates for each element comprising the Management Measure.

Management Measures estimates are provided in sequence (S1 to S12 and S24). The estimate identification for each measure and element is provided in the "Segment ID and Series" column in Table C-1. The Segment ID and Series information is available on the summary page for each estimate.

Table C-1 Estimate Segment ID and Series

USACE Designation	Management Measure	Repair Elements	Segment ID and Series
S1	Biggs Ring Levee	New Levee New Levee with SB Cutoff Wall	S1-a
S2	Gridley Ring Levee	New Levee New Levee with SB Cutoff Wall	S2-a
S3	Live Oak Ring Levee	New Levee New Levee with SB Cutoff Wall	S3-a
S4	Yuba City Ring Levee		
	East Side (River)	Centerline SB Cutoff Wall Levee Crest Widening (8' ROW) Levee Crest Widening (33' ROW)	S4-a
	North Side	New Levee New Levee with SB Cutoff Wall	S4-b
	West Side	New Levee New Levee with SB Cutoff Wall	S4-c
	South Side	New Levee New Levee with SB Cutoff Wall	S4-d
S5	Fix-in-Place, Feather River West Levee, Thermalito to Shanghai Bend		
	Reach 1	Gravel Stability Berm Centerline SB Cutoff Wall	S5-a
	Reach 2	Gravel Stability Berm Centerline SB Cutoff Wall	S5-b
	Reach 3	Gravel Stability Berm Centerline SB Cutoff Wall Levee Crest Widening (8' ROW)	S5-c
	Reach 4	Gravel Stability Berm Centerline SB Cutoff Wall Levee Crest Widening (8' ROW) Levee Crest Widening (33' ROW)	S5-d

Table C-1 Estimate Segment ID and Series

USACE Designation	Management Measure	Repair Elements	Segment ID and Series
S6	Southern Portion of J-Levee		
	South Side	New Levee New Levee with SB Cutoff Wall	S6-a
	West Side - Lower	New Levee New Levee with SB Cutoff Wall	S6-b
	West Side - Upper	New Levee New Levee with SB Cutoff Wall	S6-c
S7	Fix-in-Place, Feather River West Levee, Shanghai Bend to Sutter Bypass, including Wadsworth Canal East Levee and Sutter Bypass East Levee		
	Reach 1	Gravel Stability Berm Centerline SB Cutoff Wall Levee Crest Widening (8' ROW) Levee Crest Widening (33' ROW)	S7-d
	Reach 2	Gravel Stability Berm Centerline SB Cutoff Wall Levee Crest Widening (8' ROW) Levee Crest Widening (33' ROW)	S7-e
	Reach 3	Gravel Stability Berm Centerline SB Cutoff Wall Levee Crest Widening (8' ROW) Levee Crest Widening (33' ROW)	S7-f
	Reach 4	Gravel Stability Berm Centerline SB Cutoff Wall	S7-g
	Reach 5	Gravel Stability Berm Centerline SB Cutoff Wall	S7-h
	Reach 6	Gravel Stability Berm Centerline SB Cutoff Wall	S7-i
	Reach 7	Gravel Stability Berm Centerline SB Cutoff Wall	S7-j
S8	Butte Bypass	New Levee New Levee with SB Cutoff Wall	S8-a
S9	Sutter Bypass Setback Levee		
	Reach 1 (Same as S7, Reach 4)	New Levee with SB Cutoff Wall	S9-g
	Reach 2 (Same as S7, Reach 5)	New Levee with SB Cutoff Wall	S9-h
	Reach 3 (Same as S7, Reach 6)	New Levee with SB Cutoff Wall	S9-i
S10	Northern Feather River Setback Levee	New Levee with SB Cutoff Wall	S10-a
S11	Sutter Bypass and Feather River Confluence Setback Levee	New Levee New Levee with SB Cutoff Wall	S11-a
S12	Star Bend Setback Levee	Centerline SB Cutoff Wall New Levee with SB Cutoff Wall	S12-a

Table C-1 Estimate Segment ID and Series

USACE Designation	Management Measure	Repair Elements	Segment ID and Series
S24	New Gilsizer Cross Levee with Flap Gates	New Levee New Levee with SB Cutoff Wall	S24-a

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S1
SERIES: a
TOTAL SEGMENT LENGTH (FT): 21,648

S1 - Biggs Ring Levee

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-SL	New Levee	16,236	$ 16,353,294	$ 1,007	$ 4,088,323	$ 2,356,978	$ 22,798,596
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	5,412	$ 8,403,828	$ 1,553	$ 2,100,957	$ 933,296	$ 11,438,081
							$ 34,236,677

LS-SL **New Levee**
LOCATION: S1 - Biggs Ring Levee

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 36.89	5% of sum Items 2 to 9 and 13 to 16
2	02230	CLEARING AND GRUBBING	0.0023	ACRE	$ 5,000.00	$ 11.71	
3	02230	STRIPPING	0.0017	ACRE	$ 3,000.00	$ 5.10	
4	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
5	02300	FOUNDATION PREPARATION	6.8889	SY	$ 5.00	$ 34.44	
6	02300	SELECT LEVEE FILL	12.0370	CY	$ 43.50	$ 523.61	
7	02300	UNSUITABLE MATERIAL DISPOSAL	1.4074	CY	$ 15.00	$ 21.11	
8	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0016	ACRE	$ 3,750.00	$ 6.03	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 67.08	Qty (%) x sum Items 2 to 9 and 14 to 16
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.5926	CY	$ 4.00	$ 10.37	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 232.44	30% x sum of items above
		CONSTRUCTION COST				$ 1,007.22	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0022	ACRE	$ 31,280.00	$ 69.65	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 24.58	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 50.36	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 145.17	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 251.81	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

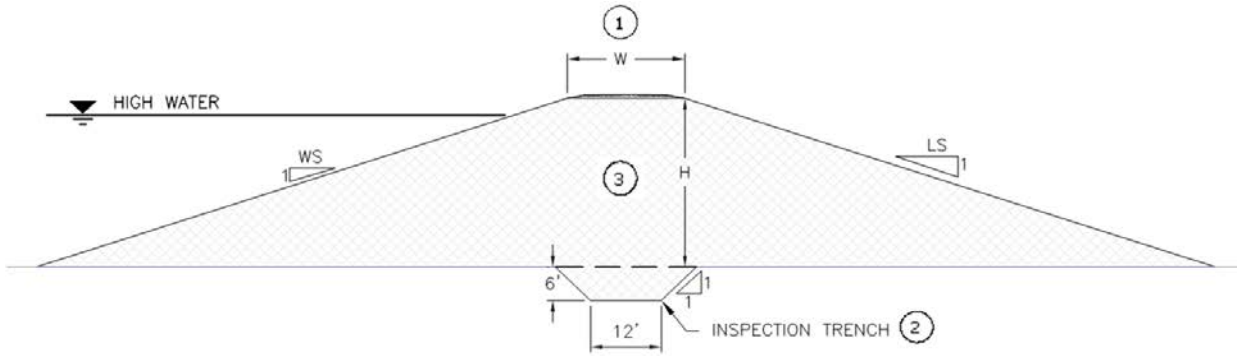
21,648 Segment Length (FT)
Repair Length 75% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 22,798,596**	For the Specified Repair Length

New Levee

Major Quantity Zone:

1. Levee Road - AB fill area
2. Inspection or cutoff trench - cut and fill area
3. Select Levee Fill - fill area



		FT Existing ROW

Levee Geometry:

H:	7	FT Levee Height
W:	20	FT
W_{AC}:		FT Asphalt Concrete Paving Width
W S:	3	:1 Waterside Slope
L S:	3	:1 Landside Slope
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	102	1	102	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00234	ACRE	5' temporary easement
3	02230	STRIPPING	74	1	74	SF	Levee footprint + 12' AB easement road
			Length	Length	0.00170	ACRE	
4	02300	EXCAVATION	108	1	108	CF	Zone 2
			Area	Length	4.00000	CY	
8	02300	FOUNDATION PREPARATION	62	1	62	SF	Levee footprint
			Length	Length	6.88889	SY	
6	02300	SELECT LEVEE FILL	325	1	325	CF	Zone 3
			Area	Length	12.03704	CY	
7	02300	UNSUITABLE MATERIAL DISPOSAL	38	1	38	CF	Zone 2 unsuitable material
			Area	Length	1.40741	CY	
8	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON to CY
9	02925	HYDROSEEDING	70	1	70	SF	Top of levee slope down to disturbed area
			Length	Length	0.00161	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	97	1	97	SF	Same footprint as the replaced levee
			Length	Length	0.00223	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70	CF	Zone 2 reusable material
			Area	Length	2.59259	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**
LOCATION: S1 - Biggs Ring Levee

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 56.88	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0023	ACRE	$ 5,000.00	$ 11.71	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0017	ACRE	$ 3,000.00	$ 5.10	
5	02300	FOUNDATION PREPARATION	6.8889	SY	$ 5.00	$ 34.44	
6	02300	SELECT LEVEE FILL	12.0370	CY	$ 43.50	$ 523.61	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0016	ACRE	$ 3,750.00	$ 6.03	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 103.42	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 358.34	30% x sum of items above
		CONSTRUCTION COST				$ 1,552.81	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0022	ACRE	$ 31,280.00	$ 69.65	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 24.58	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 77.64	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 172.45	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 388.20	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

21,648 Segment Length (FT)
Repair Length 25% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 11,438,081**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

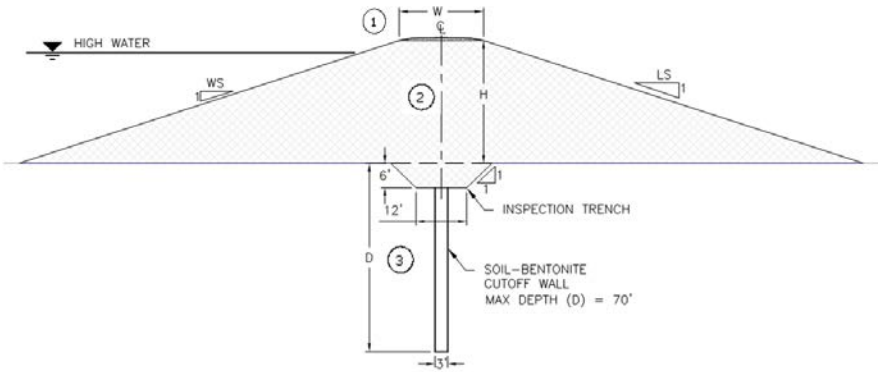
1 Levee road

2 Select Levee Fill 3 SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	7	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	102	1	102	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00234	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	74	1	74	SF	Levee footprint
			Length	Length	0.00170	ACRE	
5	02300	FOUNDATION PREPARATION	62	1	62	SF	Levee footprint
			Length	Length	6.88889	SY	
6	02300	SELECT LEVEE FILL	325	1	325	CF	Zone 2
			Area	Length	12.03704	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	70	1	70	SF	Top of levee slope down to disturbed area
			Length	Length	0.00161	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	97	1	97	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00223	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

Input cell (Variables) Linked to estimate table Formula cell

S1: 2 Levee geometry input (Fixed) 100 Length Cross-section length, area, depth, or width calculation cell

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S2
SERIES: a
TOTAL SEGMENT LENGTH (FT): 32,736

S2 - Gridley Ring Levee

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-SL	New Levee	24,552	$ 28,772,485	$ 1,172	$ 7,193,121	$ 13,361,035	$ 49,326,641
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	8,184	$ 14,055,933	$ 1,717	$ 3,513,983	$ 4,676,934	$ 22,246,849
							$ 71,573,490

LS-SL **New Levee**
LOCATION: S2 - Gridley Ring Levee

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 42.93	5% of sum Items 2 to 9 and 13 to 16
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.40	
3	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.51	
4	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
5	02300	FOUNDATION PREPARATION	7.5556	SY	$ 5.00	$ 37.78	
6	02300	SELECT LEVEE FILL	14.4444	CY	$ 43.50	$ 628.33	
7	02300	UNSUITABLE MATERIAL DISPOSAL	1.4074	CY	$ 15.00	$ 21.11	
8	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 78.05	Qty (%) x sum Items 2 to 9 and 14 to 16
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.5926	CY	$ 4.00	$ 10.37	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 270.44	30% x sum of items above
		CONSTRUCTION COST				$ 1,171.90	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0024	ACRE	$ 151,880.00	$ 359.13	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 125.90	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 58.59	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 544.19	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 292.97	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

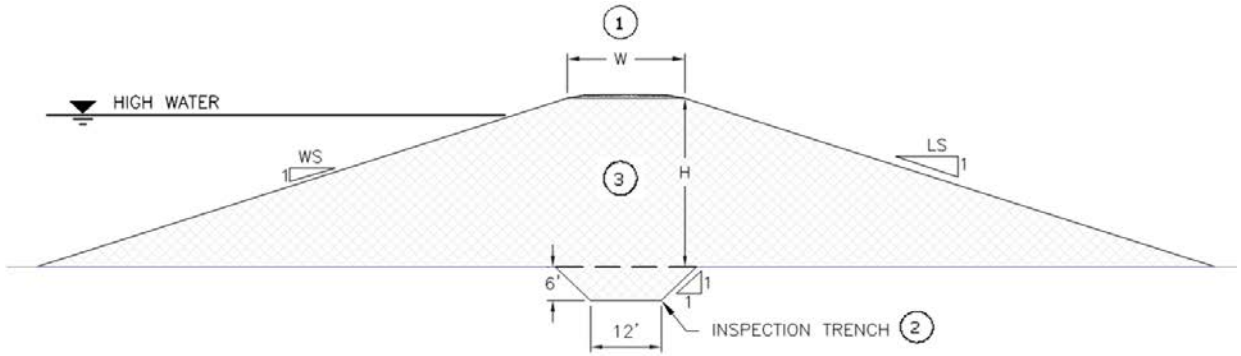
32,736 Segment Length (FT)
Repair Length 75% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 49,326,641**	For the Specified Repair Length

New Levee

Major Quantity Zone:

1. Levee Road - AB fill area
2. Inspection or cutoff trench - cut and fill area
3. Select Levee Fill - fill area



		FT Existing ROW

Levee Geometry:

H:	8	FT Levee Height
W:	20	FT
W_{AC}:		FT Asphalt Concrete Paving Width
W S:	3	:1 Waterside Slope
L S:	3	:1 Landside Slope
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	108	1	108	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00248	ACRE	5' temporary easement
3	02230	STRIPPING	80	1	80	SF	Levee footprint + 12' AB easement road
			Length	Length	0.00184	ACRE	
4	02300	EXCAVATION	108	1	108	CF	Zone 2
			Area	Length	4.00000	CY	
8	02300	FOUNDATION PREPARATION	68	1	68	SF	Levee footprint
			Length	Length	7.55556	SY	
6	02300	SELECT LEVEE FILL	390	1	390	CF	Zone 3
			Area	Length	14.44444	CY	
7	02300	UNSUITABLE MATERIAL DISPOSAL	38	1	38	CF	Zone 2 unsuitable material
			Area	Length	1.40741	CY	
8	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON to CY
9	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down to disturbed area
			Length	Length	0.00174	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	103	1	103	SF	Same footprint as the replaced levee
			Length	Length	0.00236	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70	CF	Zone 2 reusable material
			Area	Length	2.59259	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**
LOCATION: S2 - Gridley Ring Levee

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 62.91	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.40	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.51	
5	02300	FOUNDATION PREPARATION	7.5556	SY	$ 5.00	$ 37.78	
6	02300	SELECT LEVEE FILL	14.4444	CY	$ 43.50	$ 628.33	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 114.38	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 396.34	30% x sum of items above
		CONSTRUCTION COST				$ 1,717.49	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0024	ACRE	$ 151,880.00	$ 359.13	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 125.90	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 85.87	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 571.47	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 429.37	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

32,736 Segment Length (FT)
Repair Length 25% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 22,246,849**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

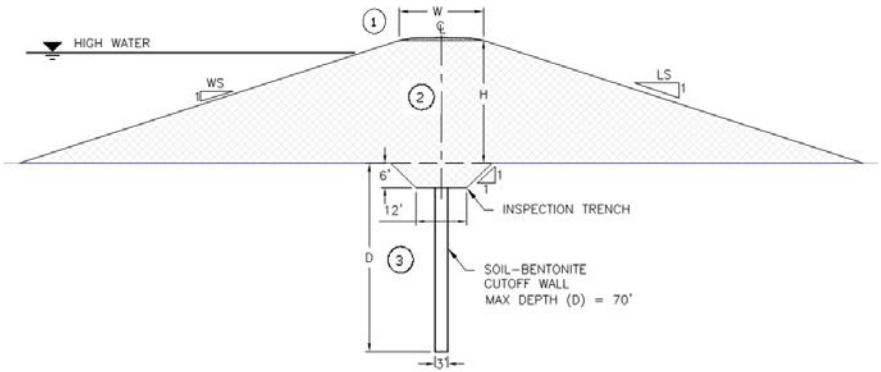
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	8	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	108	1	108	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00248	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	80	1	80	SF	Levee footprint
			Length	Length	0.00184	ACRE	
5	02300	FOUNDATION PREPARATION	68	1	68	SF	Levee footprint
			Length	Length	7.55556	SY	
6	02300	SELECT LEVEE FILL	390	1	390	CF	Zone 2
			Area	Length	14.44444	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down to disturbed area
			Length	Length	0.00174	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	103	1	103	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00236	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

Input cell (Variables) | Linked to estimate table | Formula cell

S1: 2 Levee geometry input (Fixed)

100 Length — Cross-section length, area, depth, or width calculation cell

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S3
SERIES: a
TOTAL SEGMENT LENGTH (FT): 33,792

S3 - Live Oak Ring Levee

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-SL	New Levee	25,344	$ 29,700,630	$ 1,172	$ 7,425,157	$ 4,743,977	$ 41,869,764
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	8,448	$ 14,509,350	$ 1,717	$ 3,627,337	$ 1,811,783	$ 19,948,470
							$ 61,818,233

LS-SL **New Levee**
LOCATION: S3 - Live Oak Ring Levee

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 42.93	5% of sum Items 2 to 9 and 13 to 16
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.40	
3	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.51	
4	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
5	02300	FOUNDATION PREPARATION	7.5556	SY	$ 5.00	$ 37.78	
6	02300	SELECT LEVEE FILL	14.4444	CY	$ 43.50	$ 628.33	
7	02300	UNSUITABLE MATERIAL DISPOSAL	1.4074	CY	$ 15.00	$ 21.11	
8	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 78.05	Qty (%) x sum Items 2 to 9 and 14 to 16
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.5926	CY	$ 4.00	$ 10.37	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 270.44	30% x sum of items above
		CONSTRUCTION COST				$ 1,171.90	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0024	ACRE	$ 40,040.00	$ 94.68	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 33.34	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 58.59	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 187.18	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 292.97	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

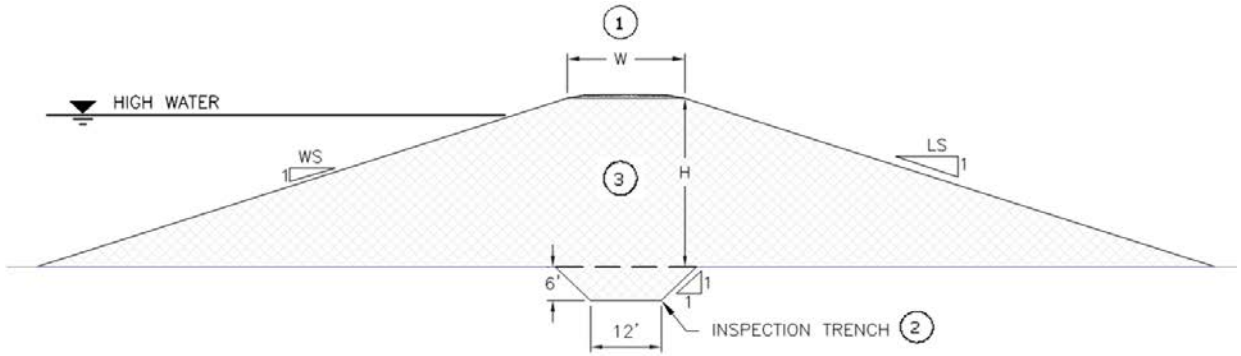
33,792 Segment Length (FT)
Repair Length 75% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 41,869,764**	For the Specified Repair Length

New Levee

Major Quantity Zone:

1. Levee Road - AB fill area
2. Inspection or cutoff trench - cut and fill area
3. Select Levee Fill - fill area



		FT Existing ROW

Levee Geometry:

H:	8	FT Levee Height
W:	20	FT
W_{AC}:		FT Asphalt Concrete Paving Width
W S:	3	:1 Waterside Slope
L S:	3	:1 Landside Slope
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	108	1	108	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00248	ACRE	5' temporary easement
3	02230	STRIPPING	80	1	80	SF	Levee footprint + 12' AB easement road
			Length	Length	0.00184	ACRE	
4	02300	EXCAVATION	108	1	108	CF	Zone 2
			Area	Length	4.00000	CY	
8	02300	FOUNDATION PREPARATION	68	1	68	SF	Levee footprint
			Length	Length	7.55556	SY	
6	02300	SELECT LEVEE FILL	390	1	390	CF	Zone 3
			Area	Length	14.44444	CY	
7	02300	UNSUITABLE MATERIAL DISPOSAL	38	1	38	CF	Zone 2 unsuitable material
			Area	Length	1.40741	CY	
8	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON to CY
9	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down to disturbed area
			Length	Length	0.00174	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	103	1	103	SF	Same footprint as the replaced levee
			Length	Length	0.00236	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70	CF	Zone 2 reusable material
			Area	Length	2.59259	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**
LOCATION: S3 - Live Oak Ring Levee

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 62.91	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.40	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.51	
5	02300	FOUNDATION PREPARATION	7.5556	SY	$ 5.00	$ 37.78	
6	02300	SELECT LEVEE FILL	14.4444	CY	$ 43.50	$ 628.33	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 114.38	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 396.34	30% x sum of items above
		CONSTRUCTION COST				$ 1,717.49	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0024	ACRE	$ 40,040.00	$ 94.68	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 33.34	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 85.87	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 214.46	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 429.37	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

33,792 Segment Length (FT)
Repair Length 25% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 19,948,470**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

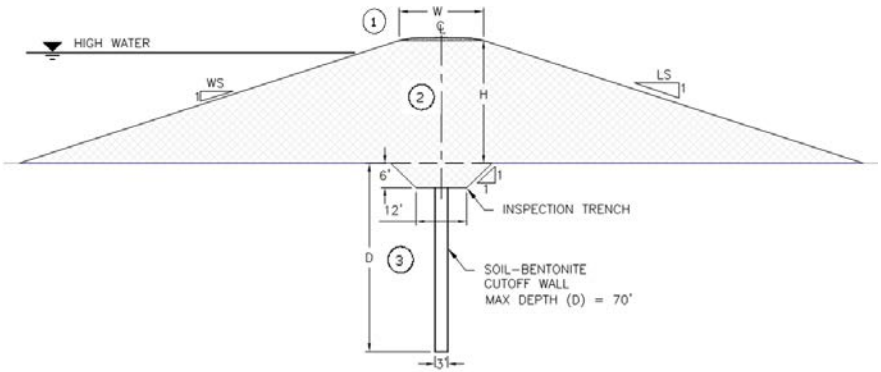
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	8	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	108	1	108	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00248	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	80	1	80	SF	Levee footprint
			Length	Length	0.00184	ACRE	
5	02300	FOUNDATION PREPARATION	68	1	68	SF	Levee footprint
			Length	Length	7.55556	SY	
6	02300	SELECT LEVEE FILL	390	1	390	CF	Zone 2
			Area	Length	14.44444	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down to disturbed area
			Length	Length	0.00174	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	103	1	103	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00236	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

Input cell (Variables) | Linked to estimate table | Formula cell

S1: 2 Levee geometry input (Fixed)

100 Length — Cross-section length, area, depth, or width calculation cell

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S4
SERIES: a
TOTAL SEGMENT LENGTH (FT): 33,600

S4 - Yuba City Ring Levee - East Side (River)

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
TL-SW-SCBCW-TEF	Centerline Soil-Bentonite	16,800	$ 38,139,248	$ 2,270	$ 9,534,812	$ 2,325,678	$ 49,999,738
LS-TB-LCW	Levee Crest Widening (50% Segment Length)	16,800	$ 15,906,884	$ 947	$ 3,976,721	$ 957,624	$ 20,841,229
LS-TB-LCW	Levee Crest Widening (50% Segment Length)	16,800	$ 16,905,758	$ 1,006	$ 4,226,439	$ 1,426,283	$ 22,558,481
							$ 93,399,448

TL-SW-SCBCW- **Centerline Soil-Bentonite**

LOCATION: S4 - Yuba City Ring Levee - East Side (River)

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 83.16	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0031	ACRE	$ 5,000.00	$ 15.61	
3	02300	LEVEE DEGRADE	21.4444	CY	$ 4.50	$ 96.50	
4	02300	SELECT LEVEE FILL	8.3704	CY	$ 43.50	$ 364.11	
5	02300	UNSUITABLE MATERIAL DISPOSAL	8.3704	CY	$ 15.00	$ 125.56	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	13.9630	CY	$ 4.00	$ 55.85	
7	02260	SOIL-BENTONITE SLURRY WALL	65.00	SF	$ 12.50	$ 812.50	
8	02720	AGGREGATE BASE LEVEE ROAD	0.4806	TON	$ 37.50	$ 18.02	
9	02925	HYDROSEEDING	0.0025	ACRE	$ 3,750.00	$ 9.38	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 151.20	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 523.89	30% x sum of items above
		CONSTRUCTION COST				$ 2,270.19	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0005	ACRE	$ 38,960.00	$ 17.89	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 6.46	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 113.51	
		ROW AND TEMP EASEMENT COST				$ 138.43	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 567.55	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	33,600	Segment Length (FT)
Repair Length	50%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 49,999,738**	For the Specified Repair Length

Centerline Soil-Bentonite

Major Quantity Zone:

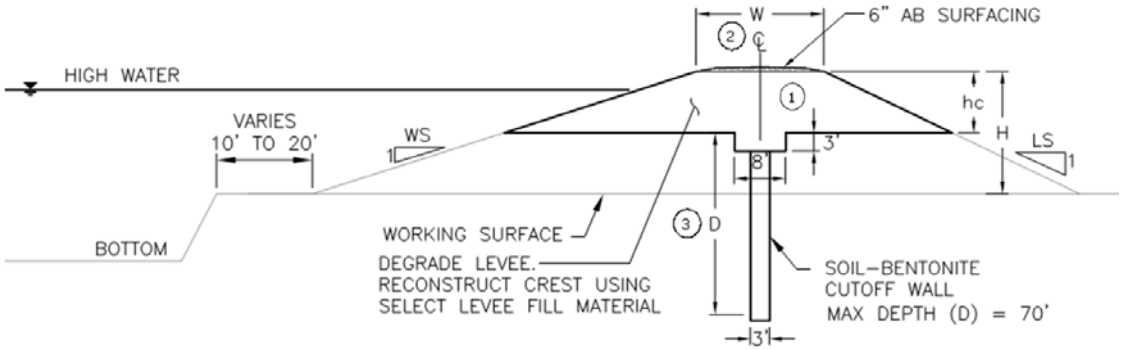
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

		FT Existing ROW

Levee Geometry:

H:	25	FT
W:	15	FT
hc:	12.5	FT Levee Degrade from Crest to Working Surface
D:	65	FT Cutoff Wall Depth from Working Surface
WS:	3	:1 (Waterside Slope)
LS:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	136	1	136	SF	LS slope length + temporary easement +
			Length	Length	0.00312	ACRE	ROW + W + 1/2 of WS slope length
3	02300	LEVEE DEGRADE	579	1	579	CF	Zone 2
			Area	Length	21.44444	CY	
4	02300	SELECT LEVEE FILL	226	1	226	CF	Zone 2
			Area	Length	8.37037	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	226	1	226	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	8.37037	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	377	1	377	CF	Zone 2 reusable material
			Area	Length	13.96296	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	65	1			
			Depth	Length	65.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	8	1	7.5	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.48056	TON	1.73 TON/CY
9	02925	HYDROSEEDING	109	1	109	SF	Top of levee down to disturbed area
			Length	Length	0.00250	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent Right of Way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

LS-TB-LCW **Levee Crest Widening**

LOCATION: S4 - Yuba City Ring Levee - East Side (River)

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 34.68	5% of sum Items 2 to 8 and 12 to 15
2	02230	CLEARING AND GRUBBING	0.0019	ACRE	$ 5,000.00	$ 9.64	
3	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.44	
4	02300	EXCAVATION	0.2963	CY	$ 5.00	$ 1.48	
5	02300	SELECT LEVEE FILL	13.3892	CY	$ 43.50	$ 582.43	
6	02300	UNSUITABLE MATERIAL DISPOSAL	0.1111	CY	$ 15.00	$ 1.67	
7	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
8	02925	HYDROSEEDING	0.0014	ACRE	$ 3,750.00	$ 5.17	
12	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 63.06	Qty (%) x sum Items 2 to 8 and 13 to 15
13	02720	AGGREGATE BASE EASEMENT ROAD		TON	$ 37.50	$ -	
14	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	0.1852	CY	$ 4.00	$ 0.74	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 218.50	30% x sum of items above
		CONSTRUCTION COST				$ 946.84	Per Linear Foot

9	01000	PERMANENT RIGHT OF WAY (ROW)	0.0002	ACRE	$ 38,960.00	$ 7.16	
10	01500	TEMPORARY EASEMENT		ACRE	$ 5,000.00	$ -	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 2.50	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 47.34	
		ROW AND TEMP EASEMENT COST				$ 57.00	
11	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 236.71	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	33,600	Segment Length (FT)
Repair Length	50%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 20,841,229**	For the Specified Repair Length

Levee Crest Widening

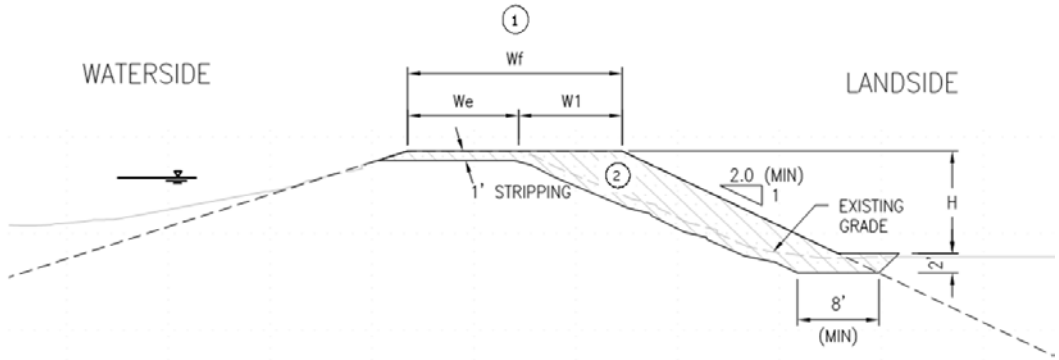
Major Quantity Zone:

(1) Levee Road - fill area (2) Select Levee Fill - fill area

		FT Temporary Easement
		FT ROW
		FT Existing ROW

Levee Geometry:

H	25	FT Crest to Ex Toe Grade
We	15	FT Existing Levee Crest Width
Wf:	20	FT Finished Levee Crest Width
W1:	5	FT (Wf-We)
L S:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	84	1	84	SF	Levee crest edge down to toe slope +
			Length	Length	0.00193	ACRE	ROW + temporary easement (if needed)
3	02230	STRIPPING	79	1	79	SF	1' deep stripping
			Length	Length	0.00181	ACRE	
4	02300	EXCAVATION	8	1	8	CF	Excavation below 1' deep stripping
			Area	Length	0.29630	CY	
5	02300	SELECT LEVEE FILL	362	1	362	CF	Zone 2
			Area	Length	13.38920	CY	
6	02300	UNSUITABLE MATERIAL DISPOSAL	3	1	3	CF	Unsuitable material from excavation
			Area	Length	0.11111	CY	
7	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: W x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
8	02925	HYDROSEEDING	60	1	60	SF	Top of levee slope down to disturbed area
			Length	Length	0.00138	ACRE	
9	01000	PERMANENT RIGHT OF WAY (ROW)	8	1	8	SF	Landside slope footprint + ROW (if needed)
			Length	Length	0.00018	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
10	01500	TEMPORARY EASEMENT		1		SF	5 feet temporary easement (if needed)
			Length	Length		ACRE	For construction beyond ROW
13	02720	AGGREGATE BASE EASEMENT ROAD		1		CF	12' x 6" AB easement road (If needed)
			Area	Length		TON	1.73 TON/CY(freestanding repair pnly)
14	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	5	1	5	CF	Reusable material from excavation
			Area	Length	0.18519	CY	Haul to stockpile for reuse

Legend:

		Input cell (Variables)		Linked to estimate table	Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

LS-TB-LCW **Levee Crest Widening**

LOCATION: S4 - Yuba City Ring Levee - East Side (River)

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 36.86	5% of sum Items 2 to 8 and 12 to 15
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.51	
3	02230	STRIPPING	0.0021	ACRE	$ 3,000.00	$ 6.27	
4	02300	EXCAVATION	0.2963	CY	$ 5.00	$ 1.48	
5	02300	SELECT LEVEE FILL	13.8336	CY	$ 43.50	$ 601.76	
6	02300	UNSUITABLE MATERIAL DISPOSAL	0.1111	CY	$ 15.00	$ 1.67	
7	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
8	02925	HYDROSEEDING	0.0020	ACRE	$ 3,750.00	$ 7.32	
12	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 67.02	Qty (%) x sum Items 2 to 8 and 13 to 15
13	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
14	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	0.1852	CY	$ 4.00	$ 0.74	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 232.22	30% x sum of items above
		CONSTRUCTION COST				$ 1,006.30	Per Linear Foot

9	01000	PERMANENT RIGHT OF WAY (ROW)	0.0006	ACRE	$ 38,960.00	$ 25.04	
10	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 8.97	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 50.31	
		ROW AND TEMP EASEMENT COST				$ 84.90	
11	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 251.57	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	33,600	Segment Length (FT)
Repair Length	50%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 22,558,481**	For the Specified Repair Length

Levee Crest Widening

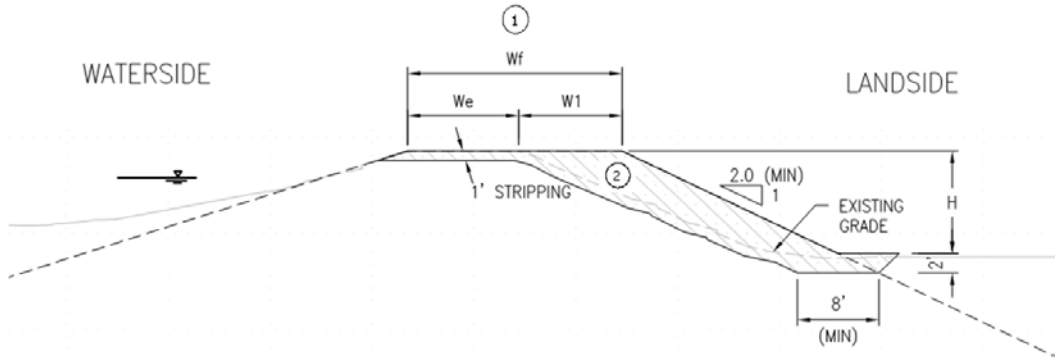
Major Quantity Zone:

(1) Levee Road - fill area (2) Select Levee Fill - fill area

	5	FT Temporary Easement
	20	FT ROW
		FT Existing ROW

Levee Geometry:

H	25	FT Crest to Ex Toe Grade
We	15	FT Existing Levee Crest Width
Wf:	20	FT Finished Levee Crest Width
W1:	5	FT (Wf-We)
L S:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	109	1	109	SF	Levee crest edge down to toe slope +
			Length	Length	0.00250	ACRE	ROW + temporary easement (if needed)
3	02230	STRIPPING	91	1	91	SF	1' deep stripping
			Length	Length	0.00209	ACRE	
4	02300	EXCAVATION	8	1	8	CF	Excavation below 1' deep stripping
			Area	Length	0.29630	CY	
5	02300	SELECT LEVEE FILL	374	1	374	CF	Zone 2
			Area	Length	13.83365	CY	
6	02300	UNSUITABLE MATERIAL DISPOSAL	3	1	3	CF	Unsuitable material from excavation
			Area	Length	0.11111	CY	
7	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: W x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
8	02925	HYDROSEEDING	85	1	85	SF	Top of levee slope down to disturbed area
			Length	Length	0.00195	ACRE	
9	01000	PERMANENT RIGHT OF WAY (ROW)	28	1	28	SF	Landside slope footprint + ROW (if needed)
			Length	Length	0.00064	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
10	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement (if needed)
			Length	Length	0.00011	ACRE	For construction beyond ROW
13	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road (If needed)
			Area	Length	0.38444	TON	1.73 TON/CY(freestanding repair pnly)
14	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	5	1	5	CF	Reusable material from excavation
			Area	Length	0.18519	CY	Haul to stockpile for reuse

Legend:

		Input cell (Variables)		Linked to estimate table	Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S4
SERIES: b
TOTAL SEGMENT LENGTH (FT): 23,460

S4 - Yuba City Ring Levee - North Side

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-SL	New Levee	11,730	$ 13,746,385	$ 1,172	$ 3,436,596	$ 2,155,222	$ 19,338,203
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	11,730	$ 20,146,150	$ 1,717	$ 5,036,537	$ 2,475,210	$ 27,657,898
							$ 46,996,101

LS-SL **New Levee**

LOCATION: S4 - Yuba City Ring Levee - North Side

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 42.93	5% of sum Items 2 to 9 and 13 to 16
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.40	
3	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.51	
4	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
5	02300	FOUNDATION PREPARATION	7.5556	SY	$ 5.00	$ 37.78	
6	02300	SELECT LEVEE FILL	14.4444	CY	$ 43.50	$ 628.33	
7	02300	UNSUITABLE MATERIAL DISPOSAL	1.4074	CY	$ 15.00	$ 21.11	
8	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 78.05	Qty (%) x sum Items 2 to 9 and 14 to 16
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.5926	CY	$ 4.00	$ 10.37	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 270.44	30% x sum of items above
		CONSTRUCTION COST				$ 1,171.90	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0024	ACRE	$ 38,960.00	$ 92.12	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 32.44	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 58.59	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 183.74	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 292.97	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

23,460 Segment Length (FT)

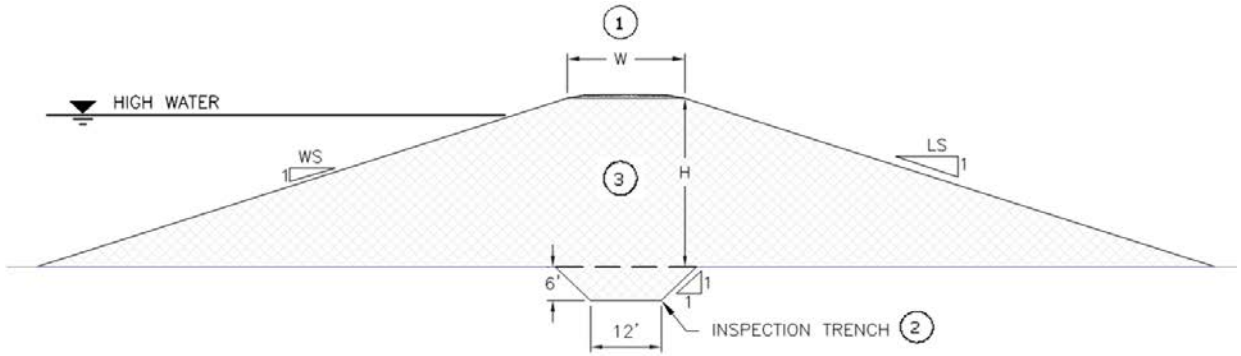
Repair Length 50% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 19,338,203**	For the Specified Repair Length

New Levee

Major Quantity Zone:

1. Levee Road - AB fill area
2. Inspection or cutoff trench - cut and fill area
3. Select Levee Fill - fill area



		FT Existing ROW

Levee Geometry:

H:	8	FT Levee Height
W:	20	FT
W_{AC}:		FT Asphalt Concrete Paving Width
W S:	3	:1 Waterside Slope
L S:	3	:1 Landside Slope
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	108	1	108	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00248	ACRE	5' temporary easement
3	02230	STRIPPING	80	1	80	SF	Levee footprint + 12' AB easement road
			Length	Length	0.00184	ACRE	
4	02300	EXCAVATION	108	1	108	CF	Zone 2
			Area	Length	4.00000	CY	
8	02300	FOUNDATION PREPARATION	68	1	68	SF	Levee footprint
			Length	Length	7.55556	SY	
6	02300	SELECT LEVEE FILL	390	1	390	CF	Zone 3
			Area	Length	14.44444	CY	
7	02300	UNSUITABLE MATERIAL DISPOSAL	38	1	38	CF	Zone 2 unsuitable material
			Area	Length	1.40741	CY	
8	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON to CY
9	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down to disturbed area
			Length	Length	0.00174	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	103	1	103	SF	Same footprint as the replaced levee
			Length	Length	0.00236	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70	CF	Zone 2 reusable material
			Area	Length	2.59259	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**

LOCATION: S4 - Yuba City Ring Levee - North Side

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 62.91	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.40	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.51	
5	02300	FOUNDATION PREPARATION	7.5556	SY	$ 5.00	$ 37.78	
6	02300	SELECT LEVEE FILL	14.4444	CY	$ 43.50	$ 628.33	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 114.38	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 396.34	30% x sum of items above
		CONSTRUCTION COST				$ 1,717.49	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0024	ACRE	$ 38,960.00	$ 92.12	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 32.44	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 85.87	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 211.02	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 429.37	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

23,460 Segment Length (FT)

Repair Length 50% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 27,657,898**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

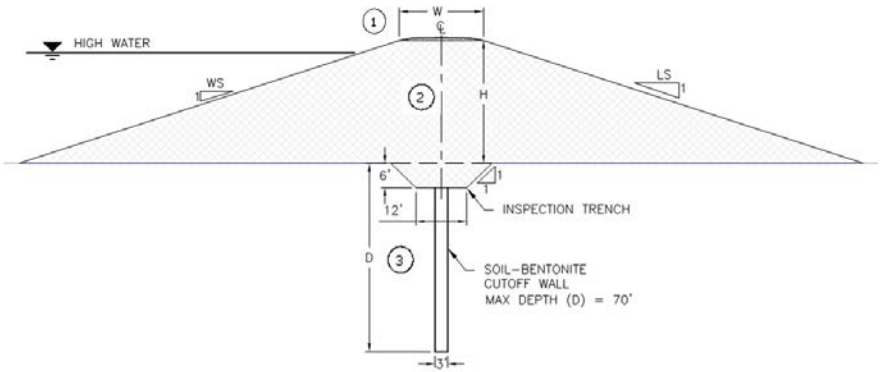
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	8	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	108	1	108	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00248	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	80	1	80	SF	Levee footprint
			Length	Length	0.00184	ACRE	
5	02300	FOUNDATION PREPARATION	68	1	68	SF	Levee footprint
			Length	Length	7.55556	SY	
6	02300	SELECT LEVEE FILL	390	1	390	CF	Zone 2
			Area	Length	14.44444	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down to disturbed area
			Length	Length	0.00174	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	103	1	103	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00236	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

Input cell (Variables) | Linked to estimate table | Formula cell

S1: 2 Levee geometry input (Fixed)

100 Length — Cross-section length, area, depth, or width calculation cell

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S4
SERIES: c
TOTAL SEGMENT LENGTH (FT): 20,600

S4 - Yuba City Ring Levee - West Side

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-SL	New Levee	15,450	$ 18,105,853	$ 1,172	$ 4,526,463	$ 2,838,720	$ 25,471,035
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	5,150	$ 8,845,070	$ 1,717	$ 2,211,268	$ 1,086,729	$ 12,143,067
							$ 37,614,102

LS-SL **New Levee**

LOCATION: S4 - Yuba City Ring Levee - West Side

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 42.93	5% of sum Items 2 to 9 and 13 to 16
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.40	
3	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.51	
4	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
5	02300	FOUNDATION PREPARATION	7.5556	SY	$ 5.00	$ 37.78	
6	02300	SELECT LEVEE FILL	14.4444	CY	$ 43.50	$ 628.33	
7	02300	UNSUITABLE MATERIAL DISPOSAL	1.4074	CY	$ 15.00	$ 21.11	
8	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 78.05	Qty (%) x sum Items 2 to 9 and 14 to 16
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.5926	CY	$ 4.00	$ 10.37	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 270.44	30% x sum of items above
		CONSTRUCTION COST				$ 1,171.90	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0024	ACRE	$ 38,960.00	$ 92.12	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 32.44	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 58.59	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 183.74	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 292.97	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

20,600 Segment Length (FT)

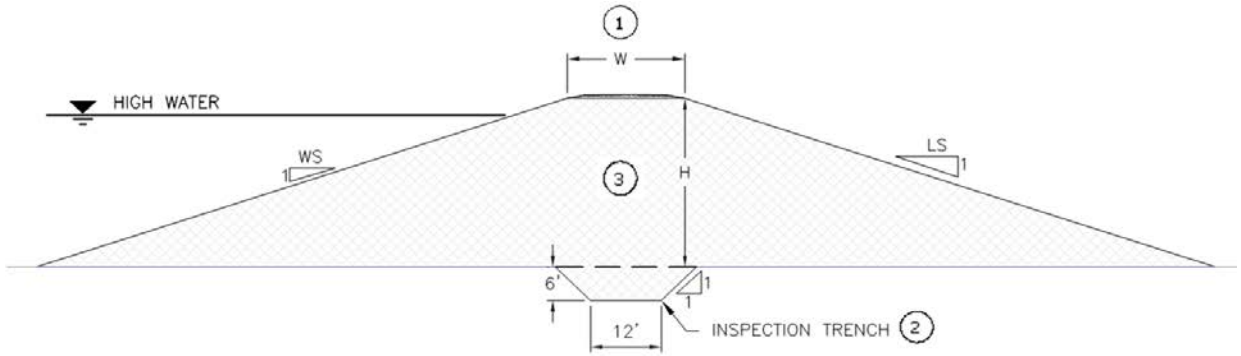
Repair Length 75% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 25,471,035**	For the Specified Repair Length

New Levee

Major Quantity Zone:

1. Levee Road - AB fill area
2. Inspection or cutoff trench - cut and fill area
3. Select Levee Fill - fill area



		FT Existing ROW

Levee Geometry:

H:	8	FT Levee Height
W:	20	FT
W_{AC}:		FT Asphalt Concrete Paving Width
W S:	3	:1 Waterside Slope
L S:	3	:1 Landside Slope
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	108	1	108	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00248	ACRE	5' temporary easement
3	02230	STRIPPING	80	1	80	SF	Levee footprint + 12' AB easement road
			Length	Length	0.00184	ACRE	
4	02300	EXCAVATION	108	1	108	CF	Zone 2
			Area	Length	4.00000	CY	
8	02300	FOUNDATION PREPARATION	68	1	68	SF	Levee footprint
			Length	Length	7.55556	SY	
6	02300	SELECT LEVEE FILL	390	1	390	CF	Zone 3
			Area	Length	14.44444	CY	
7	02300	UNSUITABLE MATERIAL DISPOSAL	38	1	38	CF	Zone 2 unsuitable material
			Area	Length	1.40741	CY	
8	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON to CY
9	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down to disturbed area
			Length	Length	0.00174	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	103	1	103	SF	Same footprint as the replaced levee
			Length	Length	0.00236	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70	CF	Zone 2 reusable material
			Area	Length	2.59259	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**

LOCATION: S4 - Yuba City Ring Levee - West Side

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 62.91	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.40	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.51	
5	02300	FOUNDATION PREPARATION	7.5556	SY	$ 5.00	$ 37.78	
6	02300	SELECT LEVEE FILL	14.4444	CY	$ 43.50	$ 628.33	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 114.38	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 396.34	30% x sum of items above
		CONSTRUCTION COST				$ 1,717.49	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0024	ACRE	$ 38,960.00	$ 92.12	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 32.44	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 85.87	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 211.02	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 429.37	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	20,600	Segment Length (FT)
Repair Length	25%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 12,143,067**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

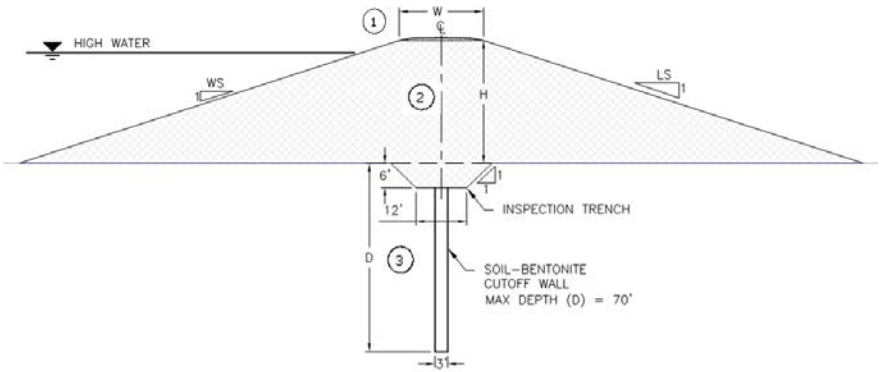
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	8	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	108	1	108	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00248	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	80	1	80	SF	Levee footprint
			Length	Length	0.00184	ACRE	
5	02300	FOUNDATION PREPARATION	68	1	68	SF	Levee footprint
			Length	Length	7.55556	SY	
6	02300	SELECT LEVEE FILL	390	1	390	CF	Zone 2
			Area	Length	14.44444	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down to disturbed area
			Length	Length	0.00174	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	103	1	103	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00236	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S4
SERIES: d
TOTAL SEGMENT LENGTH (FT): 27,410

S4 - Yuba City Ring Levee - South Side

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-SL	New Levee	13,705	$ 30,329,096	$ 2,213	$ 7,582,274	$ 3,727,949	$ 41,639,320
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	13,705	$ 37,806,400	$ 2,759	$ 9,451,600	$ 4,101,814	$ 51,359,815
							$ 92,999,134

LS-SL **New Levee**

LOCATION: S4 - Yuba City Ring Levee - South Side

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 81.06	5% of sum Items 2 to 9 and 13 to 16
2	02230	CLEARING AND GRUBBING	0.0032	ACRE	$ 5,000.00	$ 15.84	
3	02230	STRIPPING	0.0025	ACRE	$ 3,000.00	$ 7.58	
4	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
5	02300	FOUNDATION PREPARATION	10.8889	SY	$ 5.00	$ 54.44	
6	02300	SELECT LEVEE FILL	29.8148	CY	$ 43.50	$ 1,296.94	
7	02300	UNSUITABLE MATERIAL DISPOSAL	1.4074	CY	$ 15.00	$ 21.11	
8	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0024	ACRE	$ 3,750.00	$ 9.13	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 147.39	Qty (%) x sum Items 2 to 9 and 14 to 16
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.5926	CY	$ 4.00	$ 10.37	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 510.69	30% x sum of items above
		CONSTRUCTION COST				$ 2,212.99	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0031	ACRE	$ 38,960.00	$ 118.96	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 41.84	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 110.65	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 272.01	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 553.25	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

27,410 Segment Length (FT)

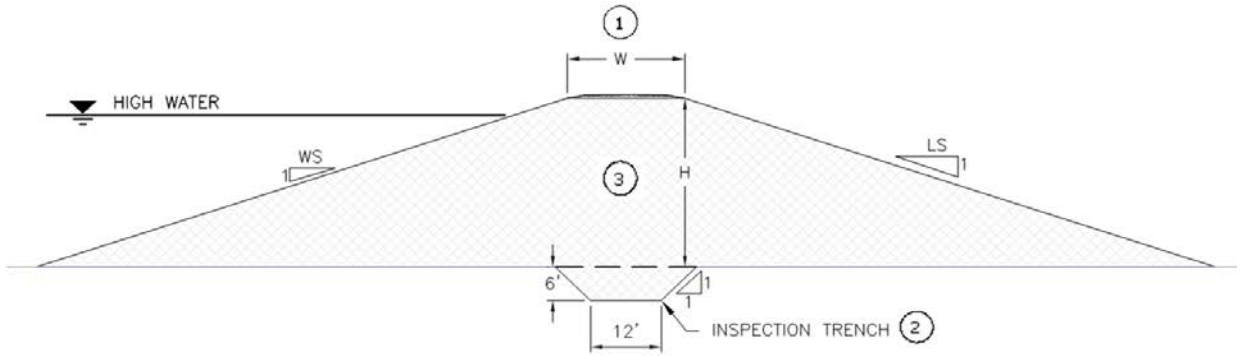
Repair Length 50% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 41,639,320**	For the Specified Repair Length

New Levee

Major Quantity Zone:

1. Levee Road - AB fill area
2. Inspection or cutoff trench - cut and fill area
3. Select Levee Fill - fill area



		FT Existing ROW

Levee Geometry:

H:	13	FT Levee Height
W:	20	FT
W_{AC}:		FT Asphalt Concrete Paving Width
W S:	3	:1 Waterside Slope
L S:	3	:1 Landside Slope
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	138	1	138	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00317	ACRE	5' temporary easement
3	02230	STRIPPING	110	1	110	SF	Levee footprint + 12' AB easement road
			Length	Length	0.00253	ACRE	
4	02300	EXCAVATION	108	1	108	CF	Zone 2
			Area	Length	4.00000	CY	
8	02300	FOUNDATION PREPARATION	98	1	98	SF	Levee footprint
			Length	Length	10.88889	SY	
6	02300	SELECT LEVEE FILL	805	1	805	CF	Zone 3
			Area	Length	29.81481	CY	
7	02300	UNSUITABLE MATERIAL DISPOSAL	38	1	38	CF	Zone 2 unsuitable material
			Area	Length	1.40741	CY	
8	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON to CY
9	02925	HYDROSEEDING	106	1	106	SF	Top of levee slope down to disturbed area
			Length	Length	0.00243	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	133	1	133	SF	Same footprint as the replaced levee
			Length	Length	0.00305	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70	CF	Zone 2 reusable material
			Area	Length	2.59259	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**

LOCATION: S4 - Yuba City Ring Levee - South Side

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 101.05	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0032	ACRE	$ 5,000.00	$ 15.84	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0025	ACRE	$ 3,000.00	$ 7.58	
5	02300	FOUNDATION PREPARATION	10.8889	SY	$ 5.00	$ 54.44	
6	02300	SELECT LEVEE FILL	29.8148	CY	$ 43.50	$ 1,296.94	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0024	ACRE	$ 3,750.00	$ 9.13	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 183.72	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 636.60	30% x sum of items above
		CONSTRUCTION COST				$ 2,758.58	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0031	ACRE	$ 38,960.00	$ 118.96	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 41.84	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 137.93	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 299.29	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 689.65	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

27,410 Segment Length (FT)

Repair Length 50% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 51,359,815**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

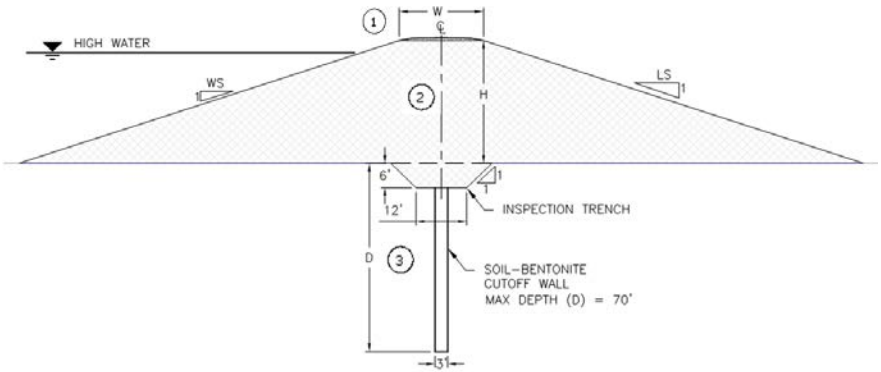
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	13	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	138	1	138	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00317	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	110	1	110	SF	Levee footprint
			Length	Length	0.00253	ACRE	
5	02300	FOUNDATION PREPARATION	98	1	98	SF	Levee footprint
			Length	Length	10.88889	SY	
6	02300	SELECT LEVEE FILL	805	1	805	CF	Zone 2
			Area	Length	29.81481	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	106	1	106	SF	Top of levee slope down to disturbed area
			Length	Length	0.00243	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	133	1	133	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00305	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

Input cell (Variables) | Linked to estimate table | Formula cell

S1: 2 Levee geometry input (Fixed)

100 Length — Cross-section length, area, depth, or width calculation cell

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S5
SERIES: a
TOTAL SEGMENT LENGTH (FT): 53,328

S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach 1

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-TB	Gravel Stability Berm	13,332	$ 9,115,726	$ 684	$ 2,278,931	$ 981,238	$ 12,375,895
TL-SW-SCBCW-TEF	Centerline Soil-Bentonite	53,328	$ 103,820,923	$ 1,947	$ 25,955,231	$ 6,520,169	$ 136,296,324
							$ 148,672,219

LS-TB **Gravel Stability Berm**

LOCATION: S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach 1

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 25.05	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	0.0018	ACRE	$ 5,000.00	$ 8.84	
3	02300	EXCAVATION	2.6667	CY	$ 5.00	$ 13.33	
4	02230	STRIPPING	0.0012	ACRE	$ 3,000.00	$ 3.58	
5	02370	GRAVEL BERM FILL	8.0000	CY	$ 50.00	$ 400.00	
6	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
7	02925	HYDROSEEDING	0.0015	ACRE	$ 3,750.00	$ 5.60	
10	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
11	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 45.54	Qty (%) x sum of Items 2 to 7 and10
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 157.79	30% x sum of items above
		CONSTRUCTION COST				$ 683.75	Per Linear Foot

8	01000	PERMANENT RIGHT OF WAY (ROW)	0.0007	ACRE	$ 38,960.00	$ 28.62	
9	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 10.22	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 34.19	
		ROW AND TEMP EASEMENT COST				$ 73.60	
10	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 170.94	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

53,328 Segment Length (FT)

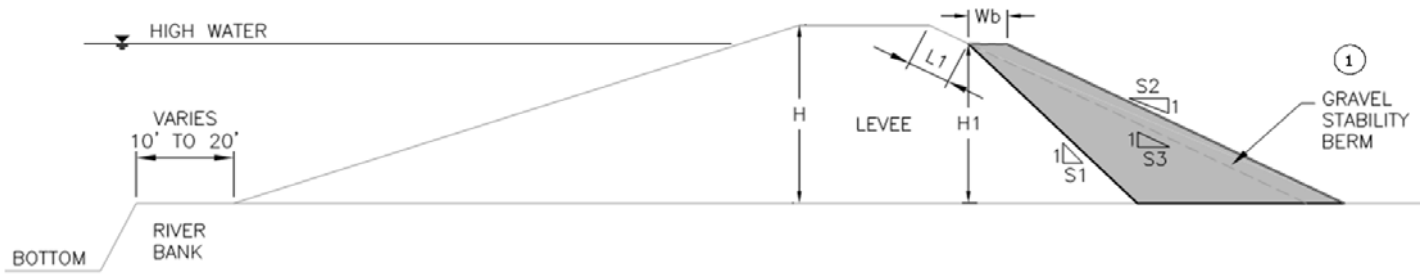
Repair Length 25% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 12,375,895**	For the Specified Repair Length

Gravel Stability Berm

Major Quantity Zone:

(1) Gravel Berm Fill



		FT Existing ROW

Levee Geometry:

H:	18	FT Levee Height
H1:	12	FT
L1:	12.30	FT
S1:	1	:1 Cut Slope
S2:	2	:1 Fill Slope
S3:	2	:1 Existing Slope (S2=>S3 Only)
Wb:	12	FT Berm Width

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	77	1	77	SF	Top of levee slope down to toe of
			Length	Length	0.00177	ACRE	berm + ROW + temporary easement
3	02300	EXCAVATION	72	1	72	CF	Material cut from S3 to S1
			Area	Length	2.66667	CY	
4	02230	STRIPPING	52	1	52	SF	Top of berm slope down to toe of
			Length	Length	0.00119	ACRE	berm + 12' AB easement road
5	02370	GRAVEL BERM FILL	216	1	216	CF	Zone 1
			Area	Length	8.00000	CY	
6	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
7	02925	HYDROSEEDING	65	1	65	SF	Top of levee slope down, disturbed area,
			Length	Length	0.00149	ACRE	and new slopes
8	01000	PERMANENT RIGHT OF WAY (ROW)	32	1	32	SF	Toe widening: Berm width + ROW
			Length	Length	0.00073	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
9	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
10	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table		Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

TL-SW-SCBCW- **Centerline Soil-Bentonite**

LOCATION: S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 71.31	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0026	ACRE	$ 5,000.00	$ 12.86	
3	02300	LEVEE DEGRADE	13.5926	CY	$ 4.50	$ 61.17	
4	02300	SELECT LEVEE FILL	5.6296	CY	$ 43.50	$ 244.89	
5	02300	UNSUITABLE MATERIAL DISPOSAL	5.6296	CY	$ 15.00	$ 84.44	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	8.8519	CY	$ 4.00	$ 35.41	
7	02260	SOIL-BENTONITE SLURRY WALL	65.00	SF	$ 12.50	$ 812.50	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0018	ACRE	$ 3,750.00	$ 6.89	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 129.66	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 449.27	30% x sum of items above
		CONSTRUCTION COST				$ 1,946.84	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0005	ACRE	$ 38,960.00	$ 17.89	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 6.46	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 97.34	
		ROW AND TEMP EASEMENT COST				$ 122.27	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 486.71	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	53,328	Segment Length (FT)
Repair Length	100%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 136,296,324**	For the Specified Repair Length

Centerline Soil-Bentonite

Major Quantity Zone:

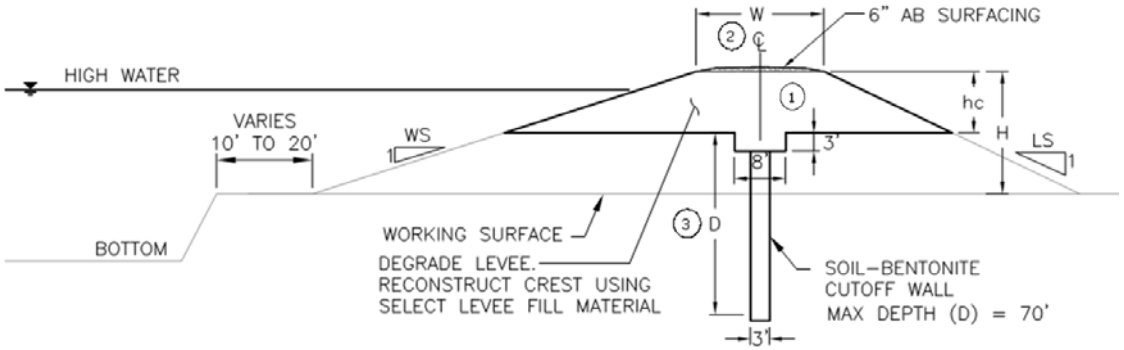
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

		FT Existing ROW

Levee Geometry:

H:	18	FT
W:	20	FT
hc:	8.75	FT Levee Degrade from Crest to Working Surface
D:	65	FT Cutoff Wall Depth from Working Surface
WS:	3	:1 (Waterside Slope)
LS:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	112	1	112	SF	LS slope length + temporary easement +
			Length	Length	0.00257	ACRE	ROW + W + 1/2 of WS slope length
3	02300	LEVEE DEGRADE	367	1	367	CF	Zone 2
			Area	Length	13.59259	CY	
4	02300	SELECT LEVEE FILL	152	1	152	CF	Zone 2
			Area	Length	5.62963	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	152	1	152	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	5.62963	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	239	1	239	CF	Zone 2 reusable material
			Area	Length	8.85185	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	65	1			
			Depth	Length	65.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	80	1	80	SF	Top of levee down to disturbed area
			Length	Length	0.00184	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent Right of Way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S5
SERIES: b
TOTAL SEGMENT LENGTH (FT): 39,072

S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach 2

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-TB	Gravel Stability Berm	29,304	$ 12,403,893	$ 423	$ 3,100,973	$ 1,775,148	$ 17,280,014
TL-SW-SCBCW-TEF	Centerline Soil-Bentonite	29,304	$ 50,446,781	$ 1,721	$ 12,611,695	$ 3,252,699	$ 66,311,175
							$ 83,591,190

LS-TB **Gravel Stability Berm**

LOCATION: S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach 2

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 15.50	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	0.0015	ACRE	$ 5,000.00	$ 7.46	
3	02300	EXCAVATION	1.1852	CY	$ 5.00	$ 5.93	
4	02230	STRIPPING	0.0010	ACRE	$ 3,000.00	$ 2.89	
5	02370	GRAVEL BERM FILL	4.7407	CY	$ 50.00	$ 237.04	
6	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
7	02925	HYDROSEEDING	0.0012	ACRE	$ 3,750.00	$ 4.56	
10	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
11	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 28.19	Qty (%) x sum of Items 2 to 7 and10
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 97.68	30% x sum of items above
		CONSTRUCTION COST				$ 423.28	Per Linear Foot

8	01000	PERMANENT RIGHT OF WAY (ROW)	0.0007	ACRE	$ 38,960.00	$ 28.62	
9	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 10.22	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 21.16	
		ROW AND TEMP EASEMENT COST				$ 60.58	
10	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 105.82	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

39,072 Segment Length (FT)

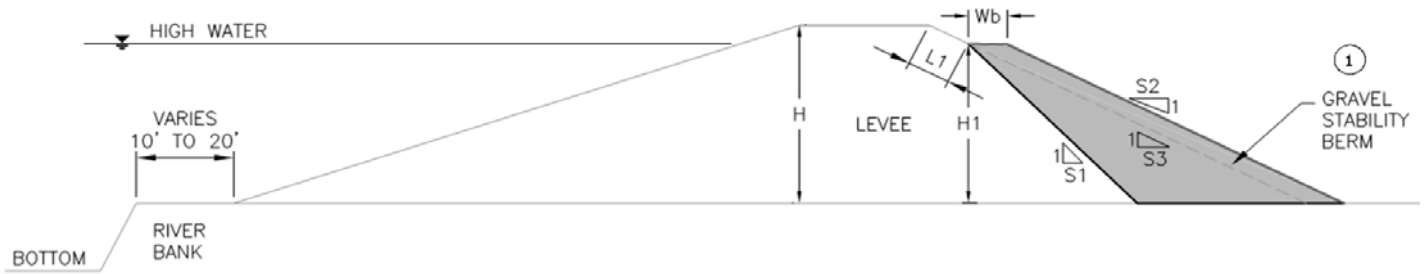
Repair Length 75% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 17,280,014**	For the Specified Repair Length

Gravel Stability Berm

Major Quantity Zone:

(1) Gravel Berm Fill



		FT Existing ROW

Levee Geometry:

H:	13	FT Levee Height
H1:	8	FT
L1:	10.06	FT
S1:	1	:1 Cut Slope
S2:	2	:1 Fill Slope
S3:	2	:1 Existing Slope (S2=>S3 Only)
Wb:	12	FT Berm Width

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	65	1	65	SF	Top of levee slope down to toe of
			Length	Length	0.00149	ACRE	berm + ROW + temporary easement
3	02300	EXCAVATION	32	1	32	CF	Material cut from S3 to S1
			Area	Length	1.18519	CY	
4	02230	STRIPPING	42	1	42	SF	Top of berm slope down to toe of
			Length	Length	0.00096	ACRE	berm + 12' AB easement road
5	02370	GRAVEL BERM FILL	128	1	128	CF	Zone 1
			Area	Length	4.74074	CY	
6	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
7	02925	HYDROSEEDING	53	1	53	SF	Top of levee slope down, disturbed area,
			Length	Length	0.00122	ACRE	and new slopes
8	01000	PERMANENT RIGHT OF WAY (ROW)	32	1	32	SF	Toe widening: Berm width + ROW
			Length	Length	0.00073	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
9	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
10	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table		Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

TL-SW-SCBCW- **Centerline Soil-Bentonite**

LOCATION: S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach 2

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 63.06	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0021	ACRE	$ 5,000.00	$ 10.67	
3	02300	LEVEE DEGRADE	8.2593	CY	$ 4.50	$ 37.17	
4	02300	SELECT LEVEE FILL	3.7778	CY	$ 43.50	$ 164.33	
5	02300	UNSUITABLE MATERIAL DISPOSAL	3.7778	CY	$ 15.00	$ 56.67	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	5.3704	CY	$ 4.00	$ 21.48	
7	02260	SOIL-BENTONITE SLURRY WALL	65.00	SF	$ 12.50	$ 812.50	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0014	ACRE	$ 3,750.00	$ 5.25	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 114.65	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 397.27	30% x sum of items above
		CONSTRUCTION COST				$ 1,721.50	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0005	ACRE	$ 38,960.00	$ 17.89	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 6.46	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 86.07	
		ROW AND TEMP EASEMENT COST				$ 111.00	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 430.37	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	39,072	Segment Length (FT)
Repair Length	75%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 66,311,175**	For the Specified Repair Length

Centerline Soil-Bentonite

Major Quantity Zone:

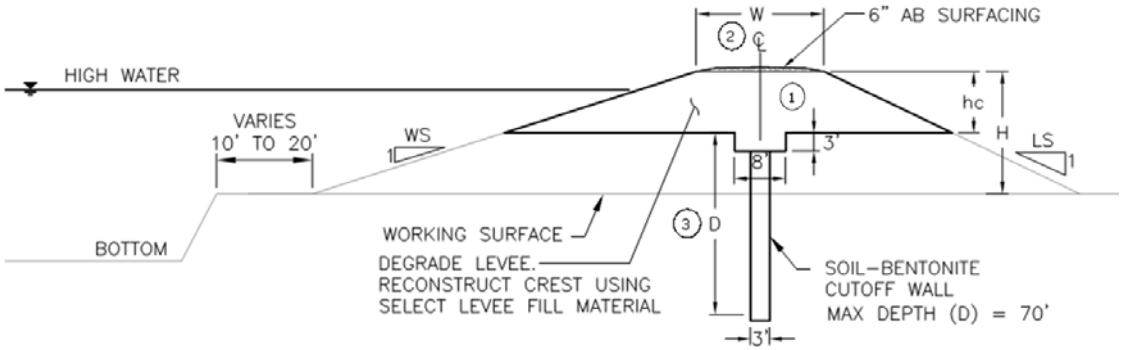
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

		FT Existing ROW

Levee Geometry:

H:	13	FT
W:	20	FT
hc:	6.25	FT Levee Degrade from Crest to Working Surface
D:	65	FT Cutoff Wall Depth from Working Surface
WS:	3	:1 (Waterside Slope)
LS:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	93	1	93	SF	LS slope length + temporary easement +
			Length	Length	0.00213	ACRE	ROW + W + 1/2 of WS slope length
3	02300	LEVEE DEGRADE	223	1	223	CF	Zone 2
			Area	Length	8.25926	CY	
4	02300	SELECT LEVEE FILL	102	1	102	CF	Zone 2
			Area	Length	3.77778	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	102	1	102	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	3.77778	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	145	1	145	CF	Zone 2 reusable material
			Area	Length	5.37037	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	65	1			
			Depth	Length	65.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	61	1	61	SF	Top of levee down to disturbed area
			Length	Length	0.00140	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent Right of Way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S5
SERIES: c
TOTAL SEGMENT LENGTH (FT): 30,624

S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach 3

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-TB	Gravel Stability Berm	7,656	$ 5,234,773	$ 684	$ 1,308,693	$ 563,483	$ 7,106,950
TL-SW-SCBCW-TEF	Centerline Soil-Bentonite	22,968	$ 43,318,063	$ 1,886	$ 10,829,516	$ 2,738,347	$ 56,885,927
LS-TB-LCW	Levee Crest Widening	30,624	$ 18,492,093	$ 604	$ 4,623,023	$ 1,220,417	$ 24,335,534
							$ 88,328,410

LS-TB **Gravel Stability Berm**

LOCATION: S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach 3

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 25.05	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	0.0018	ACRE	$ 5,000.00	$ 8.84	
3	02300	EXCAVATION	2.6667	CY	$ 5.00	$ 13.33	
4	02230	STRIPPING	0.0012	ACRE	$ 3,000.00	$ 3.58	
5	02370	GRAVEL BERM FILL	8.0000	CY	$ 50.00	$ 400.00	
6	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
7	02925	HYDROSEEDING	0.0015	ACRE	$ 3,750.00	$ 5.60	
10	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
11	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 45.54	Qty (%) x sum of Items 2 to 7 and10
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 157.79	30% x sum of items above
		CONSTRUCTION COST				$ 683.75	Per Linear Foot

8	01000	PERMANENT RIGHT OF WAY (ROW)	0.0007	ACRE	$ 38,960.00	$ 28.62	
9	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 10.22	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 34.19	
		ROW AND TEMP EASEMENT COST				$ 73.60	
10	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 170.94	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

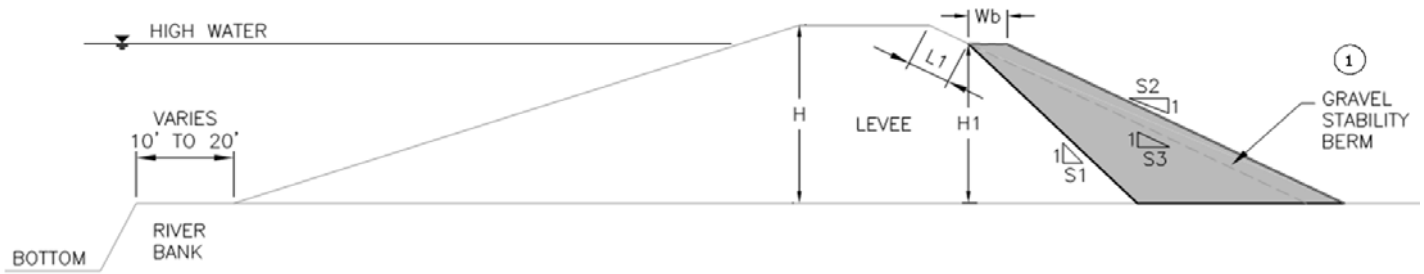
	30,624	Segment Length (FT)
Repair Length	25%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 7,106,950**	For the Specified Repair Length

Gravel Stability Berm

Major Quantity Zone:

(1) Gravel Berm Fill



		FT Existing ROW

Levee Geometry:

H:	18	FT Levee Height
H1:	12	FT
L1:	12.30	FT
S1:	1	:1 Cut Slope
S2:	2	:1 Fill Slope
S3:	2	:1 Existing Slope (S2=>S3 Only)
Wb:	12	FT Berm Width

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	77	1	77	SF	Top of levee slope down to toe of
			Length	Length	0.00177	ACRE	berm + ROW + temporary easement
3	02300	EXCAVATION	72	1	72	CF	Material cut from S3 to S1
			Area	Length	2.66667	CY	
4	02230	STRIPPING	52	1	52	SF	Top of berm slope down to toe of
			Length	Length	0.00119	ACRE	berm + 12' AB easement road
5	02370	GRAVEL BERM FILL	216	1	216	CF	Zone 1
			Area	Length	8.00000	CY	
6	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
7	02925	HYDROSEEDING	65	1	65	SF	Top of levee slope down, disturbed area,
			Length	Length	0.00149	ACRE	and new slopes
8	01000	PERMANENT RIGHT OF WAY (ROW)	32	1	32	SF	Toe widening: Berm width + ROW
			Length	Length	0.00073	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
9	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
10	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table		Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

TL-SW-SCBCW- **Centerline Soil-Bentonite**

LOCATION: S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach 3

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 69.08	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.40	
3	02300	LEVEE DEGRADE	12.2963	CY	$ 4.50	$ 55.33	
4	02300	SELECT LEVEE FILL	5.1852	CY	$ 43.50	$ 225.56	
5	02300	UNSUITABLE MATERIAL DISPOSAL	5.1852	CY	$ 15.00	$ 77.78	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	8.0000	CY	$ 4.00	$ 32.00	
7	02260	SOIL-BENTONITE SLURRY WALL	65.00	SF	$ 12.50	$ 812.50	
8	02720	AGGREGATE BASE LEVEE ROAD	0.5126	TON	$ 37.50	$ 19.22	
9	02925	HYDROSEEDING	0.0018	ACRE	$ 3,750.00	$ 6.89	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 125.61	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 435.23	30% x sum of items above
		CONSTRUCTION COST				$ 1,886.02	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0005	ACRE	$ 38,960.00	$ 17.89	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 6.46	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 94.30	
		ROW AND TEMP EASEMENT COST				$ 119.22	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 471.50	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	30,624	Segment Length (FT)
Repair Length	75%	of Segment Length (enter percent with % sign)

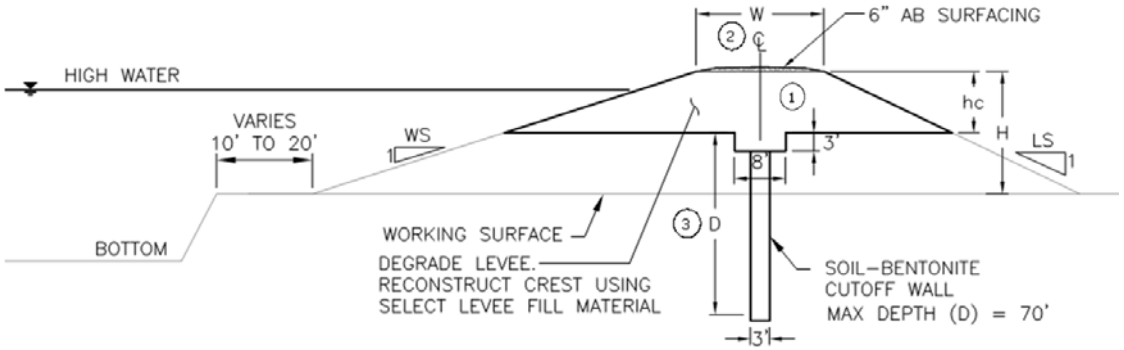
BUDGET AMOUNT	**$ 56,885,927**	For the Specified Repair Length

Centerline Soil-Bentonite

Major Quantity Zone:

1 Levee road

2 Select Levee Fill 3 SB Cutoff Wall



		FT Existing ROW

Levee Geometry:

H:	18	FT
W:	16	FT
hc:	8.75	FT Levee Degrade from Crest to Working Surface
D:	65	FT Cutoff Wall Depth from Working Surface
WS:	3	:1 (Waterside Slope)
LS:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	108	1	108	SF	LS slope length + temporary easement +
			Length	Length	0.00248	ACRE	ROW + W + 1/2 of WS slope length
3	02300	LEVEE DEGRADE	332	1	332	CF	Zone 2
			Area	Length	12.29630	CY	
4	02300	SELECT LEVEE FILL	140	1	140	CF	Zone 2
			Area	Length	5.18519	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	140	1	140	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	5.18519	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	216	1	216	CF	Zone 2 reusable material
			Area	Length	8.00000	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	65	1			
			Depth	Length	65.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	8	1	8	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.51259	TON	1.73 TON/CY
9	02925	HYDROSEEDING	80	1	80	SF	Top of levee down to disturbed area
			Length	Length	0.00184	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent Right of Way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

LS-TB-LCW **Levee Crest Widening**

LOCATION: S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach 3

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 22.12	5% of sum Items 2 to 8 and 12 to 15
2	02230	CLEARING AND GRUBBING	0.0015	ACRE	$ 5,000.00	$ 7.69	
3	02230	STRIPPING	0.0014	ACRE	$ 3,000.00	$ 4.34	
4	02300	EXCAVATION	0.2963	CY	$ 5.00	$ 1.48	
5	02300	SELECT LEVEE FILL	8.2417	CY	$ 43.50	$ 358.51	
6	02300	UNSUITABLE MATERIAL DISPOSAL	0.1111	CY	$ 15.00	$ 1.67	
7	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
8	02925	HYDROSEEDING	0.0010	ACRE	$ 3,750.00	$ 3.70	
12	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 40.22	Qty (%) x sum Items 2 to 8 and 13 to 15
13	02720	AGGREGATE BASE EASEMENT ROAD		TON	$ 37.50	$ -	
14	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	0.1852	CY	$ 4.00	$ 0.74	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 139.35	30% x sum of items above
		CONSTRUCTION COST				$ 603.84	Per Linear Foot

9	01000	PERMANENT RIGHT OF WAY (ROW)	0.0002	ACRE	$ 38,960.00	$ 7.16	
10	01500	TEMPORARY EASEMENT		ACRE	$ 5,000.00	$ -	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 2.50	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 30.19	
		ROW AND TEMP EASEMENT COST				$ 39.85	
11	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 150.96	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	30,624	Segment Length (FT)
Repair Length	100%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 24,335,534**	For the Specified Repair Length

Levee Crest Widening

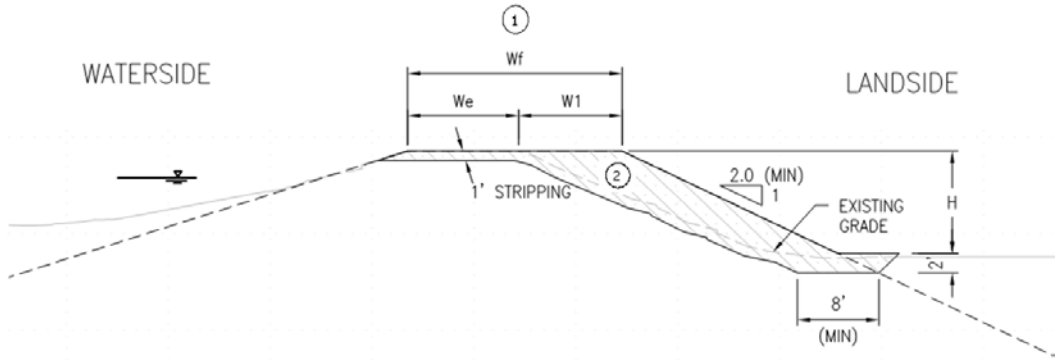
Major Quantity Zone:

(1) Levee Road - fill area (2) Select Levee Fill - fill area

		FT Temporary Easement
		FT ROW
		FT Existing ROW

Levee Geometry:

H	18	FT Crest to Ex Toe Grade
We	16	FT Existing Levee Crest Width
Wf:	20	FT Finished Levee Crest Width
W1:	4	FT (Wf-We)
L S:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	67	1	67	SF	Levee crest edge down to toe slope +
			Length	Length	0.00154	ACRE	ROW + temporary easement (if needed)
3	02230	STRIPPING	63	1	63	SF	1' deep stripping
			Length	Length	0.00145	ACRE	
4	02300	EXCAVATION	8	1	8	CF	Excavation below 1' deep stripping
			Area	Length	0.29630	CY	
5	02300	SELECT LEVEE FILL	223	1	223	CF	Zone 2
			Area	Length	8.24166	CY	
6	02300	UNSUITABLE MATERIAL DISPOSAL	3	1	3	CF	Unsuitable material from excavation
			Area	Length	0.11111	CY	
7	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: W x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
8	02925	HYDROSEEDING	43	1	43	SF	Top of levee slope down to disturbed area
			Length	Length	0.00099	ACRE	
9	01000	PERMANENT RIGHT OF WAY (ROW)	8	1	8	SF	Landside slope footprint + ROW (if needed)
			Length	Length	0.00018	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
10	01500	TEMPORARY EASEMENT		1		SF	5 feet temporary easement (if needed)
			Length	Length		ACRE	For construction beyond ROW
13	02720	AGGREGATE BASE EASEMENT ROAD		1		CF	12' x 6" AB easement road (If needed)
			Area	Length		TON	1.73 TON/CY(freestanding repair pnly)
14	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	5	1	5	CF	Reusable material from excavation
			Area	Length	0.18519	CY	Haul to stockpile for reuse

Legend:

		Input cell (Variables)		Linked to estimate table	Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S5
SERIES: d
TOTAL SEGMENT LENGTH (FT): 31,152

S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach 4

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-TB	Gravel Stability Berm	3,115	$ 3,359,101	$ 1,078	$ 839,775	$ 290,734	$ 4,489,609
TL-SW-SCBCW-TEF	Centerline Soil-Bentonite	15,576	$ 35,360,532	$ 2,270	$ 8,840,133	$ 2,156,236	$ 46,356,900
LS-TB-LCW	Levee Crest Widening (60% Segment Length)	18,691	$ 17,697,545	$ 947	$ 4,424,386	$ 1,065,425	$ 23,187,356
LS-TB-LCW	Levee Crest Widening (40% Segment Length)	12,461	$ 12,539,242	$ 1,006	$ 3,134,811	$ 1,057,895	$ 16,731,947
							$ 90,765,813

LS-TB **Gravel Stability Berm**

LOCATION: S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach 4

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 39.50	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	0.0021	ACRE	$ 5,000.00	$ 10.67	
3	02300	EXCAVATION	5.3519	CY	$ 5.00	$ 26.76	
4	02230	STRIPPING	0.0014	ACRE	$ 3,000.00	$ 4.34	
5	02370	GRAVEL BERM FILL	12.9074	CY	$ 50.00	$ 645.37	
6	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
7	02925	HYDROSEEDING	0.0019	ACRE	$ 3,750.00	$ 6.97	
10	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
11	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 71.81	Qty (%) x sum of Items 2 to 7 and10
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 248.84	30% x sum of items above
		CONSTRUCTION COST				$ 1,078.29	Per Linear Foot

8	01000	PERMANENT RIGHT OF WAY (ROW)	0.0007	ACRE	$ 38,960.00	$ 28.62	
9	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 10.22	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 53.91	
		ROW AND TEMP EASEMENT COST				$ 93.33	
10	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 269.57	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

31,152 Segment Length (FT)

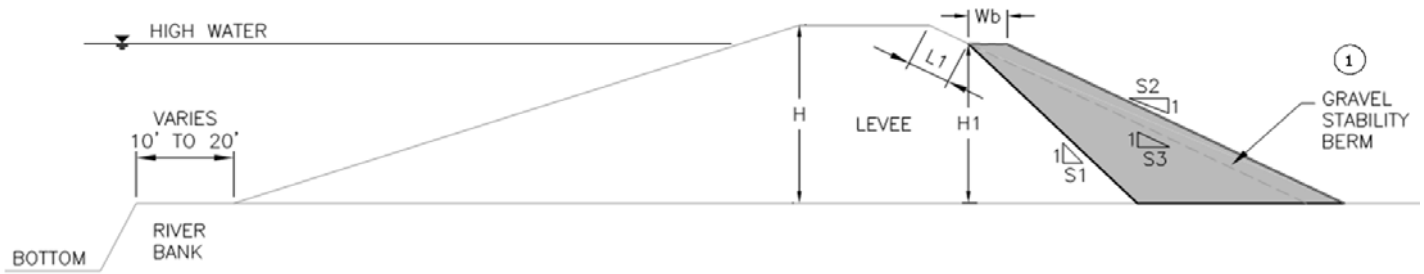
Repair Length 10% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 4,489,609**	For the Specified Repair Length

Gravel Stability Berm

Major Quantity Zone:

(1) Gravel Berm Fill



		FT Existing ROW

Levee Geometry:

H:	25	FT Levee Height
H1:	17	FT
L1:	17.89	FT
S1:	1	:1 Cut Slope
S2:	2	:1 Fill Slope
S3:	2	:1 Existing Slope (S2=>S3 Only)
Wb:	12	FT Berm Width

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	93	1	93	SF	Top of levee slope down to toe of
			Length	Length	0.00213	ACRE	berm + ROW + temporary easement
3	02300	EXCAVATION	144.5	1	144.5	CF	Material cut from S3 to S1
			Area	Length	5.35185	CY	
4	02230	STRIPPING	63	1	63	SF	Top of berm slope down to toe of
			Length	Length	0.00145	ACRE	berm + 12' AB easement road
5	02370	GRAVEL BERM FILL	348.5	1	348.5	CF	Zone 1
			Area	Length	12.90741	CY	
6	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
7	02925	HYDROSEEDING	81	1	81	SF	Top of levee slope down, disturbed area,
			Length	Length	0.00186	ACRE	and new slopes
8	01000	PERMANENT RIGHT OF WAY (ROW)	32	1	32	SF	Toe widening: Berm width + ROW
			Length	Length	0.00073	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
9	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
10	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table		Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

TL-SW-SCBCW- **Centerline Soil-Bentonite**

LOCATION: S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach 4

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 83.16	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0031	ACRE	$ 5,000.00	$ 15.61	
3	02300	LEVEE DEGRADE	21.4444	CY	$ 4.50	$ 96.50	
4	02300	SELECT LEVEE FILL	8.3704	CY	$ 43.50	$ 364.11	
5	02300	UNSUITABLE MATERIAL DISPOSAL	8.3704	CY	$ 15.00	$ 125.56	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	13.9630	CY	$ 4.00	$ 55.85	
7	02260	SOIL-BENTONITE SLURRY WALL	65.00	SF	$ 12.50	$ 812.50	
8	02720	AGGREGATE BASE LEVEE ROAD	0.4806	TON	$ 37.50	$ 18.02	
9	02925	HYDROSEEDING	0.0025	ACRE	$ 3,750.00	$ 9.38	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 151.20	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 523.89	30% x sum of items above
		CONSTRUCTION COST				$ 2,270.19	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0005	ACRE	$ 38,960.00	$ 17.89	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 6.46	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 113.51	
		ROW AND TEMP EASEMENT COST				$ 138.43	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 567.55	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	31,152	Segment Length (FT)
Repair Length	50%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 46,356,900**	For the Specified Repair Length

Centerline Soil-Bentonite

Major Quantity Zone:

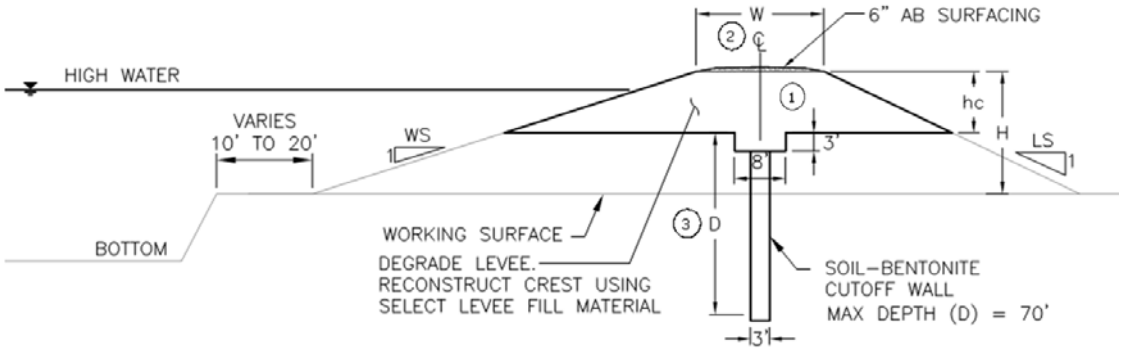
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

		FT Existing ROW

Levee Geometry:

H:	25	FT
W:	15	FT
hc:	12.5	FT Levee Degrade from Crest to Working Surface
D:	65	FT Cutoff Wall Depth from Working Surface
WS:	3	:1 (Waterside Slope)
LS:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	136	1	136	SF	LS slope length + temporary easement +
			Length	Length	0.00312	ACRE	ROW + W + 1/2 of WS slope length
3	02300	LEVEE DEGRADE	579	1	579	CF	Zone 2
			Area	Length	21.44444	CY	
4	02300	SELECT LEVEE FILL	226	1	226	CF	Zone 2
			Area	Length	8.37037	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	226	1	226	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	8.37037	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	377	1	377	CF	Zone 2 reusable material
			Area	Length	13.96296	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	65	1			
			Depth	Length	65.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	8	1	7.5	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.48056	TON	1.73 TON/CY
9	02925	HYDROSEEDING	109	1	109	SF	Top of levee down to disturbed area
			Length	Length	0.00250	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent Right of Way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

LS-TB-LCW **Levee Crest Widening**

LOCATION: S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach 4

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 34.68	5% of sum Items 2 to 8 and 12 to 15
2	02230	CLEARING AND GRUBBING	0.0019	ACRE	$ 5,000.00	$ 9.64	
3	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.44	
4	02300	EXCAVATION	0.2963	CY	$ 5.00	$ 1.48	
5	02300	SELECT LEVEE FILL	13.3892	CY	$ 43.50	$ 582.43	
6	02300	UNSUITABLE MATERIAL DISPOSAL	0.1111	CY	$ 15.00	$ 1.67	
7	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
8	02925	HYDROSEEDING	0.0014	ACRE	$ 3,750.00	$ 5.17	
12	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 63.06	Qty (%) x sum Items 2 to 8 and 13 to 15
13	02720	AGGREGATE BASE EASEMENT ROAD		TON	$ 37.50	$ -	
14	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	0.1852	CY	$ 4.00	$ 0.74	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 218.50	30% x sum of items above
		CONSTRUCTION COST				$ 946.84	Per Linear Foot

9	01000	PERMANENT RIGHT OF WAY (ROW)	0.0002	ACRE	$ 38,960.00	$ 7.16	
10	01500	TEMPORARY EASEMENT		ACRE	$ 5,000.00	$ -	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 2.50	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 47.34	
		ROW AND TEMP EASEMENT COST				$ 57.00	
11	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 236.71	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	31,152	Segment Length (FT)
Repair Length	60%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 23,187,356**	For the Specified Repair Length

Levee Crest Widening

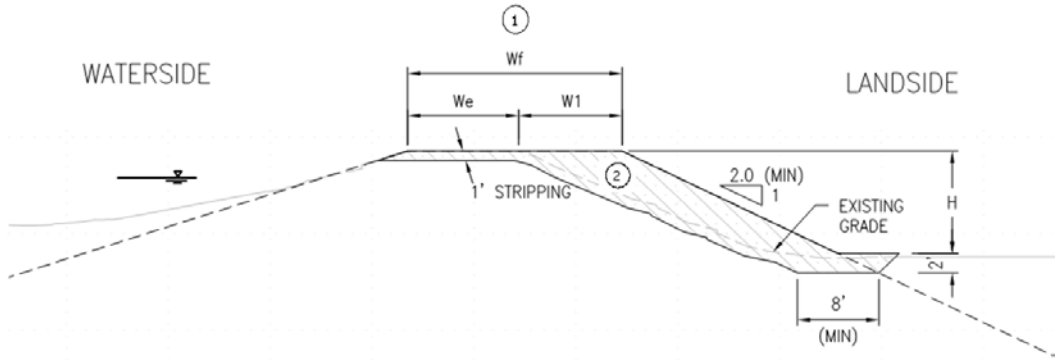
Major Quantity Zone:

(1) Levee Road - fill area (2) Select Levee Fill - fill area

		FT Temporary Easement
		FT ROW
		FT Existing ROW

Levee Geometry:

H	25	FT Crest to Ex Toe Grade
We	15	FT Existing Levee Crest Width
Wf:	20	FT Finished Levee Crest Width
W1:	5	FT (Wf-We)
L S:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	84	1	84	SF	Levee crest edge down to toe slope +
			Length	Length	0.00193	ACRE	ROW + temporary easement (if needed)
3	02230	STRIPPING	79	1	79	SF	1' deep stripping
			Length	Length	0.00181	ACRE	
4	02300	EXCAVATION	8	1	8	CF	Excavation below 1' deep stripping
			Area	Length	0.29630	CY	
5	02300	SELECT LEVEE FILL	362	1	362	CF	Zone 2
			Area	Length	13.38920	CY	
6	02300	UNSUITABLE MATERIAL DISPOSAL	3	1	3	CF	Unsuitable material from excavation
			Area	Length	0.11111	CY	
7	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: W x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
8	02925	HYDROSEEDING	60	1	60	SF	Top of levee slope down to disturbed area
			Length	Length	0.00138	ACRE	
9	01000	PERMANENT RIGHT OF WAY (ROW)	8	1	8	SF	Landside slope footprint + ROW (if needed)
			Length	Length	0.00018	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
10	01500	TEMPORARY EASEMENT		1		SF	5 feet temporary easement (if needed)
			Length	Length		ACRE	For construction beyond ROW
13	02720	AGGREGATE BASE EASEMENT ROAD		1		CF	12' x 6" AB easement road (If needed)
			Area	Length		TON	1.73 TON/CY(freestanding repair pnly)
14	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	5	1	5	CF	Reusable material from excavation
			Area	Length	0.18519	CY	Haul to stockpile for reuse

Legend:

		Input cell (Variables)		Linked to estimate table	Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

LS-TB-LCW **Levee Crest Widening**

LOCATION: S5 - Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend - Reach 4

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 36.86	5% of sum Items 2 to 8 and 12 to 15
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.51	
3	02230	STRIPPING	0.0021	ACRE	$ 3,000.00	$ 6.27	
4	02300	EXCAVATION	0.2963	CY	$ 5.00	$ 1.48	
5	02300	SELECT LEVEE FILL	13.8336	CY	$ 43.50	$ 601.76	
6	02300	UNSUITABLE MATERIAL DISPOSAL	0.1111	CY	$ 15.00	$ 1.67	
7	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
8	02925	HYDROSEEDING	0.0020	ACRE	$ 3,750.00	$ 7.32	
12	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 67.02	Qty (%) x sum Items 2 to 8 and 13 to 15
13	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
14	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	0.1852	CY	$ 4.00	$ 0.74	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 232.22	30% x sum of items above
		CONSTRUCTION COST				$ 1,006.30	Per Linear Foot

9	01000	PERMANENT RIGHT OF WAY (ROW)	0.0006	ACRE	$ 38,960.00	$ 25.04	
10	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 8.97	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 50.31	
		ROW AND TEMP EASEMENT COST				$ 84.90	
11	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 251.57	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	31,152	Segment Length (FT)
Repair Length	40%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 16,731,947**	For the Specified Repair Length

Levee Crest Widening

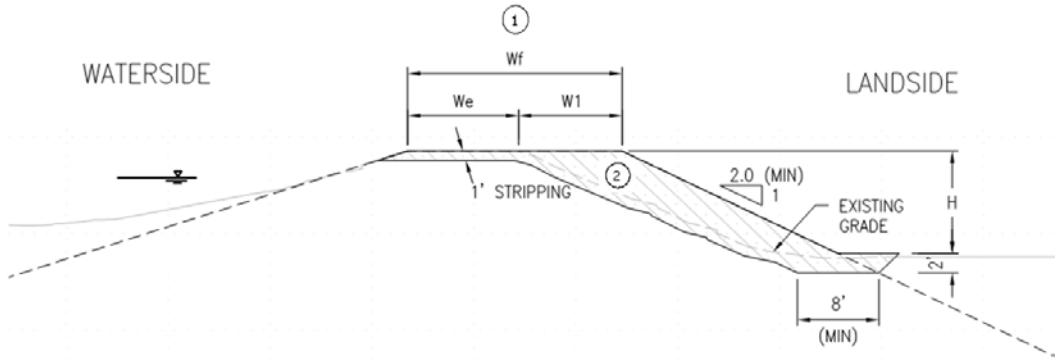
Major Quantity Zone:

(1) Levee Road - fill area (2) Select Levee Fill - fill area

	5	FT Temporary Easement
	20	FT ROW
		FT Existing ROW

Levee Geometry:

H	25	FT Crest to Ex Toe Grade
We	15	FT Existing Levee Crest Width
Wf:	20	FT Finished Levee Crest Width
W1:	5	FT (Wf-We)
L S:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	109	1	109	SF	Levee crest edge down to toe slope +
			Length	Length	0.00250	ACRE	ROW + temporary easement (if needed)
3	02230	STRIPPING	91	1	91	SF	1' deep stripping
			Length	Length	0.00209	ACRE	
4	02300	EXCAVATION	8	1	8	CF	Excavation below 1' deep stripping
			Area	Length	0.29630	CY	
5	02300	SELECT LEVEE FILL	374	1	374	CF	Zone 2
			Area	Length	13.83365	CY	
6	02300	UNSUITABLE MATERIAL DISPOSAL	3	1	3	CF	Unsuitable material from excavation
			Area	Length	0.11111	CY	
7	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: W x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
8	02925	HYDROSEEDING	85	1	85	SF	Top of levee slope down to disturbed area
			Length	Length	0.00195	ACRE	
9	01000	PERMANENT RIGHT OF WAY (ROW)	28	1	28	SF	Landside slope footprint + ROW (if needed)
			Length	Length	0.00064	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
10	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement (if needed)
			Length	Length	0.00011	ACRE	For construction beyond ROW
13	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road (If needed)
			Area	Length	0.38444	TON	1.73 TON/CY(freestanding repair pnly)
14	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	5	1	5	CF	Reusable material from excavation
			Area	Length	0.18519	CY	Haul to stockpile for reuse

Legend:

		Input cell (Variables)		Linked to estimate table	Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S6
SERIES: a
TOTAL SEGMENT LENGTH (FT): 27,410

S6 - Southern Portion of J-Levee - South Side

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-SL	New Levee	13,705	$ 30,329,096	$ 2,213	$ 7,582,274	$ 3,002,609	$ 40,913,980
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	13,705	$ 37,806,400	$ 2,759	$ 9,451,600	$ 3,376,474	$ 50,634,475
							$ 91,548,454

LS-SL **New Levee**

LOCATION: S6 - Southern Portion of J-Levee - South Side

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 81.06	5% of sum Items 2 to 9 and 13 to 16
2	02230	CLEARING AND GRUBBING	0.0032	ACRE	$ 5,000.00	$ 15.84	
3	02230	STRIPPING	0.0025	ACRE	$ 3,000.00	$ 7.58	
4	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
5	02300	FOUNDATION PREPARATION	10.8889	SY	$ 5.00	$ 54.44	
6	02300	SELECT LEVEE FILL	29.8148	CY	$ 43.50	$ 1,296.94	
7	02300	UNSUITABLE MATERIAL DISPOSAL	1.4074	CY	$ 15.00	$ 21.11	
8	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0024	ACRE	$ 3,750.00	$ 9.13	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 147.39	Qty (%) x sum Items 2 to 9 and 14 to 16
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.5926	CY	$ 4.00	$ 10.37	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 510.69	30% x sum of items above
		CONSTRUCTION COST				$ 2,212.99	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0031	ACRE	$ 26,120.00	$ 79.75	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 28.11	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 110.65	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 219.09	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 553.25	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

27,410 Segment Length (FT)

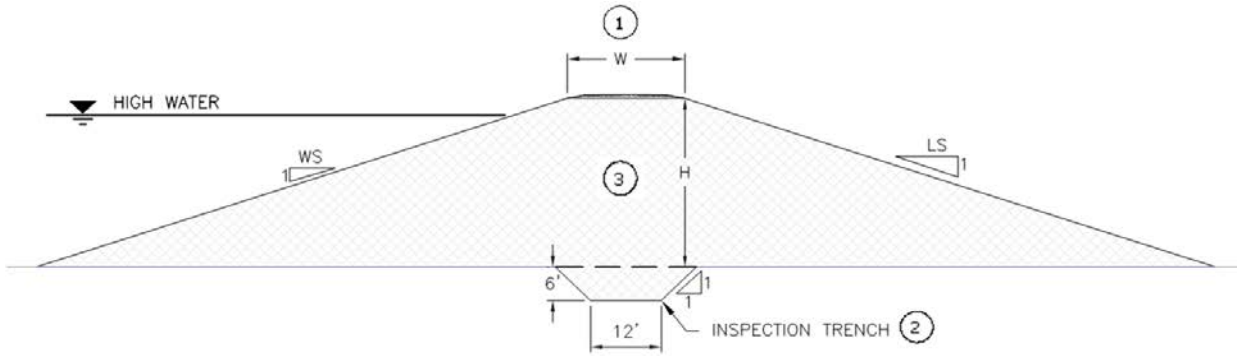
Repair Length 50% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 40,913,980**	For the Specified Repair Length

New Levee

Major Quantity Zone:

1. Levee Road - AB fill area
2. Inspection or cutoff trench - cut and fill area
3. Select Levee Fill - fill area



		FT Existing ROW

Levee Geometry:

H:	13	FT Levee Height
W:	20	FT
W_{AC}:		FT Asphalt Concrete Paving Width
W S:	3	:1 Waterside Slope
L S:	3	:1 Landside Slope
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	138	1	138	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00317	ACRE	5' temporary easement
3	02230	STRIPPING	110	1	110	SF	Levee footprint + 12' AB easement road
			Length	Length	0.00253	ACRE	
4	02300	EXCAVATION	108	1	108	CF	Zone 2
			Area	Length	4.00000	CY	
8	02300	FOUNDATION PREPARATION	98	1	98	SF	Levee footprint
			Length	Length	10.88889	SY	
6	02300	SELECT LEVEE FILL	805	1	805	CF	Zone 3
			Area	Length	29.81481	CY	
7	02300	UNSUITABLE MATERIAL DISPOSAL	38	1	38	CF	Zone 2 unsuitable material
			Area	Length	1.40741	CY	
8	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON to CY
9	02925	HYDROSEEDING	106	1	106	SF	Top of levee slope down to disturbed area
			Length	Length	0.00243	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	133	1	133	SF	Same footprint as the replaced levee
			Length	Length	0.00305	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70	CF	Zone 2 reusable material
			Area	Length	2.59259	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**

LOCATION: S6 - Southern Portion of J-Levee - South Side

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 101.05	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0032	ACRE	$ 5,000.00	$ 15.84	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0025	ACRE	$ 3,000.00	$ 7.58	
5	02300	FOUNDATION PREPARATION	10.8889	SY	$ 5.00	$ 54.44	
6	02300	SELECT LEVEE FILL	29.8148	CY	$ 43.50	$ 1,296.94	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0024	ACRE	$ 3,750.00	$ 9.13	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 183.72	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 636.60	30% x sum of items above
		CONSTRUCTION COST				$ 2,758.58	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0031	ACRE	$ 26,120.00	$ 79.75	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 28.11	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 137.93	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 246.37	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 689.65	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

27,410 Segment Length (FT)

Repair Length 50% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 50,634,475**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

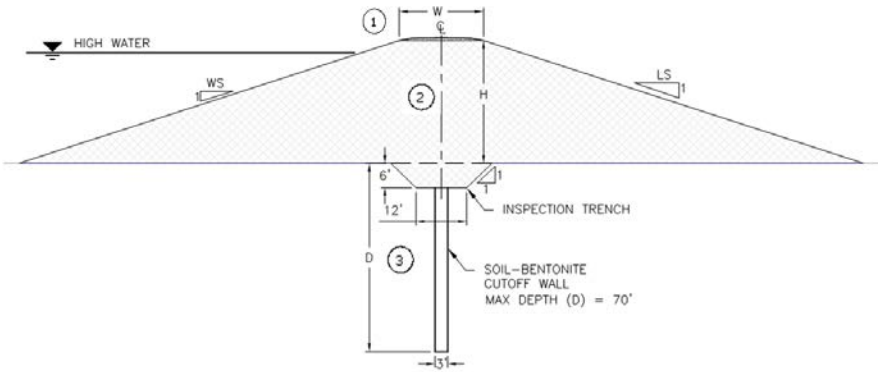
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	13	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	138	1	138	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00317	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	110	1	110	SF	Levee footprint
			Length	Length	0.00253	ACRE	
5	02300	FOUNDATION PREPARATION	98	1	98	SF	Levee footprint
			Length	Length	10.88889	SY	
6	02300	SELECT LEVEE FILL	805	1	805	CF	Zone 2
			Area	Length	29.81481	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	106	1	106	SF	Top of levee slope down to disturbed area
			Length	Length	0.00243	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	133	1	133	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00305	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

Input cell (Variables) — Linked to estimate table — Formula cell

S1: 2 Levee geometry input (Fixed)

100 Length — Cross-section length, area, depth, or width calculation cell

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S6
SERIES: b
TOTAL SEGMENT LENGTH (FT): 20,600

S6 - Southern Portion of J-Levee - West Side - Lower

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-SL	New Levee	15,450	$ 18,105,853	$ 1,172	$ 4,526,463	$ 2,205,468	$ 24,837,783
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	5,150	$ 8,845,070	$ 1,717	$ 2,211,268	$ 875,645	$ 11,931,983
							$ 36,769,766

LS-SL **New Levee**

LOCATION: S6 - Southern Portion of J-Levee - West Side - Lower

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 42.93	5% of sum Items 2 to 9 and 13 to 16
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.40	
3	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.51	
4	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
5	02300	FOUNDATION PREPARATION	7.5556	SY	$ 5.00	$ 37.78	
6	02300	SELECT LEVEE FILL	14.4444	CY	$ 43.50	$ 628.33	
7	02300	UNSUITABLE MATERIAL DISPOSAL	1.4074	CY	$ 15.00	$ 21.11	
8	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 78.05	Qty (%) x sum Items 2 to 9 and 14 to 16
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.5926	CY	$ 4.00	$ 10.37	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 270.44	30% x sum of items above
		CONSTRUCTION COST				$ 1,171.90	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0024	ACRE	$ 26,120.00	$ 61.76	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 21.82	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 58.59	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 142.75	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 292.97	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

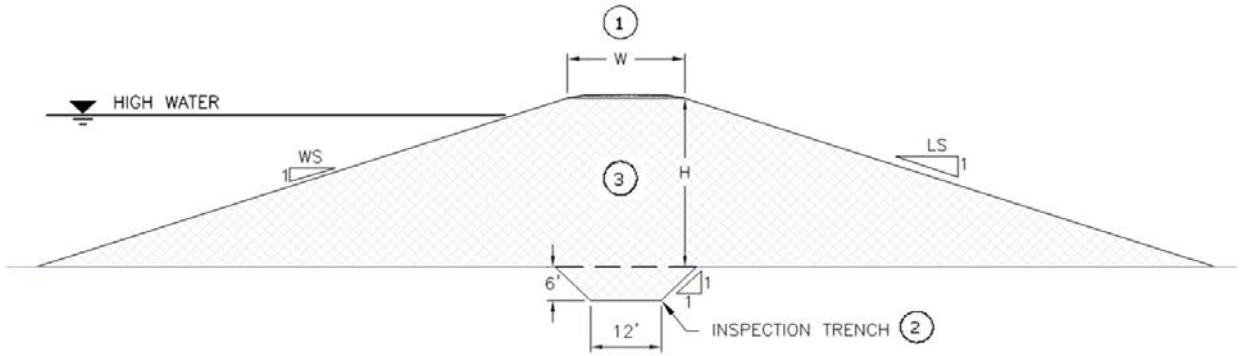
	20,600	Segment Length (FT)
Repair Length	75%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 24,837,783**	For the Specified Repair Length

New Levee

Major Quantity Zone:

1. Levee Road - AB fill area
2. Inspection or cutoff trench - cut and fill area
3. Select Levee Fill - fill area



		FT Existing ROW

Levee Geometry:

H:	8	FT Levee Height
W:	20	FT
W_{AC}:		FT Asphalt Concrete Paving Width
W S:	3	:1 Waterside Slope
L S:	3	:1 Landside Slope
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	108	1	108	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00248	ACRE	5' temporary easement
3	02230	STRIPPING	80	1	80	SF	Levee footprint + 12' AB easement road
			Length	Length	0.00184	ACRE	
4	02300	EXCAVATION	108	1	108	CF	Zone 2
			Area	Length	4.00000	CY	
8	02300	FOUNDATION PREPARATION	68	1	68	SF	Levee footprint
			Length	Length	7.55556	SY	
6	02300	SELECT LEVEE FILL	390	1	390	CF	Zone 3
			Area	Length	14.44444	CY	
7	02300	UNSUITABLE MATERIAL DISPOSAL	38	1	38	CF	Zone 2 unsuitable material
			Area	Length	1.40741	CY	
8	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON to CY
9	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down to disturbed area
			Length	Length	0.00174	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	103	1	103	SF	Same footprint as the replaced levee
			Length	Length	0.00236	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70	CF	Zone 2 reusable material
			Area	Length	2.59259	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**

LOCATION: S6 - Southern Portion of J-Levee - West Side - Lower

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 62.91	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.40	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.51	
5	02300	FOUNDATION PREPARATION	7.5556	SY	$ 5.00	$ 37.78	
6	02300	SELECT LEVEE FILL	14.4444	CY	$ 43.50	$ 628.33	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 114.38	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 396.34	30% x sum of items above
		CONSTRUCTION COST				$ 1,717.49	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0024	ACRE	$ 26,120.00	$ 61.76	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 21.82	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 85.87	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 170.03	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 429.37	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	20,600	Segment Length (FT)
Repair Length	25%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 11,931,983**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

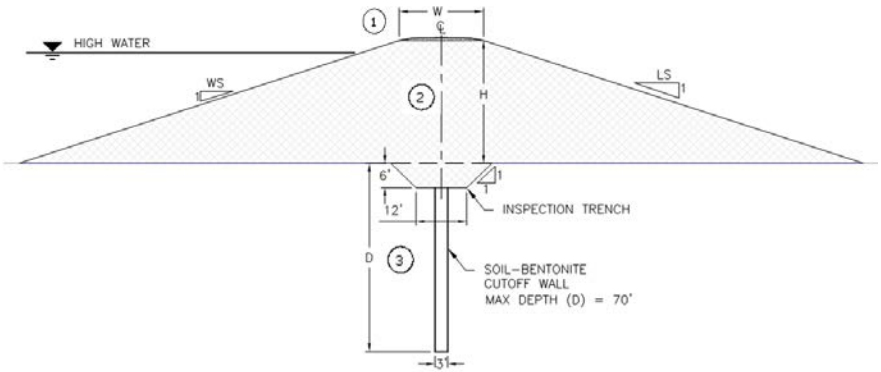
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	8	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	108	1	108	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00248	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	80	1	80	SF	Levee footprint
			Length	Length	0.00184	ACRE	
5	02300	FOUNDATION PREPARATION	68	1	68	SF	Levee footprint
			Length	Length	7.55556	SY	
6	02300	SELECT LEVEE FILL	390	1	390	CF	Zone 2
			Area	Length	14.44444	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down to disturbed area
			Length	Length	0.00174	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	103	1	103	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00236	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

Input cell (Variables) | Linked to estimate table | Formula cell

S1: 2 Levee geometry input (Fixed)

100 Length — Cross-section length, area, depth, or width calculation cell

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S6
SERIES: c
TOTAL SEGMENT LENGTH (FT): 6,400

S6 - Southern Portion of J-Levee - West Side - Upper

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-SL	New Levee	4,800	$ 5,625,119	$ 1,172	$ 1,406,280	$ 685,194	$ 7,716,593
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	1,600	$ 2,747,983	$ 1,717	$ 686,996	$ 272,045	$ 3,707,024
							$ 11,423,617

LS-SL **New Levee**

LOCATION: S6 - Southern Portion of J-Levee - West Side - Upper

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 42.93	5% of sum Items 2 to 9 and 13 to 16
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.40	
3	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.51	
4	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
5	02300	FOUNDATION PREPARATION	7.5556	SY	$ 5.00	$ 37.78	
6	02300	SELECT LEVEE FILL	14.4444	CY	$ 43.50	$ 628.33	
7	02300	UNSUITABLE MATERIAL DISPOSAL	1.4074	CY	$ 15.00	$ 21.11	
8	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 78.05	Qty (%) x sum Items 2 to 9 and 14 to 16
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.5926	CY	$ 4.00	$ 10.37	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 270.44	30% x sum of items above
		CONSTRUCTION COST				$ 1,171.90	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0024	ACRE	$ 26,120.00	$ 61.76	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 21.82	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 58.59	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 142.75	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 292.97	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

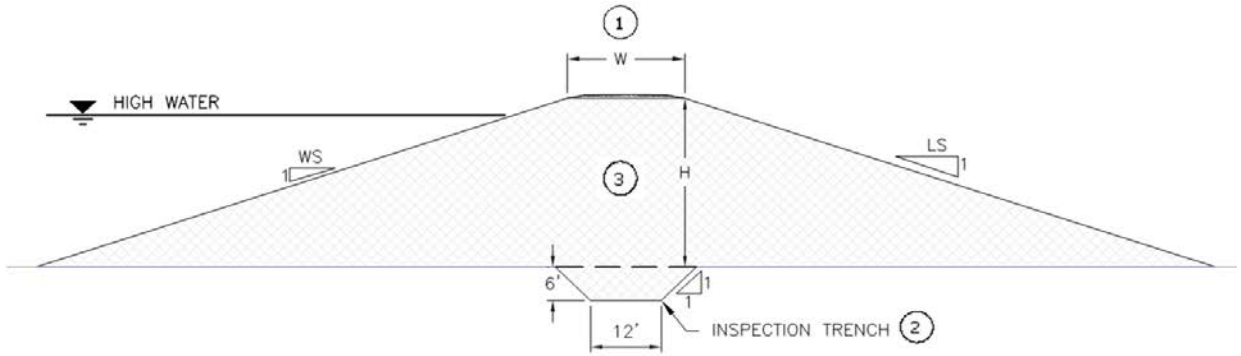
	6,400	Segment Length (FT)
Repair Length	75%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 7,716,593**	For the Specified Repair Length

New Levee

Major Quantity Zone:

1. Levee Road - AB fill area
2. Inspection or cutoff trench - cut and fill area
3. Select Levee Fill - fill area



		FT Existing ROW

Levee Geometry:

H:	8	FT Levee Height
W:	20	FT
W_{AC}:		FT Asphalt Concrete Paving Width
W S:	3	:1 Waterside Slope
L S:	3	:1 Landside Slope
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	108	1	108	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00248	ACRE	5' temporary easement
3	02230	STRIPPING	80	1	80	SF	Levee footprint + 12' AB easement road
			Length	Length	0.00184	ACRE	
4	02300	EXCAVATION	108	1	108	CF	Zone 2
			Area	Length	4.00000	CY	
8	02300	FOUNDATION PREPARATION	68	1	68	SF	Levee footprint
			Length	Length	7.55556	SY	
6	02300	SELECT LEVEE FILL	390	1	390	CF	Zone 3
			Area	Length	14.44444	CY	
7	02300	UNSUITABLE MATERIAL DISPOSAL	38	1	38	CF	Zone 2 unsuitable material
			Area	Length	1.40741	CY	
8	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON to CY
9	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down to disturbed area
			Length	Length	0.00174	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	103	1	103	SF	Same footprint as the replaced levee
			Length	Length	0.00236	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70	CF	Zone 2 reusable material
			Area	Length	2.59259	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**

LOCATION: S6 - Southern Portion of J-Levee - West Side - Upper

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 62.91	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.40	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.51	
5	02300	FOUNDATION PREPARATION	7.5556	SY	$ 5.00	$ 37.78	
6	02300	SELECT LEVEE FILL	14.4444	CY	$ 43.50	$ 628.33	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 114.38	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
						-	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 396.34	30% x sum of items above
		CONSTRUCTION COST				$ 1,717.49	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0024	ACRE	$ 26,120.00	$ 61.76	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 21.82	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 85.87	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 170.03	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 429.37	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	6,400	Segment Length (FT)
Repair Length	25%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 3,707,024**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

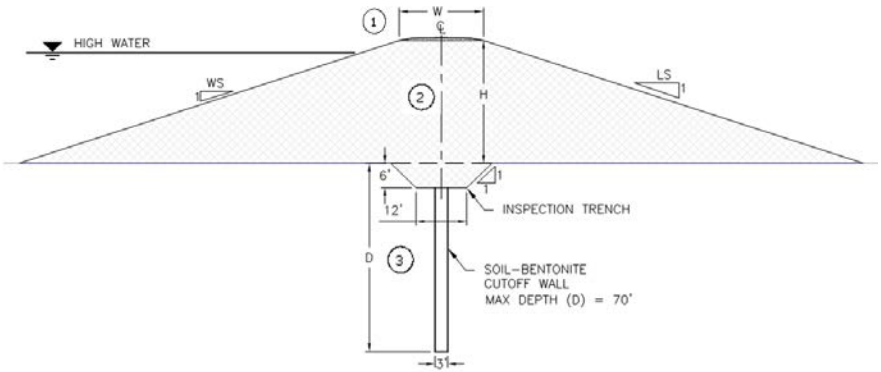
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	8	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	108	1	108	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00248	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	80	1	80	SF	Levee footprint
			Length	Length	0.00184	ACRE	
5	02300	FOUNDATION PREPARATION	68	1	68	SF	Levee footprint
			Length	Length	7.55556	SY	
6	02300	SELECT LEVEE FILL	390	1	390	CF	Zone 2
			Area	Length	14.44444	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down to disturbed area
			Length	Length	0.00174	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	103	1	103	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00236	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

Input cell (Variables) | Linked to estimate table | Formula cell

S1: 2 Levee geometry input (Fixed)

100 Length — Cross-section length, area, depth, or width calculation cell

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S7
SERIES: d
TOTAL SEGMENT LENGTH (FT): 21,120

S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee - Reach 1

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-TB	Gravel Stability Berm	2,112	$ 1,170,119	$ 554	$ 292,530	$ 141,746	$ 1,604,395
TL-SW-SCBCW-TEF	Centerline Soil-Bentonite	10,560	$ 23,973,242	$ 2,270	$ 5,993,310	$ 1,461,855	$ 31,428,407
LS-TB-LCW	Levee Crest Widening (60% Segment Length)	12,672	$ 11,998,335	$ 947	$ 2,999,584	$ 722,322	$ 15,720,241
LS-TB-LCW	Levee Crest Widening (40% Segment Length)	8,448	$ 8,501,181	$ 1,006	$ 2,125,295	$ 717,217	$ 11,343,693
							$ 60,096,736

LS-TB **Gravel Stability Berm**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus V

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 20.29	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	0.0021	ACRE	$ 5,000.00	$ 10.67	
3	02300	EXCAVATION	1.8519	CY	$ 5.00	$ 9.26	
4	02230	STRIPPING	0.0011	ACRE	$ 3,000.00	$ 3.24	
5	02370	GRAVEL BERM FILL	6.2963	CY	$ 50.00	$ 314.81	
6	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
7	02925	HYDROSEEDING	0.0019	ACRE	$ 3,750.00	$ 6.97	
10	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
11	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 36.90	Qty (%) x sum of Items 2 to 7 and10
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 127.85	30% x sum of items above
		CONSTRUCTION COST				$ 554.03	Per Linear Foot

8	01000	PERMANENT RIGHT OF WAY (ROW)	0.0007	ACRE	$ 38,960.00	$ 28.62	
9	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 10.22	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 27.70	
		ROW AND TEMP EASEMENT COST				$ 67.11	
10	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 138.51	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

21,120 Segment Length (FT)

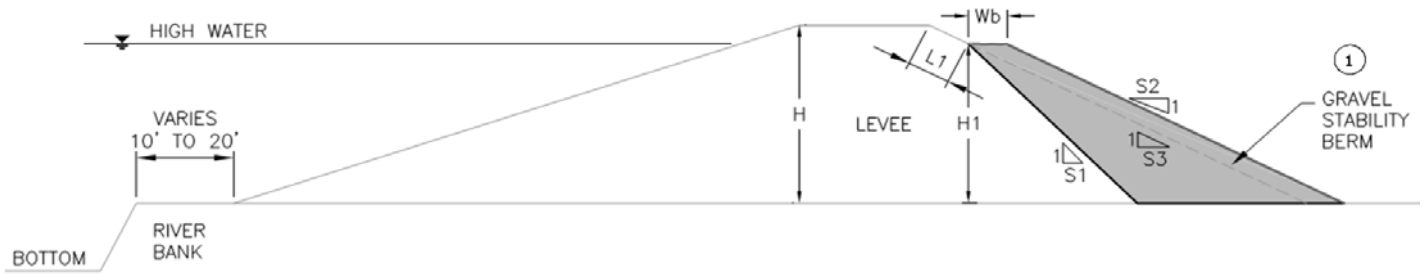
Repair Length 10% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 1,604,395**	For the Specified Repair Length

Gravel Stability Berm

Major Quantity Zone:

(1) Gravel Berm Fill



		FT Existing ROW

Levee Geometry:

H:	25	FT Levee Height
H1:	10	FT
L1:	33.54	FT
S1:	1	:1 Cut Slope
S2:	2	:1 Fill Slope
S3:	2	:1 Existing Slope (S2=>S3 Only)
Wb:	12	FT Berm Width

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	93	1	93	SF	Top of levee slope down to toe of
			Length	Length	0.00213	ACRE	berm + ROW + temporary easement
3	02300	EXCAVATION	50	1	50	CF	Material cut from S3 to S1
			Area	Length	1.85185	CY	
4	02230	STRIPPING	47	1	47	SF	Top of berm slope down to toe of
			Length	Length	0.00108	ACRE	berm + 12' AB easement road
5	02370	GRAVEL BERM FILL	170	1	170	CF	Zone 1
			Area	Length	6.29630	CY	
6	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
7	02925	HYDROSEEDING	81	1	81	SF	Top of levee slope down, disturbed area,
			Length	Length	0.00186	ACRE	and new slopes
8	01000	PERMANENT RIGHT OF WAY (ROW)	32	1	32	SF	Toe widening: Berm width + ROW
			Length	Length	0.00073	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
9	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
10	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table		Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

TL-SW-SCBCW- **Centerline Soil-Bentonite**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 83.16	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0031	ACRE	$ 5,000.00	$ 15.61	
3	02300	LEVEE DEGRADE	21.4444	CY	$ 4.50	$ 96.50	
4	02300	SELECT LEVEE FILL	8.3704	CY	$ 43.50	$ 364.11	
5	02300	UNSUITABLE MATERIAL DISPOSAL	8.3704	CY	$ 15.00	$ 125.56	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	13.9630	CY	$ 4.00	$ 55.85	
7	02260	SOIL-BENTONITE SLURRY WALL	65.00	SF	$ 12.50	$ 812.50	
8	02720	AGGREGATE BASE LEVEE ROAD	0.4806	TON	$ 37.50	$ 18.02	
9	02925	HYDROSEEDING	0.0025	ACRE	$ 3,750.00	$ 9.38	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 151.20	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 523.89	30% x sum of items above
		CONSTRUCTION COST				$ 2,270.19	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0005	ACRE	$ 38,960.00	$ 17.89	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 6.46	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 113.51	
		ROW AND TEMP EASEMENT COST				$ 138.43	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 567.55	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	21,120	Segment Length (FT)
Repair Length	50%	of Segment Length (enter percent with % sign)

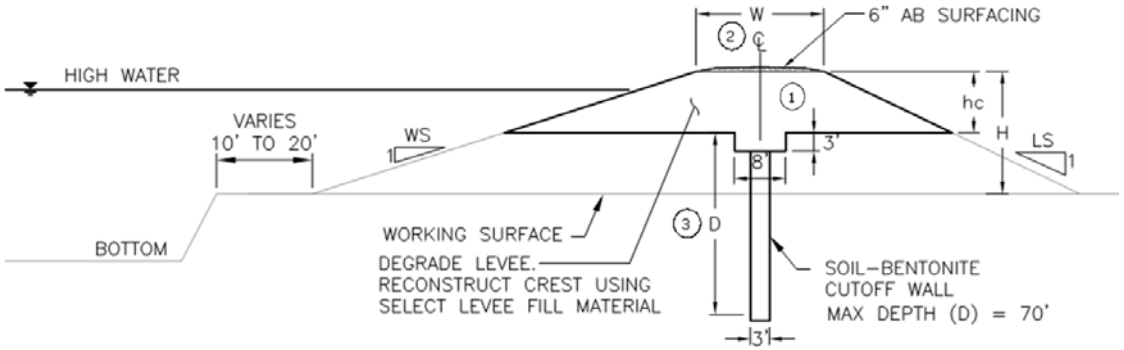
BUDGET AMOUNT	**$ 31,428,407**	For the Specified Repair Length

Centerline Soil-Bentonite

Major Quantity Zone:

1 Levee road

2 Select Levee Fill 3 SB Cutoff Wall



		FT Existing ROW

Levee Geometry:

H:	25	FT
W:	15	FT
hc:	12.5	FT Levee Degrade from Crest to Working Surface
D:	65	FT Cutoff Wall Depth from Working Surface
WS:	3	:1 (Waterside Slope)
LS:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	136	1	136	SF	LS slope length + temporary easement +
			Length	Length	0.00312	ACRE	ROW + W + 1/2 of WS slope length
3	02300	LEVEE DEGRADE	579	1	579	CF	Zone 2
			Area	Length	21.44444	CY	
4	02300	SELECT LEVEE FILL	226	1	226	CF	Zone 2
			Area	Length	8.37037	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	226	1	226	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	8.37037	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	377	1	377	CF	Zone 2 reusable material
			Area	Length	13.96296	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	65	1			
			Depth	Length	65.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	8	1	7.5	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.48056	TON	1.73 TON/CY
9	02925	HYDROSEEDING	109	1	109	SF	Top of levee down to disturbed area
			Length	Length	0.00250	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent Right of Way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

LS-TB-LCW **Levee Crest Widening**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 34.68	5% of sum Items 2 to 8 and 12 to 15
2	02230	CLEARING AND GRUBBING	0.0019	ACRE	$ 5,000.00	$ 9.64	
3	02230	STRIPPING	0.0018	ACRE	$ 3,000.00	$ 5.44	
4	02300	EXCAVATION	0.2963	CY	$ 5.00	$ 1.48	
5	02300	SELECT LEVEE FILL	13.3892	CY	$ 43.50	$ 582.43	
6	02300	UNSUITABLE MATERIAL DISPOSAL	0.1111	CY	$ 15.00	$ 1.67	
7	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
8	02925	HYDROSEEDING	0.0014	ACRE	$ 3,750.00	$ 5.17	
12	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 63.06	Qty (%) x sum Items 2 to 8 and 13 to 15
13	02720	AGGREGATE BASE EASEMENT ROAD		TON	$ 37.50	$ -	
14	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	0.1852	CY	$ 4.00	$ 0.74	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 218.50	30% x sum of items above
		CONSTRUCTION COST				$ 946.84	Per Linear Foot

9	01000	PERMANENT RIGHT OF WAY (ROW)	0.0002	ACRE	$ 38,960.00	$ 7.16	
10	01500	TEMPORARY EASEMENT		ACRE	$ 5,000.00	$ -	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 2.50	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 47.34	
		ROW AND TEMP EASEMENT COST				$ 57.00	
11	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 236.71	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	21,120	Segment Length (FT)
Repair Length	60%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 15,720,241**	For the Specified Repair Length

Levee Crest Widening

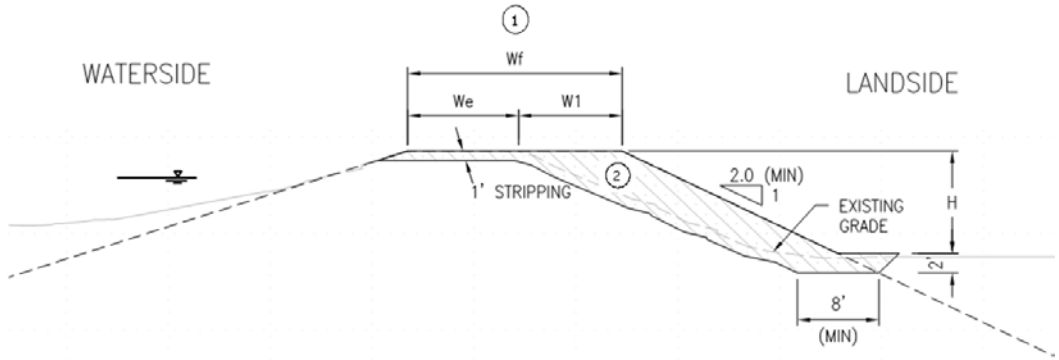
Major Quantity Zone:

(1) Levee Road - fill area (2) Select Levee Fill - fill area

		FT Temporary Easement
		FT ROW
		FT Existing ROW

Levee Geometry:

H	25	FT Crest to Ex Toe Grade
We	15	FT Existing Levee Crest Width
Wf:	20	FT Finished Levee Crest Width
W1:	5	FT (Wf-We)
L S:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	84	1	84	SF	Levee crest edge down to toe slope +
			Length	Length	0.00193	ACRE	ROW + temporary easement (if needed)
3	02230	STRIPPING	79	1	79	SF	1' deep stripping
			Length	Length	0.00181	ACRE	
4	02300	EXCAVATION	8	1	8	CF	Excavation below 1' deep stripping
			Area	Length	0.29630	CY	
5	02300	SELECT LEVEE FILL	362	1	362	CF	Zone 2
			Area	Length	13.38920	CY	
6	02300	UNSUITABLE MATERIAL DISPOSAL	3	1	3	CF	Unsuitable material from excavation
			Area	Length	0.11111	CY	
7	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: W x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
8	02925	HYDROSEEDING	60	1	60	SF	Top of levee slope down to disturbed area
			Length	Length	0.00138	ACRE	
9	01000	PERMANENT RIGHT OF WAY (ROW)	8	1	8	SF	Landside slope footprint + ROW (if needed)
			Length	Length	0.00018	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
10	01500	TEMPORARY EASEMENT		1		SF	5 feet temporary easement (if needed)
			Length	Length		ACRE	For construction beyond ROW
13	02720	AGGREGATE BASE EASEMENT ROAD		1		CF	12' x 6" AB easement road (If needed)
			Area	Length		TON	1.73 TON/CY(freestanding repair pnly)
14	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	5	1	5	CF	Reusable material from excavation
			Area	Length	0.18519	CY	Haul to stockpile for reuse

Legend:

		Input cell (Variables)		Linked to estimate table	Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

LS-TB-LCW **Levee Crest Widening**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 36.86	5% of sum Items 2 to 8 and 12 to 15
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.51	
3	02230	STRIPPING	0.0021	ACRE	$ 3,000.00	$ 6.27	
4	02300	EXCAVATION	0.2963	CY	$ 5.00	$ 1.48	
5	02300	SELECT LEVEE FILL	13.8336	CY	$ 43.50	$ 601.76	
6	02300	UNSUITABLE MATERIAL DISPOSAL	0.1111	CY	$ 15.00	$ 1.67	
7	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
8	02925	HYDROSEEDING	0.0020	ACRE	$ 3,750.00	$ 7.32	
12	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 67.02	Qty (%) x sum Items 2 to 8 and 13 to 15
13	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
14	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	0.1852	CY	$ 4.00	$ 0.74	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 232.22	30% x sum of items above
		CONSTRUCTION COST				$ 1,006.30	Per Linear Foot

9	01000	PERMANENT RIGHT OF WAY (ROW)	0.0006	ACRE	$ 38,960.00	$ 25.04	
10	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 8.97	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 50.31	
		ROW AND TEMP EASEMENT COST				$ 84.90	
11	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 251.57	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	21,120	Segment Length (FT)
Repair Length	40%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 11,343,693**	For the Specified Repair Length

Levee Crest Widening

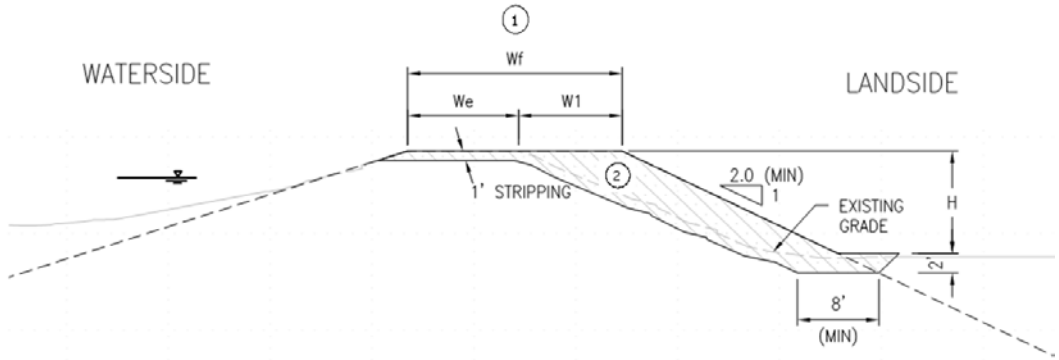
Major Quantity Zone:

(1) Levee Road - fill area (2) Select Levee Fill - fill area

	5	FT Temporary Easement
	20	FT ROW
		FT Existing ROW

Levee Geometry:

H	25	FT Crest to Ex Toe Grade
We	15	FT Existing Levee Crest Width
Wf:	20	FT Finished Levee Crest Width
W1:	5	FT (Wf-We)
L S:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	109	1	109	SF	Levee crest edge down to toe slope +
			Length	Length	0.00250	ACRE	ROW + temporary easement (if needed)
3	02230	STRIPPING	91	1	91	SF	1' deep stripping
			Length	Length	0.00209	ACRE	
4	02300	EXCAVATION	8	1	8	CF	Excavation below 1' deep stripping
			Area	Length	0.29630	CY	
5	02300	SELECT LEVEE FILL	374	1	374	CF	Zone 2
			Area	Length	13.83365	CY	
6	02300	UNSUITABLE MATERIAL DISPOSAL	3	1	3	CF	Unsuitable material from excavation
			Area	Length	0.11111	CY	
7	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: W x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
8	02925	HYDROSEEDING	85	1	85	SF	Top of levee slope down to disturbed area
			Length	Length	0.00195	ACRE	
9	01000	PERMANENT RIGHT OF WAY (ROW)	28	1	28	SF	Landside slope footprint + ROW (if needed)
			Length	Length	0.00064	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
10	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement (if needed)
			Length	Length	0.00011	ACRE	For construction beyond ROW
13	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road (If needed)
			Area	Length	0.38444	TON	1.73 TON/CY(freestanding repair pnly)
14	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	5	1	5	CF	Reusable material from excavation
			Area	Length	0.18519	CY	Haul to stockpile for reuse

Legend:

		Input cell (Variables)		Linked to estimate table	Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S7
SERIES: e
TOTAL SEGMENT LENGTH (FT): 19,536

S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee - Reach 2

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-TB	Gravel Stability Berm	1,954	$ 1,781,220	$ 912	$ 445,305	$ 166,058	$ 2,392,583
TL-SW-SCBCW-TEF	Centerline Soil-Bentonite	14,652	$ 31,674,668	$ 2,162	$ 7,918,667	$ 1,948,913	$ 41,542,249
LS-TB-LCW	Levee Crest Widening (85% Segment Length)	16,606	$ 10,360,362	$ 624	$ 2,590,090	$ 678,420	$ 13,628,872
LS-TB-LCW	Levee Crest Widening (15% Segment Length)	2,930	$ 2,002,531	$ 683	$ 500,633	$ 201,469	$ 2,704,633
							$ 60,268,337

LS-TB **Gravel Stability Berm**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus \

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 33.40	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	0.0020	ACRE	$ 5,000.00	$ 10.10	
3	02300	EXCAVATION	4.1667	CY	$ 5.00	$ 20.83	
4	02230	STRIPPING	0.0014	ACRE	$ 3,000.00	$ 4.06	
5	02370	GRAVEL BERM FILL	10.8333	CY	$ 50.00	$ 541.67	
6	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
7	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
10	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
11	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 60.72	Qty (%) x sum of Items 2 to 7 and10
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 210.41	30% x sum of items above
		CONSTRUCTION COST				$ 911.76	Per Linear Foot

8	01000	PERMANENT RIGHT OF WAY (ROW)	0.0007	ACRE	$ 38,960.00	$ 28.62	
9	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 10.22	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 45.59	
		ROW AND TEMP EASEMENT COST				$ 85.00	
10	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 227.94	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

19,536 Segment Length (FT)

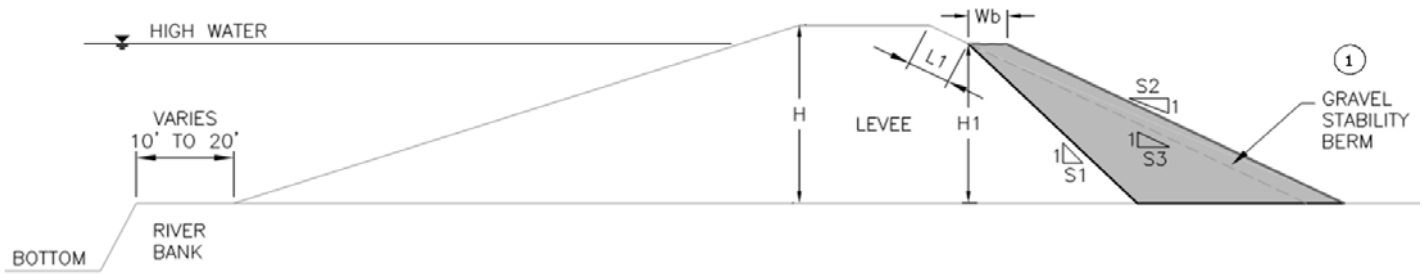
Repair Length 10% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 2,392,583**	For the Specified Repair Length

Gravel Stability Berm

Major Quantity Zone:

(1) Gravel Berm Fill



		FT Existing ROW

Levee Geometry:

H:	23	FT Levee Height
H1:	15	FT
L1:	16.77	FT
S1:	1	:1 Cut Slope
S2:	2	:1 Fill Slope
S3:	2	:1 Existing Slope (S2=>S3 Only)
Wb:	12	FT Berm Width

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	88	1	88	SF	Top of levee slope down to toe of
			Length	Length	0.00202	ACRE	berm + ROW + temporary easement
3	02300	EXCAVATION	112.5	1	112.5	CF	Material cut from S3 to S1
			Area	Length	4.16667	CY	
4	02230	STRIPPING	59	1	59	SF	Top of berm slope down to toe of
			Length	Length	0.00135	ACRE	berm + 12' AB easement road
5	02370	GRAVEL BERM FILL	292.5	1	292.5	CF	Zone 1
			Area	Length	10.83333	CY	
6	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
7	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down, disturbed area,
			Length	Length	0.00174	ACRE	and new slopes
8	01000	PERMANENT RIGHT OF WAY (ROW)	32	1	32	SF	Toe widening: Berm width + ROW
			Length	Length	0.00073	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
9	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
10	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table		Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

TL-SW-SCBCW- **Centerline Soil-Bentonite**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 79.19	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0029	ACRE	$ 5,000.00	$ 14.69	
3	02300	LEVEE DEGRADE	18.8148	CY	$ 4.50	$ 84.67	
4	02300	SELECT LEVEE FILL	7.4444	CY	$ 43.50	$ 323.83	
5	02300	UNSUITABLE MATERIAL DISPOSAL	7.4444	CY	$ 15.00	$ 111.67	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	12.2593	CY	$ 4.00	$ 49.04	
7	02260	SOIL-BENTONITE SLURRY WALL	65.00	SF	$ 12.50	$ 812.50	
8	02720	AGGREGATE BASE LEVEE ROAD	0.5446	TON	$ 37.50	$ 20.42	
9	02925	HYDROSEEDING	0.0023	ACRE	$ 3,750.00	$ 8.52	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 143.98	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 498.88	30% x sum of items above
		CONSTRUCTION COST				$ 2,161.80	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0005	ACRE	$ 38,960.00	$ 17.89	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 6.46	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 108.09	
		ROW AND TEMP EASEMENT COST				$ 133.01	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 540.45	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	19,536	Segment Length (FT)
Repair Length	75%	of Segment Length (enter percent with % sign)

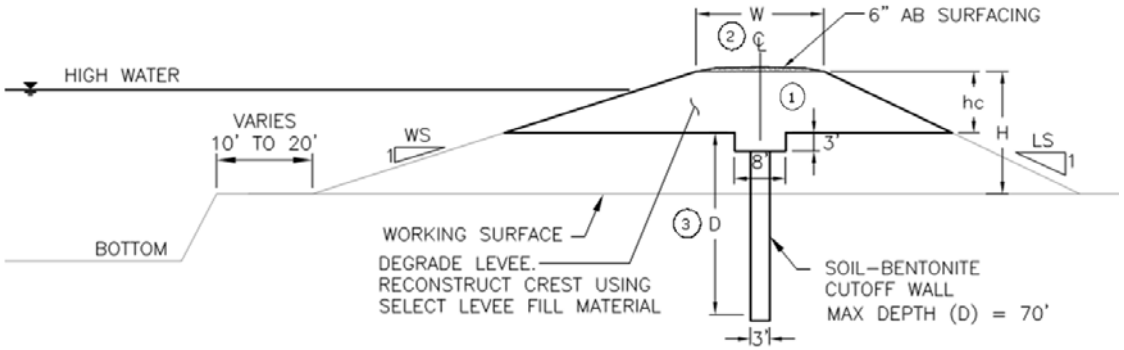
BUDGET AMOUNT	**$ 41,542,249**	For the Specified Repair Length

Centerline Soil-Bentonite

Major Quantity Zone:

1 Levee road

2 Select Levee Fill 3 SB Cutoff Wall



		FT Existing ROW

Levee Geometry:

H:	23	FT
W:	17	FT
hc:	11.25	FT Levee Degrade from Crest to Working Surface
D:	65	FT Cutoff Wall Depth from Working Surface
WS:	3	:1 (Waterside Slope)
LS:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	128	1	128	SF	LS slope length + temporary easement +
			Length	Length	0.00294	ACRE	ROW + W + 1/2 of WS slope length
3	02300	LEVEE DEGRADE	508	1	508	CF	Zone 2
			Area	Length	18.81481	CY	
4	02300	SELECT LEVEE FILL	201	1	201	CF	Zone 2
			Area	Length	7.44444	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	201	1	201	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	7.44444	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	331	1	331	CF	Zone 2 reusable material
			Area	Length	12.25926	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	65	1			
			Depth	Length	65.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	9	1	8.5	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.54463	TON	1.73 TON/CY
9	02925	HYDROSEEDING	99	1	99	SF	Top of levee down to disturbed area
			Length	Length	0.00227	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent Right of Way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

LS-TB-LCW **Levee Crest Widening**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 22.85	5% of sum Items 2 to 8 and 12 to 15
2	02230	CLEARING AND GRUBBING	0.0018	ACRE	$ 5,000.00	$ 8.95	
3	02230	STRIPPING	0.0017	ACRE	$ 3,000.00	$ 5.17	
4	02300	EXCAVATION	0.2963	CY	$ 5.00	$ 1.48	
5	02300	SELECT LEVEE FILL	8.4791	CY	$ 43.50	$ 368.84	
6	02300	UNSUITABLE MATERIAL DISPOSAL	0.1111	CY	$ 15.00	$ 1.67	
7	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
8	02925	HYDROSEEDING	0.0012	ACRE	$ 3,750.00	$ 4.65	
12	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 41.55	Qty (%) x sum Items 2 to 8 and 13 to 15
13	02720	AGGREGATE BASE EASEMENT ROAD		TON	$ 37.50	$ -	
14	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	0.1852	CY	$ 4.00	$ 0.74	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 143.98	30% x sum of items above
		CONSTRUCTION COST				$ 623.91	Per Linear Foot

9	01000	PERMANENT RIGHT OF WAY (ROW)	0.0002	ACRE	$ 38,960.00	$ 7.16	
10	01500	TEMPORARY EASEMENT		ACRE	$ 5,000.00	$ -	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 2.50	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 31.20	
		ROW AND TEMP EASEMENT COST				$ 40.85	
11	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 155.98	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	19,536	Segment Length (FT)
Repair Length	85%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 13,628,872**	For the Specified Repair Length

Levee Crest Widening

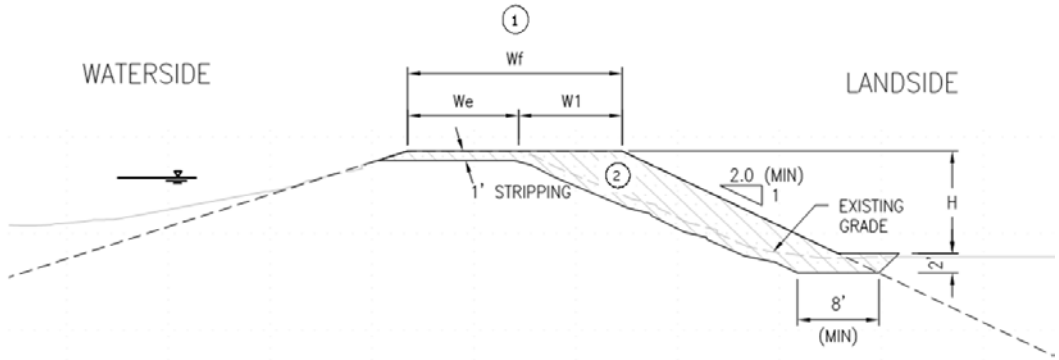
Major Quantity Zone:

(1) Levee Road - fill area (2) Select Levee Fill - fill area

		FT Temporary Easement
		FT ROW
		FT Existing ROW

Levee Geometry:

H	23	FT Crest to Ex Toe Grade
We	17	FT Existing Levee Crest Width
Wf:	20	FT Finished Levee Crest Width
W1:	3	FT (Wf-We)
L S:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	78	1	78	SF	Levee crest edge down to toe slope +
			Length	Length	0.00179	ACRE	ROW + temporary easement (if needed)
3	02230	STRIPPING	75	1	75	SF	1' deep stripping
			Length	Length	0.00172	ACRE	
4	02300	EXCAVATION	8	1	8	CF	Excavation below 1' deep stripping
			Area	Length	0.29630	CY	
5	02300	SELECT LEVEE FILL	229	1	229	CF	Zone 2
			Area	Length	8.47906	CY	
6	02300	UNSUITABLE MATERIAL DISPOSAL	3	1	3	CF	Unsuitable material from excavation
			Area	Length	0.11111	CY	
7	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: W x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
8	02925	HYDROSEEDING	54	1	54	SF	Top of levee slope down to disturbed area
			Length	Length	0.00124	ACRE	
9	01000	PERMANENT RIGHT OF WAY (ROW)	8	1	8	SF	Landside slope footprint + ROW (if needed)
			Length	Length	0.00018	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
10	01500	TEMPORARY EASEMENT		1		SF	5 feet temporary easement (if needed)
			Length	Length		ACRE	For construction beyond ROW
13	02720	AGGREGATE BASE EASEMENT ROAD		1		CF	12' x 6" AB easement road (If needed)
			Area	Length		TON	1.73 TON/CY(freestanding repair pnly)
14	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	5	1	5	CF	Reusable material from excavation
			Area	Length	0.18519	CY	Haul to stockpile for reuse

Legend:

		Input cell (Variables)		Linked to estimate table	Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

LS-TB-LCW **Levee Crest Widening**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 25.03	5% of sum Items 2 to 8 and 12 to 15
2	02230	CLEARING AND GRUBBING	0.0024	ACRE	$ 5,000.00	$ 11.82	
3	02230	STRIPPING	0.0020	ACRE	$ 3,000.00	$ 5.99	
4	02300	EXCAVATION	0.2963	CY	$ 5.00	$ 1.48	
5	02300	SELECT LEVEE FILL	8.9235	CY	$ 43.50	$ 388.17	
6	02300	UNSUITABLE MATERIAL DISPOSAL	0.1111	CY	$ 15.00	$ 1.67	
7	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
8	02925	HYDROSEEDING	0.0018	ACRE	$ 3,750.00	$ 6.80	
12	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 45.51	Qty (%) x sum Items 2 to 8 and 13 to 15
13	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
14	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	0.1852	CY	$ 4.00	$ 0.74	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 157.70	30% x sum of items above
		CONSTRUCTION COST				$ 683.36	Per Linear Foot

9	01000	PERMANENT RIGHT OF WAY (ROW)	0.0006	ACRE	$ 38,960.00	$ 25.04	
10	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 8.97	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 34.17	
		ROW AND TEMP EASEMENT COST				$ 68.75	
11	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 170.84	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	19,536	Segment Length (FT)
Repair Length	15%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 2,704,633**	For the Specified Repair Length

Levee Crest Widening

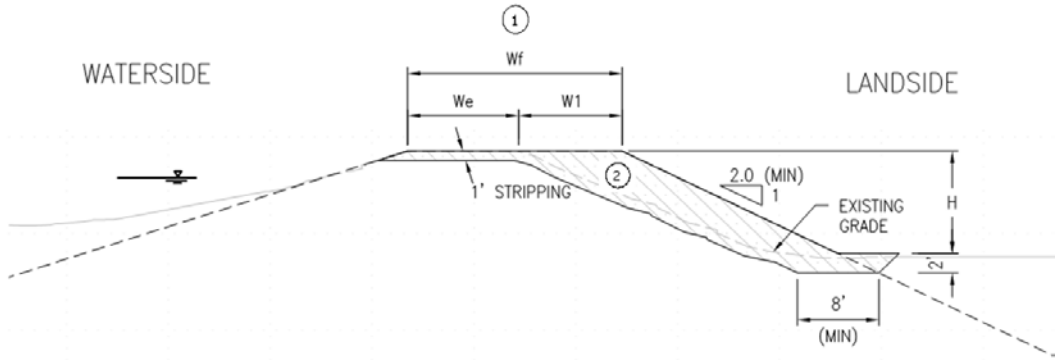
Major Quantity Zone:

(1) Levee Road - fill area (2) Select Levee Fill - fill area

	5	FT Temporary Easement
	20	FT ROW
		FT Existing ROW

Levee Geometry:

H	23	FT Crest to Ex Toe Grade
We	17	FT Existing Levee Crest Width
Wf:	20	FT Finished Levee Crest Width
W1:	3	FT (Wf-We)
L S:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	103	1	103	SF	Levee crest edge down to toe slope +
			Length	Length	0.00236	ACRE	ROW + temporary easement (if needed)
3	02230	STRIPPING	87	1	87	SF	1' deep stripping
			Length	Length	0.00200	ACRE	
4	02300	EXCAVATION	8	1	8	CF	Excavation below 1' deep stripping
			Area	Length	0.29630	CY	
5	02300	SELECT LEVEE FILL	241	1	241	CF	Zone 2
			Area	Length	8.92350	CY	
6	02300	UNSUITABLE MATERIAL DISPOSAL	3	1	3	CF	Unsuitable material from excavation
			Area	Length	0.11111	CY	
7	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: W x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
8	02925	HYDROSEEDING	79	1	79	SF	Top of levee slope down to disturbed area
			Length	Length	0.00181	ACRE	
9	01000	PERMANENT RIGHT OF WAY (ROW)	28	1	28	SF	Landside slope footprint + ROW (if needed)
			Length	Length	0.00064	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
10	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement (if needed)
			Length	Length	0.00011	ACRE	For construction beyond ROW
13	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road (If needed)
			Area	Length	0.38444	TON	1.73 TON/CY(freestanding repair pnly)
14	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	5	1	5	CF	Reusable material from excavation
			Area	Length	0.18519	CY	Haul to stockpile for reuse

Legend:

		Input cell (Variables)		Linked to estimate table	Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S7
SERIES: f
TOTAL SEGMENT LENGTH (FT): 41,184

S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee - Reach 3

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-TB	Gravel Stability Berm	4,118	$ 3,755,005	$ 912	$ 938,751	$ 350,068	$ 5,043,825
TL-SW-SCBCW-TEF	Centerline Soil-Bentonite	30,888	$ 64,468,198	$ 2,087	$ 16,117,050	$ 3,993,249	$ 84,578,496
LS-TB-LCW	Levee Crest Widening (85% Segment Length)	35,006	$ 38,529,754	$ 1,101	$ 9,632,439	$ 2,264,632	$ 50,426,825
LS-TB-LCW	Levee Crest Widening (15% Segment Length)	6,178	$ 7,166,669	$ 1,160	$ 1,791,667	$ 571,974	$ 9,530,309
							$ 149,579,455

LS-TB **Gravel Stability Berm**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus \

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 33.40	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	0.0020	ACRE	$ 5,000.00	$ 10.10	
3	02300	EXCAVATION	4.1667	CY	$ 5.00	$ 20.83	
4	02230	STRIPPING	0.0014	ACRE	$ 3,000.00	$ 4.06	
5	02370	GRAVEL BERM FILL	10.8333	CY	$ 50.00	$ 541.67	
6	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
7	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
10	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
11	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 60.72	Qty (%) x sum of Items 2 to 7 and10
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 210.41	30% x sum of items above
		CONSTRUCTION COST				$ 911.76	Per Linear Foot

8	01000	PERMANENT RIGHT OF WAY (ROW)	0.0007	ACRE	$ 38,960.00	$ 28.62	
9	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 10.22	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 45.59	
		ROW AND TEMP EASEMENT COST				$ 85.00	
10	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 227.94	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

41,184 Segment Length (FT)

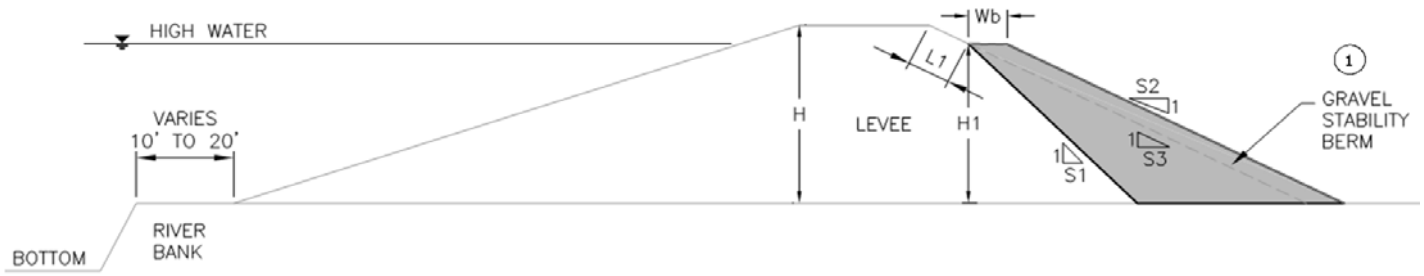
Repair Length 10% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 5,043,825**	For the Specified Repair Length

Gravel Stability Berm

Major Quantity Zone:

(1) Gravel Berm Fill



		FT Existing ROW

Levee Geometry:

H:	23	FT Levee Height
H1:	15	FT
L1:	16.77	FT
S1:	1	:1 Cut Slope
S2:	2	:1 Fill Slope
S3:	2	:1 Existing Slope (S2=>S3 Only)
Wb:	12	FT Berm Width

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	88	1	88	SF	Top of levee slope down to toe of
			Length	Length	0.00202	ACRE	berm + ROW + temporary easement
3	02300	EXCAVATION	112.5	1	112.5	CF	Material cut from S3 to S1
			Area	Length	4.16667	CY	
4	02230	STRIPPING	59	1	59	SF	Top of berm slope down to toe of
			Length	Length	0.00135	ACRE	berm + 12' AB easement road
5	02370	GRAVEL BERM FILL	292.5	1	292.5	CF	Zone 1
			Area	Length	10.83333	CY	
6	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
7	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down, disturbed area,
			Length	Length	0.00174	ACRE	and new slopes
8	01000	PERMANENT RIGHT OF WAY (ROW)	32	1	32	SF	Toe widening: Berm width + ROW
			Length	Length	0.00073	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
9	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
10	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table		Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

TL-SW-SCBCW- **Centerline Soil-Bentonite**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 76.45	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0028	ACRE	$ 5,000.00	$ 14.23	
3	02300	LEVEE DEGRADE	17.1481	CY	$ 4.50	$ 77.17	
4	02300	SELECT LEVEE FILL	6.8889	CY	$ 43.50	$ 299.67	
5	02300	UNSUITABLE MATERIAL DISPOSAL	6.8889	CY	$ 15.00	$ 103.33	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	11.1481	CY	$ 4.00	$ 44.59	
7	02260	SOIL-BENTONITE SLURRY WALL	65.00	SF	$ 12.50	$ 812.50	
8	02720	AGGREGATE BASE LEVEE ROAD	0.4165	TON	$ 37.50	$ 15.62	
9	02925	HYDROSEEDING	0.0023	ACRE	$ 3,750.00	$ 8.52	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 139.00	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 481.65	30% x sum of items above
		CONSTRUCTION COST				$ 2,087.16	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0005	ACRE	$ 38,960.00	$ 17.89	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 6.46	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 104.36	
		ROW AND TEMP EASEMENT COST				$ 129.28	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 521.79	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	41,184	Segment Length (FT)
Repair Length	75%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 84,578,496**	For the Specified Repair Length

Centerline Soil-Bentonite

Major Quantity Zone:

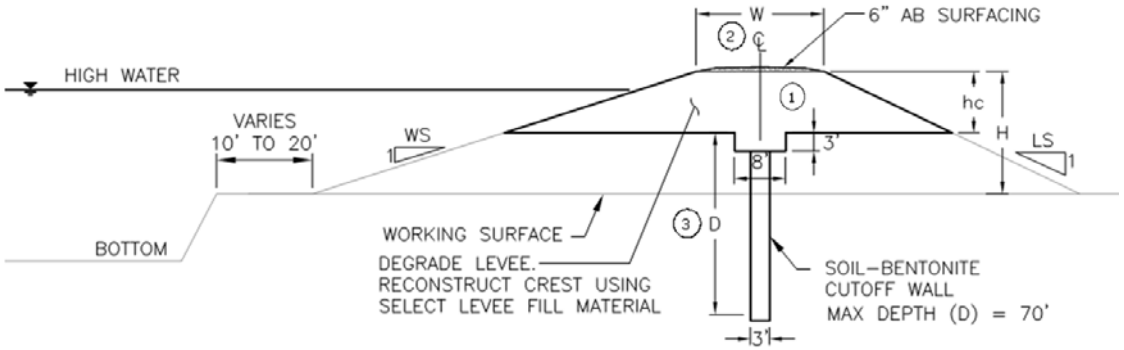
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

		FT Existing ROW

Levee Geometry:

H:	23	FT
W:	13	FT
hc:	11.25	FT Levee Degrade from Crest to Working Surface
D:	65	FT Cutoff Wall Depth from Working Surface
WS:	3	:1 (Waterside Slope)
LS:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	124	1	124	SF	LS slope length + temporary easement +
			Length	Length	0.00285	ACRE	ROW + W + 1/2 of WS slope length
3	02300	LEVEE DEGRADE	463	1	463	CF	Zone 2
			Area	Length	17.14815	CY	
4	02300	SELECT LEVEE FILL	186	1	186	CF	Zone 2
			Area	Length	6.88889	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	186	1	186	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	6.88889	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	301	1	301	CF	Zone 2 reusable material
			Area	Length	11.14815	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	65	1			
			Depth	Length	65.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	7	1	6.5	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.41648	TON	1.73 TON/CY
9	02925	HYDROSEEDING	99	1	99	SF	Top of levee down to disturbed area
			Length	Length	0.00227	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent Right of Way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

LS-TB-LCW **Levee Crest Widening**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 40.32	5% of sum Items 2 to 8 and 12 to 15
2	02230	CLEARING AND GRUBBING	0.0018	ACRE	$ 5,000.00	$ 8.95	
3	02230	STRIPPING	0.0016	ACRE	$ 3,000.00	$ 4.89	
4	02300	EXCAVATION	0.2963	CY	$ 5.00	$ 1.48	
5	02300	SELECT LEVEE FILL	15.7845	CY	$ 43.50	$ 686.62	
6	02300	UNSUITABLE MATERIAL DISPOSAL	0.1111	CY	$ 15.00	$ 1.67	
7	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
8	02925	HYDROSEEDING	0.0012	ACRE	$ 3,750.00	$ 4.65	
12	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 73.30	Qty (%) x sum Items 2 to 8 and 13 to 15
13	02720	AGGREGATE BASE EASEMENT ROAD		TON	$ 37.50	$ -	
14	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	0.1852	CY	$ 4.00	$ 0.74	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 254.00	30% x sum of items above
		CONSTRUCTION COST				$ 1,100.65	Per Linear Foot

9	01000	PERMANENT RIGHT OF WAY (ROW)	0.0002	ACRE	$ 38,960.00	$ 7.16	
10	01500	TEMPORARY EASEMENT		ACRE	$ 5,000.00	$ -	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 2.50	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 55.03	
		ROW AND TEMP EASEMENT COST				$ 64.69	
11	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 275.16	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	41,184	Segment Length (FT)
Repair Length	85%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 50,426,825**	For the Specified Repair Length

Levee Crest Widening

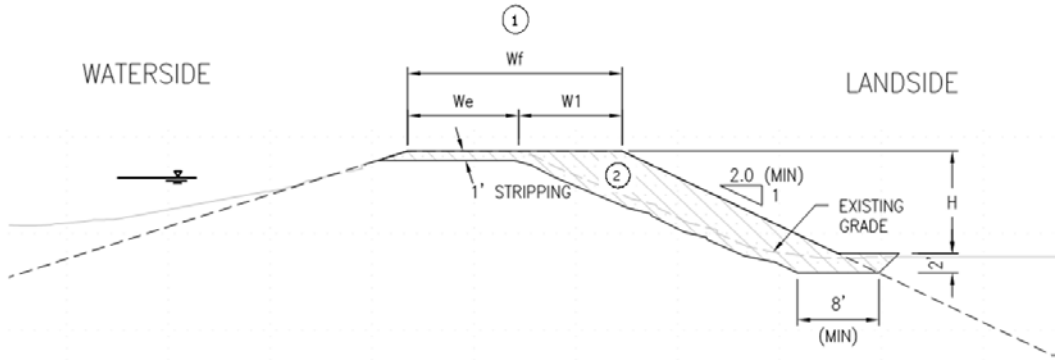
Major Quantity Zone:

(1) Levee Road - fill area (2) Select Levee Fill - fill area

		FT Temporary Easement
		FT ROW
		FT Existing ROW

Levee Geometry:

H	23	FT Crest to Ex Toe Grade
We	13	FT Existing Levee Crest Width
Wf:	20	FT Finished Levee Crest Width
W1:	7	FT (Wf-We)
L S:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	78	1	78	SF	Levee crest edge down to toe slope +
			Length	Length	0.00179	ACRE	ROW + temporary easement (if needed)
3	02230	STRIPPING	71	1	71	SF	1' deep stripping
			Length	Length	0.00163	ACRE	
4	02300	EXCAVATION	8	1	8	CF	Excavation below 1' deep stripping
			Area	Length	0.29630	CY	
5	02300	SELECT LEVEE FILL	426	1	426	CF	Zone 2
			Area	Length	15.78447	CY	
6	02300	UNSUITABLE MATERIAL DISPOSAL	3	1	3	CF	Unsuitable material from excavation
			Area	Length	0.11111	CY	
7	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: W x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
8	02925	HYDROSEEDING	54	1	54	SF	Top of levee slope down to disturbed area
			Length	Length	0.00124	ACRE	
9	01000	PERMANENT RIGHT OF WAY (ROW)	8	1	8	SF	Landside slope footprint + ROW (if needed)
			Length	Length	0.00018	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
10	01500	TEMPORARY EASEMENT		1		SF	5 feet temporary easement (if needed)
			Length	Length		ACRE	For construction beyond ROW
13	02720	AGGREGATE BASE EASEMENT ROAD		1		CF	12' x 6" AB easement road (If needed)
			Area	Length		TON	1.73 TON/CY(freestanding repair pnly)
14	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	5	1	5	CF	Reusable material from excavation
			Area	Length	0.18519	CY	Haul to stockpile for reuse

Legend:

		Input cell (Variables)		Linked to estimate table	Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

LS-TB-LCW **Levee Crest Widening**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 42.49	5% of sum Items 2 to 8 and 12 to 15
2	02230	CLEARING AND GRUBBING	0.0024	ACRE	$ 5,000.00	$ 11.82	
3	02230	STRIPPING	0.0019	ACRE	$ 3,000.00	$ 5.72	
4	02300	EXCAVATION	0.2963	CY	$ 5.00	$ 1.48	
5	02300	SELECT LEVEE FILL	16.2289	CY	$ 43.50	$ 705.96	
6	02300	UNSUITABLE MATERIAL DISPOSAL	0.1111	CY	$ 15.00	$ 1.67	
7	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
8	02925	HYDROSEEDING	0.0018	ACRE	$ 3,750.00	$ 6.80	
12	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 77.26	Qty (%) x sum Items 2 to 8 and 13 to 15
13	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
14	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	0.1852	CY	$ 4.00	$ 0.74	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 267.72	30% x sum of items above
		CONSTRUCTION COST				$ 1,160.11	Per Linear Foot

9	01000	PERMANENT RIGHT OF WAY (ROW)	0.0006	ACRE	$ 38,960.00	$ 25.04	
10	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 8.97	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 58.01	
		ROW AND TEMP EASEMENT COST				$ 92.59	
11	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 290.03	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	41,184	Segment Length (FT)
Repair Length	15%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 9,530,309**	For the Specified Repair Length

Levee Crest Widening

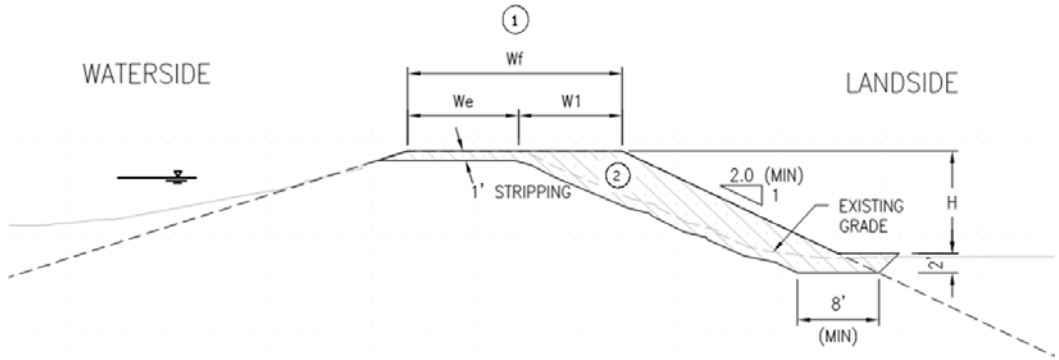
Major Quantity Zone:

(1) Levee Road - fill area (2) Select Levee Fill - fill area

	5	FT Temporary Easement
	20	FT ROW
		FT Existing ROW

Levee Geometry:

H	23	FT Crest to Ex Toe Grade
We	13	FT Existing Levee Crest Width
Wf:	20	FT Finished Levee Crest Width
W1:	7	FT (Wf-We)
L S:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	103	1	103	SF	Levee crest edge down to toe slope +
			Length	Length	0.00236	ACRE	ROW + temporary easement (if needed)
3	02230	STRIPPING	83	1	83	SF	1' deep stripping
			Length	Length	0.00191	ACRE	
4	02300	EXCAVATION	8	1	8	CF	Excavation below 1' deep stripping
			Area	Length	0.29630	CY	
5	02300	SELECT LEVEE FILL	438	1	438	CF	Zone 2
			Area	Length	16.22892	CY	
6	02300	UNSUITABLE MATERIAL DISPOSAL	3	1	3	CF	Unsuitable material from excavation
			Area	Length	0.11111	CY	
7	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: W x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
8	02925	HYDROSEEDING	79	1	79	SF	Top of levee slope down to disturbed area
			Length	Length	0.00181	ACRE	
9	01000	PERMANENT RIGHT OF WAY (ROW)	28	1	28	SF	Landside slope footprint + ROW (if needed)
			Length	Length	0.00064	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
10	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement (if needed)
			Length	Length	0.00011	ACRE	For construction beyond ROW
13	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road (If needed)
			Area	Length	0.38444	TON	1.73 TON/CY(freestanding repair pnly)
14	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
15	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	5	1	5	CF	Reusable material from excavation
			Area	Length	0.18519	CY	Haul to stockpile for reuse

Legend:

		Input cell (Variables)		Linked to estimate table	Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S7
SERIES: g
TOTAL SEGMENT LENGTH (FT): 40,128

S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee - Reach 4

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-TB	Gravel Stability Berm	4,013	$ 3,658,723	$ 912	$ 914,681	$ 341,092	$ 4,914,496
TL-SW-SCBCW-TEF	Centerline Soil-Bentonite	40,128	$ 71,810,970	$ 1,790	$ 17,952,742	$ 4,590,681	$ 94,354,393
							$ 99,268,889

LS-TB **Gravel Stability Berm**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus \

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 33.40	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	0.0020	ACRE	$ 5,000.00	$ 10.10	
3	02300	EXCAVATION	4.1667	CY	$ 5.00	$ 20.83	
4	02230	STRIPPING	0.0014	ACRE	$ 3,000.00	$ 4.06	
5	02370	GRAVEL BERM FILL	10.8333	CY	$ 50.00	$ 541.67	
6	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
7	02925	HYDROSEEDING	0.0017	ACRE	$ 3,750.00	$ 6.54	
10	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
11	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 60.72	Qty (%) x sum of Items 2 to 7 and10
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 210.41	30% x sum of items above
		CONSTRUCTION COST				$ 911.76	Per Linear Foot

8	01000	PERMANENT RIGHT OF WAY (ROW)	0.0007	ACRE	$ 38,960.00	$ 28.62	
9	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 10.22	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 45.59	
		ROW AND TEMP EASEMENT COST				$ 85.00	
10	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 227.94	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

40,128 Segment Length (FT)

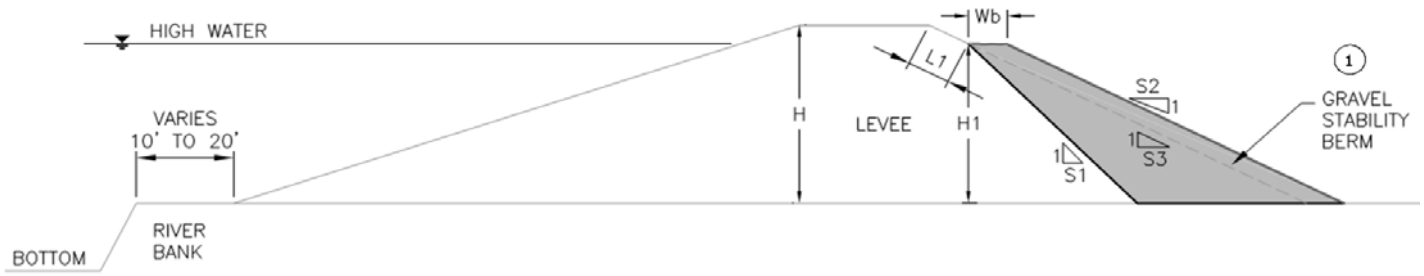
Repair Length 10% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 4,914,496**	For the Specified Repair Length

Gravel Stability Berm

Major Quantity Zone:

(1) Gravel Berm Fill



		FT Existing ROW

Levee Geometry:

H:	23	FT Levee Height
H1:	15	FT
L1:	16.77	FT
S1:	1	:1 Cut Slope
S2:	2	:1 Fill Slope
S3:	2	:1 Existing Slope (S2=>S3 Only)
Wb:	12	FT Berm Width

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	88	1	88	SF	Top of levee slope down to toe of
			Length	Length	0.00202	ACRE	berm + ROW + temporary easement
3	02300	EXCAVATION	112.5	1	112.5	CF	Material cut from S3 to S1
			Area	Length	4.16667	CY	
4	02230	STRIPPING	59	1	59	SF	Top of berm slope down to toe of
			Length	Length	0.00135	ACRE	berm + 12' AB easement road
5	02370	GRAVEL BERM FILL	292.5	1	292.5	CF	Zone 1
			Area	Length	10.83333	CY	
6	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
7	02925	HYDROSEEDING	76	1	76	SF	Top of levee slope down, disturbed area,
			Length	Length	0.00174	ACRE	and new slopes
8	01000	PERMANENT RIGHT OF WAY (ROW)	32	1	32	SF	Toe widening: Berm width + ROW
			Length	Length	0.00073	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
9	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
10	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table		Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

TL-SW-SCBCW- **Centerline Soil-Bentonite**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 65.55	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0031	ACRE	$ 5,000.00	$ 15.27	
3	02300	LEVEE DEGRADE	20.8889	CY	$ 4.50	$ 94.00	
4	02300	SELECT LEVEE FILL	8.1852	CY	$ 43.50	$ 356.06	
5	02300	UNSUITABLE MATERIAL DISPOSAL	8.1852	CY	$ 15.00	$ 122.78	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	13.5926	CY	$ 4.00	$ 54.37	
7	02260	SOIL-BENTONITE SLURRY WALL	40.00	SF	$ 12.50	$ 500.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.7048	TON	$ 37.50	$ 26.43	
9	02925	HYDROSEEDING	0.0023	ACRE	$ 3,750.00	$ 8.52	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 119.18	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 412.97	30% x sum of items above
		CONSTRUCTION COST				$ 1,789.55	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0005	ACRE	$ 38,960.00	$ 17.89	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 6.46	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 89.48	
		ROW AND TEMP EASEMENT COST				$ 114.40	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 447.39	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	40,128	Segment Length (FT)
Repair Length	100%	of Segment Length (enter percent with % sign)

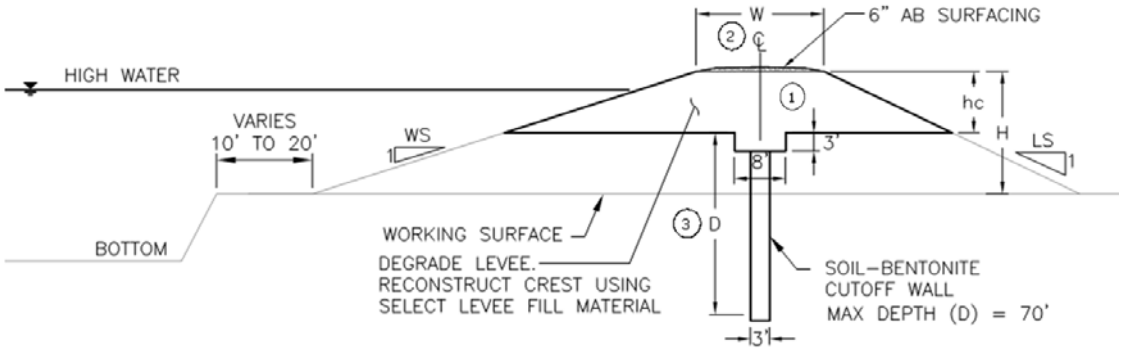
BUDGET AMOUNT	**$ 94,354,393**	For the Specified Repair Length

Centerline Soil-Bentonite

Major Quantity Zone:

1 Levee road

2 Select Levee Fill 3 SB Cutoff Wall



		FT Existing ROW

Levee Geometry:

H:	23	FT
W:	22	FT
hc:	11.25	FT Levee Degrade from Crest to Working Surface
D:	40	FT Cutoff Wall Depth from Working Surface
WS:	3	:1 (Waterside Slope)
LS:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	133	1	133	SF	LS slope length + temporary easement +
			Length	Length	0.00305	ACRE	ROW + W + 1/2 of WS slope length
3	02300	LEVEE DEGRADE	564	1	564	CF	Zone 2
			Area	Length	20.88889	CY	
4	02300	SELECT LEVEE FILL	221	1	221	CF	Zone 2
			Area	Length	8.18519	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	221	1	221	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	8.18519	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	367	1	367	CF	Zone 2 reusable material
			Area	Length	13.59259	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	40	1			
			Depth	Length	40.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	11	1	11	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.70481	TON	1.73 TON/CY
9	02925	HYDROSEEDING	99	1	99	SF	Top of levee down to disturbed area
			Length	Length	0.00227	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent Right of Way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S7
SERIES: h
TOTAL SEGMENT LENGTH (FT): 9,504

S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee - Reach 5

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-TB	Gravel Stability Berm	950	$ 719,512	$ 757	$ 179,878	$ 73,434	$ 972,823
TL-SW-SCBCW-TEF	Centerline Soil-Bentonite	9,504	$ 17,392,993	$ 1,830	$ 4,348,248	$ 1,106,523	$ 22,847,765
							$ 23,820,588

LS-TB **Gravel Stability Berm**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus \

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 27.73	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	0.0019	ACRE	$ 5,000.00	$ 9.41	
3	02300	EXCAVATION	3.1296	CY	$ 5.00	$ 15.65	
4	02230	STRIPPING	0.0012	ACRE	$ 3,000.00	$ 3.72	
5	02370	GRAVEL BERM FILL	8.9074	CY	$ 50.00	$ 445.37	
6	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
7	02925	HYDROSEEDING	0.0016	ACRE	$ 3,750.00	$ 6.03	
10	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
11	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 50.42	Qty (%) x sum of Items 2 to 7 and10
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 174.71	30% x sum of items above
		CONSTRUCTION COST				$ 757.06	Per Linear Foot

8	01000	PERMANENT RIGHT OF WAY (ROW)	0.0007	ACRE	$ 38,960.00	$ 28.62	
9	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 10.22	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 37.85	
		ROW AND TEMP EASEMENT COST				$ 77.27	
10	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 189.27	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

9,504 Segment Length (FT)

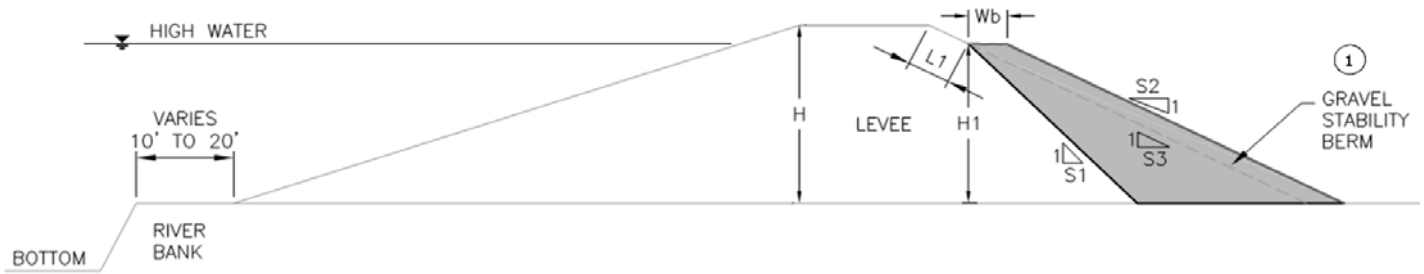
Repair Length 10% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 972,823**	For the Specified Repair Length

Gravel Stability Berm

Major Quantity Zone:

(1) Gravel Berm Fill



		FT Existing ROW

Levee Geometry:

H:	20	FT Levee Height
H1:	13	FT
L1:	15.65	FT
S1:	1	:1 Cut Slope
S2:	2	:1 Fill Slope
S3:	2	:1 Existing Slope (S2=>S3 Only)
Wb:	12	FT Berm Width

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	82	1	82	SF	Top of levee slope down to toe of
			Length	Length	0.00188	ACRE	berm + ROW + temporary easement
3	02300	EXCAVATION	84.5	1	84.5	CF	Material cut from S3 to S1
			Area	Length	3.12963	CY	
4	02230	STRIPPING	54	1	54	SF	Top of berm slope down to toe of
			Length	Length	0.00124	ACRE	berm + 12' AB easement road
5	02370	GRAVEL BERM FILL	240.5	1	240.5	CF	Zone 1
			Area	Length	8.90741	CY	
6	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
7	02925	HYDROSEEDING	70	1	70	SF	Top of levee slope down, disturbed area,
			Length	Length	0.00161	ACRE	and new slopes
8	01000	PERMANENT RIGHT OF WAY (ROW)	32	1	32	SF	Toe widening: Berm width + ROW
			Length	Length	0.00073	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
9	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
10	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table		Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

TL-SW-SCBCW- **Centerline Soil-Bentonite**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 67.04	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0028	ACRE	$ 5,000.00	$ 14.23	
3	02300	LEVEE DEGRADE	17.4074	CY	$ 4.50	$ 78.33	
4	02300	SELECT LEVEE FILL	6.9630	CY	$ 43.50	$ 302.89	
5	02300	UNSUITABLE MATERIAL DISPOSAL	6.9630	CY	$ 15.00	$ 104.44	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	11.3333	CY	$ 4.00	$ 45.33	
7	02260	SOIL-BENTONITE SLURRY WALL	50.00	SF	$ 12.50	$ 625.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.7048	TON	$ 37.50	$ 26.43	
9	02925	HYDROSEEDING	0.0021	ACRE	$ 3,750.00	$ 7.75	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 121.88	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 422.32	30% x sum of items above
		CONSTRUCTION COST				$ 1,830.07	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0005	ACRE	$ 38,960.00	$ 17.89	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 6.46	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 91.50	
		ROW AND TEMP EASEMENT COST				$ 116.43	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 457.52	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	9,504	Segment Length (FT)
Repair Length	100%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 22,847,765**	For the Specified Repair Length

Centerline Soil-Bentonite

Major Quantity Zone:

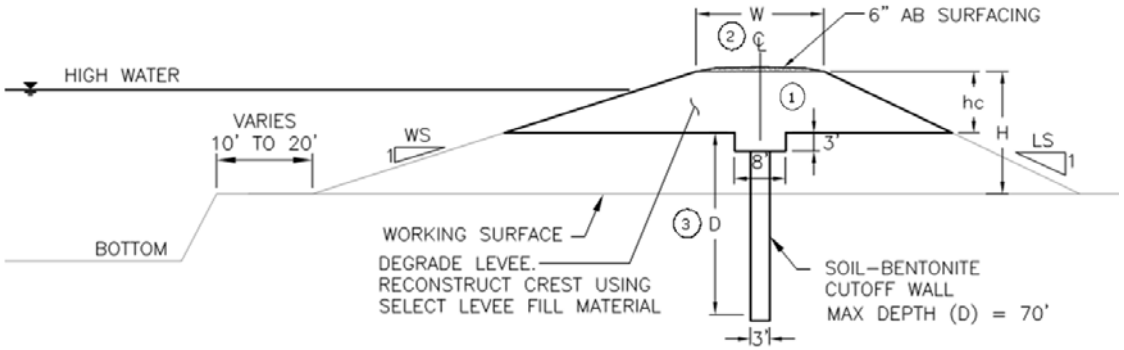
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

		FT Existing ROW

Levee Geometry:

H:	20	FT
W:	22	FT
hc:	10	FT Levee Degrade from Crest to Working Surface
D:	50	FT Cutoff Wall Depth from Working Surface
WS:	3	:1 (Waterside Slope)
LS:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	124	1	124	SF	LS slope length + temporary easement +
			Length	Length	0.00285	ACRE	ROW + W + 1/2 of WS slope length
3	02300	LEVEE DEGRADE	470	1	470	CF	Zone 2
			Area	Length	17.40741	CY	
4	02300	SELECT LEVEE FILL	188	1	188	CF	Zone 2
			Area	Length	6.96296	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	188	1	188	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	6.96296	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	306	1	306	CF	Zone 2 reusable material
			Area	Length	11.33333	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	50	1			
			Depth	Length	50.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	11	1	11	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.70481	TON	1.73 TON/CY
9	02925	HYDROSEEDING	90	1	90	SF	Top of levee down to disturbed area
			Length	Length	0.00207	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent Right of Way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S7
SERIES: i
TOTAL SEGMENT LENGTH (FT): 42,768

S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee - Reach 6

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-TB	Gravel Stability Berm	4,277	$ 3,237,803	$ 757	$ 809,451	$ 330,451	$ 4,377,704
TL-SW-SCBCW-TEF	Centerline Soil-Bentonite	42,768	$ 60,609,028	$ 1,417	$ 15,152,257	$ 4,096,382	$ 79,857,667
							$ 84,235,371

LS-TB **Gravel Stability Berm**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus \

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 27.73	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	0.0019	ACRE	$ 5,000.00	$ 9.41	
3	02300	EXCAVATION	3.1296	CY	$ 5.00	$ 15.65	
4	02230	STRIPPING	0.0012	ACRE	$ 3,000.00	$ 3.72	
5	02370	GRAVEL BERM FILL	8.9074	CY	$ 50.00	$ 445.37	
6	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
7	02925	HYDROSEEDING	0.0016	ACRE	$ 3,750.00	$ 6.03	
10	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
11	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 50.42	Qty (%) x sum of Items 2 to 7 and10
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 174.71	30% x sum of items above
		CONSTRUCTION COST				$ 757.06	Per Linear Foot

8	01000	PERMANENT RIGHT OF WAY (ROW)	0.0007	ACRE	$ 38,960.00	$ 28.62	
9	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 10.22	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 37.85	
		ROW AND TEMP EASEMENT COST				$ 77.27	
10	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 189.27	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

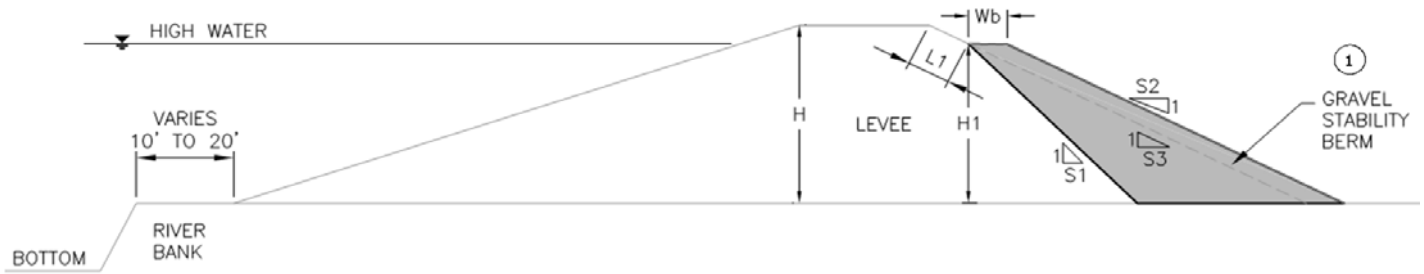
	42,768	Segment Length (FT)
Repair Length	10%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 4,377,704**	For the Specified Repair Length

Gravel Stability Berm

Major Quantity Zone:

(1) Gravel Berm Fill



		FT Existing ROW

Levee Geometry:

H:	20	FT Levee Height
H1:	13	FT
L1:	15.65	FT
S1:	1	:1 Cut Slope
S2:	2	:1 Fill Slope
S3:	2	:1 Existing Slope (S2=>S3 Only)
Wb:	12	FT Berm Width

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	82	1	82	SF	Top of levee slope down to toe of
			Length	Length	0.00188	ACRE	berm + ROW + temporary easement
3	02300	EXCAVATION	84.5	1	84.5	CF	Material cut from S3 to S1
			Area	Length	3.12963	CY	
4	02230	STRIPPING	54	1	54	SF	Top of berm slope down to toe of
			Length	Length	0.00124	ACRE	berm + 12' AB easement road
5	02370	GRAVEL BERM FILL	240.5	1	240.5	CF	Zone 1
			Area	Length	8.90741	CY	
6	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
7	02925	HYDROSEEDING	70	1	70	SF	Top of levee slope down, disturbed area,
			Length	Length	0.00161	ACRE	and new slopes
8	01000	PERMANENT RIGHT OF WAY (ROW)	32	1	32	SF	Toe widening: Berm width + ROW
			Length	Length	0.00073	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
9	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
10	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table		Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

TL-SW-SCBCW- **Centerline Soil-Bentonite**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 51.91	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0028	ACRE	$ 5,000.00	$ 14.23	
3	02300	LEVEE DEGRADE	17.4074	CY	$ 4.50	$ 78.33	
4	02300	SELECT LEVEE FILL	6.9630	CY	$ 43.50	$ 302.89	
5	02300	UNSUITABLE MATERIAL DISPOSAL	6.9630	CY	$ 15.00	$ 104.44	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	11.3333	CY	$ 4.00	$ 45.33	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.7048	TON	$ 37.50	$ 26.43	
9	02925	HYDROSEEDING	0.0021	ACRE	$ 3,750.00	$ 7.75	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 94.38	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 327.04	30% x sum of items above
		CONSTRUCTION COST				$ 1,417.16	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0005	ACRE	$ 38,960.00	$ 17.89	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 6.46	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 70.86	
		ROW AND TEMP EASEMENT COST				$ 95.78	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 354.29	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	42,768	Segment Length (FT)
Repair Length	100%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 79,857,667**	For the Specified Repair Length

Centerline Soil-Bentonite

Major Quantity Zone:

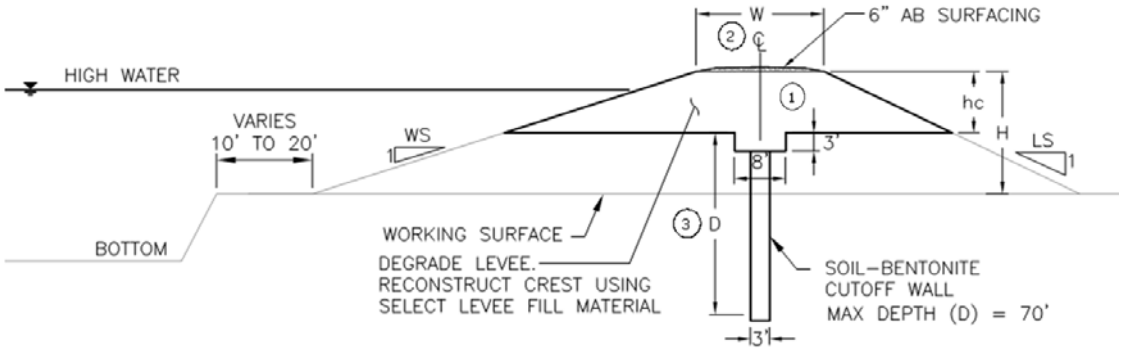
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

		FT Existing ROW

Levee Geometry:

H:	20	FT
W:	22	FT
hc:	10	FT Levee Degrade from Crest to Working Surface
D:	35	FT Cutoff Wall Depth from Working Surface
WS:	3	:1 (Waterside Slope)
LS:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	124	1	124	SF	LS slope length + temporary easement +
			Length	Length	0.00285	ACRE	ROW + W + 1/2 of WS slope length
3	02300	LEVEE DEGRADE	470	1	470	CF	Zone 2
			Area	Length	17.40741	CY	
4	02300	SELECT LEVEE FILL	188	1	188	CF	Zone 2
			Area	Length	6.96296	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	188	1	188	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	6.96296	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	306	1	306	CF	Zone 2 reusable material
			Area	Length	11.33333	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	11	1	11	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.70481	TON	1.73 TON/CY
9	02925	HYDROSEEDING	90	1	90	SF	Top of levee down to disturbed area
			Length	Length	0.00207	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent Right of Way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S7
SERIES: j
TOTAL SEGMENT LENGTH (FT): 24,288

S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee - Reach 7

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-TB	Gravel Stability Berm	2,429	$ 1,535,075	$ 632	$ 383,769	$ 181,277	$ 2,100,121
TL-SW-SCBCW-TEF	Centerline Soil-Bentonite	12,144	$ 22,852,465	$ 1,882	$ 5,713,116	$ 1,445,295	$ 30,010,876
							$ 32,110,997

LS-TB **Gravel Stability Berm**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus V

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 23.15	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	0.0017	ACRE	$ 5,000.00	$ 8.49	
3	02300	EXCAVATION	1.8519	CY	$ 5.00	$ 9.26	
4	02230	STRIPPING	0.0011	ACRE	$ 3,000.00	$ 3.44	
5	02370	GRAVEL BERM FILL	7.4074	CY	$ 50.00	$ 370.37	
6	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
7	02925	HYDROSEEDING	0.0014	ACRE	$ 3,750.00	$ 5.34	
10	02720	AGGREGATE BASE CREST SUPPLEMENT	0.2563	TON	$ 37.50	$ 9.61	
11	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 42.09	Qty (%) x sum of Items 2 to 7 and10
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 145.85	30% x sum of items above
		CONSTRUCTION COST				$ 632.03	Per Linear Foot

8	01000	PERMANENT RIGHT OF WAY (ROW)	0.0008	ACRE	$ 38,960.00	$ 31.30	
9	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 11.16	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 31.60	
		ROW AND TEMP EASEMENT COST				$ 74.64	
10	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 158.01	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

24,288 Segment Length (FT)

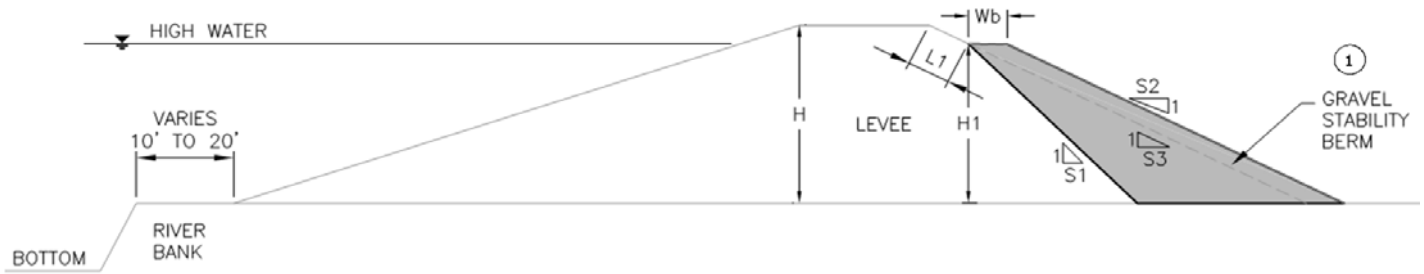
Repair Length 10% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 2,100,121**	For the Specified Repair Length

Gravel Stability Berm

Major Quantity Zone:

(1) Gravel Berm Fill



		FT Existing ROW

Levee Geometry:

H:	15	FT Levee Height
H1:	10	FT
L1:	11.18	FT
S1:	1	:1 Cut Slope
S2:	2	:1 Fill Slope
S3:	2	:1 Existing Slope (S2=>S3 Only)
Wb:	15	FT Berm Width

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 7 and 10 to 11
2	02230	CLEARING AND GRUBBING	74	1	74	SF	Top of levee slope down to toe of
			Length	Length	0.00170	ACRE	berm + ROW + temporary easement
3	02300	EXCAVATION	50	1	50	CF	Material cut from S3 to S1
			Area	Length	1.85185	CY	
4	02230	STRIPPING	50	1	50	SF	Top of berm slope down to toe of
			Length	Length	0.00115	ACRE	berm + 12' AB easement road
5	02370	GRAVEL BERM FILL	200	1	200	CF	Zone 1
			Area	Length	7.40741	CY	
6	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
7	02925	HYDROSEEDING	62	1	62	SF	Top of levee slope down, disturbed area,
			Length	Length	0.00142	ACRE	and new slopes
8	01000	PERMANENT RIGHT OF WAY (ROW)	35	1	35	SF	Toe widening: Berm width + ROW
			Length	Length	0.00080	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
9	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
10	02720	AGGREGATE BASE CREST SUPPLEMENT	4	1	4	CF	12' x 4" AB resurface road
			Area	Length	0.25630	TON	1.73 TON/CY

Legend:

		Input cell (Variables)		Linked to estimate table		Formula cell
S1:	2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell	

TL-SW-SCBCW- **Centerline Soil-Bentonite**

LOCATION: S7 - Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 68.93	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0025	ACRE	$ 5,000.00	$ 12.28	
3	02300	LEVEE DEGRADE	11.8889	CY	$ 4.50	$ 53.50	
4	02300	SELECT LEVEE FILL	5.0370	CY	$ 43.50	$ 219.11	
5	02300	UNSUITABLE MATERIAL DISPOSAL	5.0370	CY	$ 15.00	$ 75.56	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	7.7407	CY	$ 4.00	$ 30.96	
7	02260	SOIL-BENTONITE SLURRY WALL	65.00	SF	$ 12.50	$ 812.50	
8	02720	AGGREGATE BASE LEVEE ROAD	0.7689	TON	$ 37.50	$ 28.83	
9	02925	HYDROSEEDING	0.0016	ACRE	$ 3,750.00	$ 6.11	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 125.33	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 434.26	30% x sum of items above
		CONSTRUCTION COST				$ 1,881.79	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0005	ACRE	$ 38,960.00	$ 17.89	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 6.46	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 94.09	
		ROW AND TEMP EASEMENT COST				$ 119.01	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 470.45	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	24,288	Segment Length (FT)
Repair Length	50%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 30,010,876**	For the Specified Repair Length

Centerline Soil-Bentonite

Major Quantity Zone:

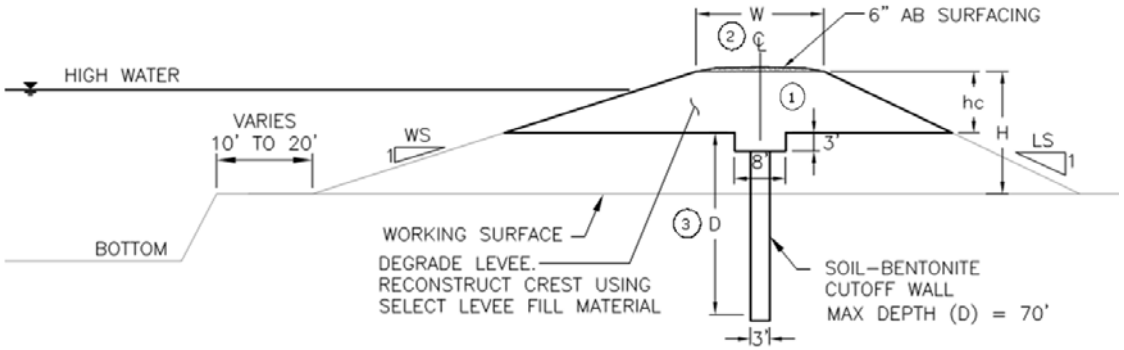
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

		FT Existing ROW

Levee Geometry:

H:	15	FT
W:	24	FT
hc:	7.5	FT Levee Degrade from Crest to Working Surface
D:	65	FT Cutoff Wall Depth from Working Surface
WS:	3	:1 (Waterside Slope)
LS:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	107	1	107	SF	LS slope length + temporary easement +
			Length	Length	0.00246	ACRE	ROW + W + 1/2 of WS slope length
3	02300	LEVEE DEGRADE	321	1	321	CF	Zone 2
			Area	Length	11.88889	CY	
4	02300	SELECT LEVEE FILL	136	1	136	CF	Zone 2
			Area	Length	5.03704	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	136	1	136	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	5.03704	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	209	1	209	CF	Zone 2 reusable material
			Area	Length	7.74074	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	65	1			
			Depth	Length	65.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	12	1	12	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.76889	TON	1.73 TON/CY
9	02925	HYDROSEEDING	71	1	71	SF	Top of levee down to disturbed area
			Length	Length	0.00163	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent Right of Way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S8
SERIES: a
TOTAL SEGMENT LENGTH (FT): 101,376

S8 - Butte Bypass

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-SL	New Levee	25,344	$ 39,151,269	$ 1,545	$ 9,787,817	$ 3,003,318	$ 51,942,404
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	76,032	$ 158,936,068	$ 2,090	$ 39,734,017	$ 11,084,066	$ 209,754,151
							$ 261,696,555

LS-SL **New Levee**
LOCATION: S8 - Butte Bypass

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 56.59	5% of sum Items 2 to 9 and 13 to 16
2	02230	CLEARING AND GRUBBING	0.0028	ACRE	$ 5,000.00	$ 13.77	
3	02230	STRIPPING	0.0021	ACRE	$ 3,000.00	$ 6.34	
4	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
5	02300	FOUNDATION PREPARATION	8.8889	SY	$ 5.00	$ 44.44	
6	02300	SELECT LEVEE FILL	19.9259	CY	$ 43.50	$ 866.78	
7	02300	UNSUITABLE MATERIAL DISPOSAL	1.4074	CY	$ 15.00	$ 21.11	
8	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0020	ACRE	$ 3,750.00	$ 7.58	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 102.88	Qty (%) x sum Items 2 to 9 and 14 to 16
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.5926	CY	$ 4.00	$ 10.37	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 356.49	30% x sum of items above
		CONSTRUCTION COST				$ 1,544.79	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0026	ACRE	$ 11,360.00	$ 29.99	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 10.70	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 77.24	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 118.50	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 386.20	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

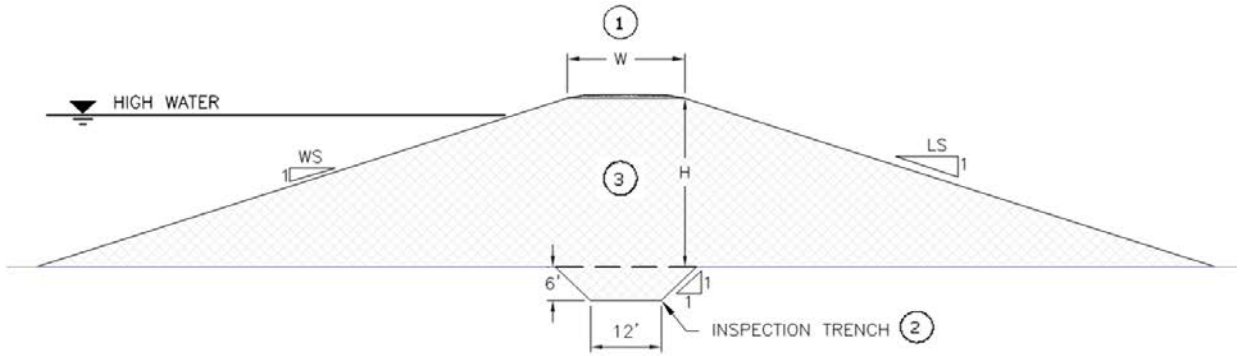
101,376 Segment Length (FT)
Repair Length 25% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 51,942,404**	For the Specified Repair Length

New Levee

Major Quantity Zone:

1. Levee Road - AB fill area
2. Inspection or cutoff trench - cut and fill area
3. Select Levee Fill - fill area



		FT Existing ROW

Levee Geometry:

H:	10	FT Levee Height
W:	20	FT
W_{AC}:		FT Asphalt Concrete Paving Width
W S:	3	:1 Waterside Slope
L S:	3	:1 Landside Slope
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	120	1	120	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00275	ACRE	5' temporary easement
3	02230	STRIPPING	92	1	92	SF	Levee footprint + 12' AB easement road
			Length	Length	0.00211	ACRE	
4	02300	EXCAVATION	108	1	108	CF	Zone 2
			Area	Length	4.00000	CY	
8	02300	FOUNDATION PREPARATION	80	1	80	SF	Levee footprint
			Length	Length	8.88889	SY	
6	02300	SELECT LEVEE FILL	538	1	538	CF	Zone 3
			Area	Length	19.92593	CY	
7	02300	UNSUITABLE MATERIAL DISPOSAL	38	1	38	CF	Zone 2 unsuitable material
			Area	Length	1.40741	CY	
8	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON to CY
9	02925	HYDROSEEDING	88	1	88	SF	Top of levee slope down to disturbed area
			Length	Length	0.00202	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	115	1	115	SF	Same footprint as the replaced levee
			Length	Length	0.00264	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70	CF	Zone 2 reusable material
			Area	Length	2.59259	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**
LOCATION: S8 - Butte Bypass

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 76.57	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0028	ACRE	$ 5,000.00	$ 13.77	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0021	ACRE	$ 3,000.00	$ 6.34	
5	02300	FOUNDATION PREPARATION	8.8889	SY	$ 5.00	$ 44.44	
6	02300	SELECT LEVEE FILL	19.9259	CY	$ 43.50	$ 866.78	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0020	ACRE	$ 3,750.00	$ 7.58	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 139.22	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
						-	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 482.40	30% x sum of items above
		CONSTRUCTION COST				$ 2,090.38	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0026	ACRE	$ 11,360.00	$ 29.99	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 10.70	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 104.52	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 145.78	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 522.60	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

101,376 Segment Length (FT)
Repair Length 75% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 209,754,151**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

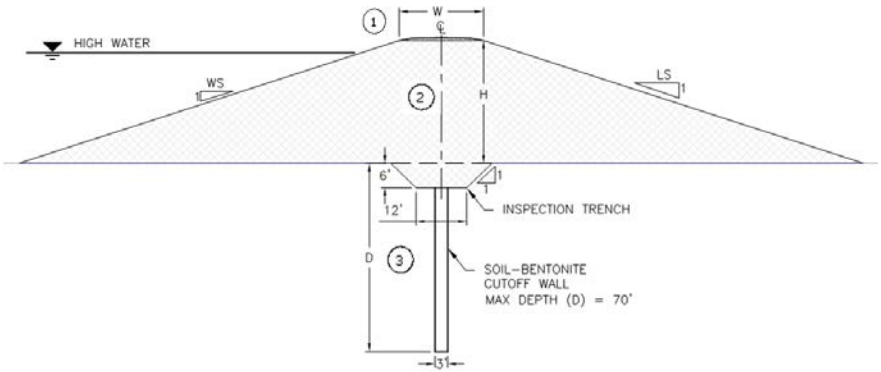
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

[ ] FT Existing ROW

Levee Geometry:

H:	10	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	120	1	120	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00275	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	92	1	92	SF	Levee footprint
			Length	Length	0.00211	ACRE	
5	02300	FOUNDATION PREPARATION	80	1	80	SF	Levee footprint
			Length	Length	8.88889	SY	
6	02300	SELECT LEVEE FILL	538	1	538	CF	Zone 2
			Area	Length	19.92593	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	88	1	88	SF	Top of levee slope down to disturbed area
			Length	Length	0.00202	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	115	1	115	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00264	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

[ ] Input cell (Variables) [ ] Linked to estimate table [ ] Formula cell

S1: 2 Levee geometry input (Fixed) 100 Length Cross-section length, area, depth, or width calculation cell

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S9
SERIES: g
TOTAL SEGMENT LENGTH (FT): 40,128

S9 - Sutter Bypass Setback Levee - Reach 1 (Same as S7, Reach 4)

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	40,128	$ 230,212,579	$ 5,737	$ 57,553,145	$ 14,027,500	$ 301,793,224
							$ 301,793,224

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**

LOCATION: S9 - Sutter Bypass Setback Levee - Reach 1 (Same as S7, Reach 4)

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 210.14	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0045	ACRE	$ 5,000.00	$ 22.38	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0038	ACRE	$ 3,000.00	$ 11.50	
5	02300	FOUNDATION PREPARATION	17.2222	SY	$ 5.00	$ 86.11	
6	02300	SELECT LEVEE FILL	74.3333	CY	$ 43.50	$ 3,233.50	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0037	ACRE	$ 3,750.00	$ 14.03	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 382.08	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
						-	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 1,323.91	30% x sum of items above
		CONSTRUCTION COST				$ 5,736.96	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0044	ACRE	$ 10,520.00	$ 45.89	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 16.26	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 286.85	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 349.57	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 1,434.24	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	40,128	Segment Length (FT)
Repair Length	100%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 301,793,224**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

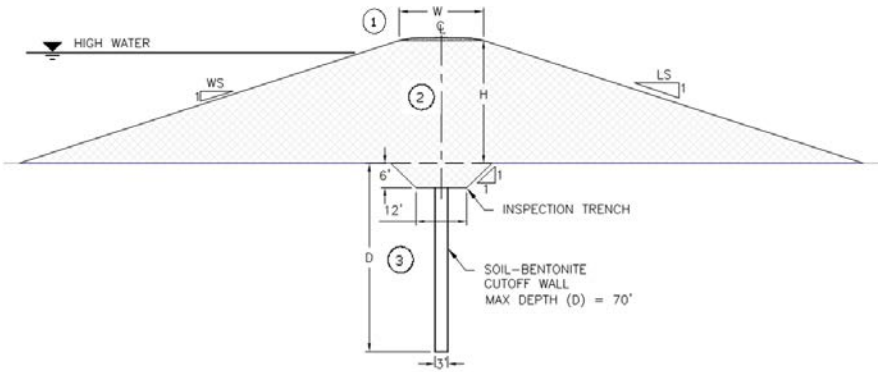
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	22.5	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	195	1	195	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00448	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	167	1	167	SF	Levee footprint
			Length	Length	0.00383	ACRE	
5	02300	FOUNDATION PREPARATION	155	1	155	SF	Levee footprint
			Length	Length	17.22222	SY	
6	02300	SELECT LEVEE FILL	2007	1	2007	CF	Zone 2
			Area	Length	74.33333	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	163	1	163	SF	Top of levee slope down to disturbed area
			Length	Length	0.00374	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	190	1	190	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00436	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

Input cell (Variables) — Linked to estimate table — Formula cell

S1: 2 Levee geometry input (Fixed)

100 Length — Cross-section length, area, depth, or width calculation cell

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S9
SERIES: h
TOTAL SEGMENT LENGTH (FT): 9,504

S9 - Sutter Bypass Setback Levee - Reach 2 (Same as S7, Reach 5)

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	9,504	$ 45,863,706	$ 4,826	$ 11,465,927	$ 2,842,807	$ 60,172,440
							$ 60,172,440

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**

LOCATION: S9 - Sutter Bypass Setback Levee - Reach 2 (Same as S7, Reach 5)

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 176.77	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0041	ACRE	$ 5,000.00	$ 20.66	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0035	ACRE	$ 3,000.00	$ 10.47	
5	02300	FOUNDATION PREPARATION	15.5556	SY	$ 5.00	$ 77.78	
6	02300	SELECT LEVEE FILL	60.6667	CY	$ 43.50	$ 2,639.00	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0034	ACRE	$ 3,750.00	$ 12.74	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 321.39	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 1,113.63	30% x sum of items above
		CONSTRUCTION COST				$ 4,825.73	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0040	ACRE	$ 10,520.00	$ 42.26	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 14.99	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 241.29	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 299.12	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 1,206.43	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	9,504	Segment Length (FT)
Repair Length	100%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 60,172,440**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

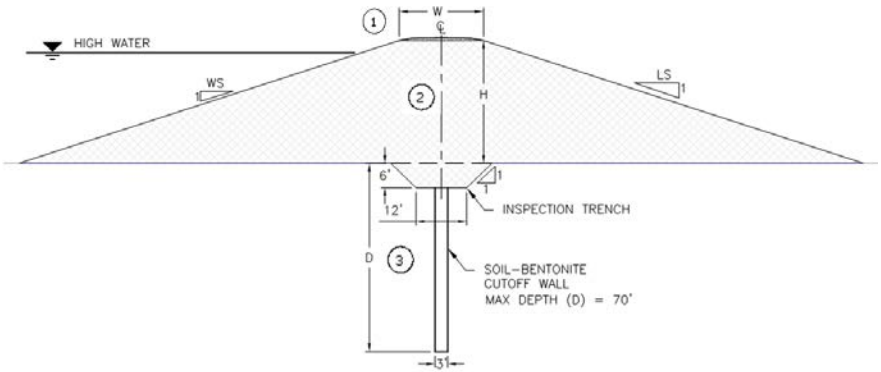
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

		FT Existing ROW

Levee Geometry:

H:	20	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	180	1	180	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00413	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	152	1	152	SF	Levee footprint
			Length	Length	0.00349	ACRE	
5	02300	FOUNDATION PREPARATION	140	1	140	SF	Levee footprint
			Length	Length	15.55556	SY	
6	02300	SELECT LEVEE FILL	1638	1	1638	CF	Zone 2
			Area	Length	60.66667	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	148	1	148	SF	Top of levee slope down to disturbed area
			Length	Length	0.00340	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	175	1	175	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00402	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S9
SERIES: i
TOTAL SEGMENT LENGTH (FT): 42,768

S9 - Sutter Bypass Setback Levee - Reach 3 (Same as S7, Reach 6)

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	42,768	$ 206,386,679	$ 4,826	$ 51,596,670	$ 12,792,632	$ 270,775,981
							$ 270,775,981

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**

LOCATION: S9 - Sutter Bypass Setback Levee - Reach 3 (Same as S7, Reach 6)

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 176.77	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0041	ACRE	$ 5,000.00	$ 20.66	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0035	ACRE	$ 3,000.00	$ 10.47	
5	02300	FOUNDATION PREPARATION	15.5556	SY	$ 5.00	$ 77.78	
6	02300	SELECT LEVEE FILL	60.6667	CY	$ 43.50	$ 2,639.00	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0034	ACRE	$ 3,750.00	$ 12.74	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 321.39	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
						-	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 1,113.63	30% x sum of items above
		CONSTRUCTION COST				$ 4,825.73	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0040	ACRE	$ 10,520.00	$ 42.26	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 14.99	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 241.29	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 299.12	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 1,206.43	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	42,768	Segment Length (FT)
Repair Length	100%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 270,775,981**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

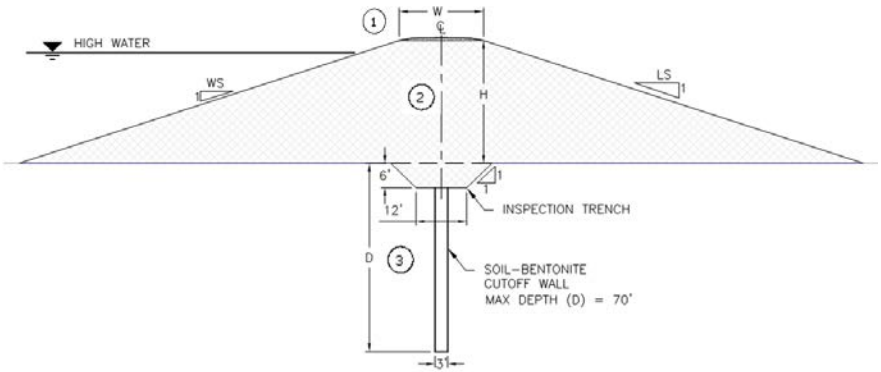
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	20	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	180	1	180	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00413	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	152	1	152	SF	Levee footprint
			Length	Length	0.00349	ACRE	
5	02300	FOUNDATION PREPARATION	140	1	140	SF	Levee footprint
			Length	Length	15.55556	SY	
6	02300	SELECT LEVEE FILL	1638	1	1638	CF	Zone 2
			Area	Length	60.66667	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	148	1	148	SF	Top of levee slope down to disturbed area
			Length	Length	0.00340	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	175	1	175	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00402	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

Input cell (Variables) — Linked to estimate table — Formula cell

S1: 2 Levee geometry input (Fixed)

100 Length — Cross-section length, area, depth, or width calculation cell

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S10
SERIES: a
TOTAL SEGMENT LENGTH (FT): 27,984

S10 - Northern Feather River Setback Levee

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	27,984	$ 159,728,697	$ 5,708	$ 39,932,174	$ 11,134,635	$ 210,795,506
							$ 210,795,506

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**

LOCATION: S10 - Northern Feather River Setback Levee

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 209.08	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0041	ACRE	$ 5,000.00	$ 20.66	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0035	ACRE	$ 3,000.00	$ 10.47	
5	02300	FOUNDATION PREPARATION	15.5556	SY	$ 5.00	$ 77.78	
6	02300	SELECT LEVEE FILL	60.6667	CY	$ 43.50	$ 2,639.00	
7	02260	SOIL-BENTONITE SLURRY WALL	75.00	SF	$ 12.50	$ 937.50	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0034	ACRE	$ 3,750.00	$ 12.74	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 380.14	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 1,317.20	30% x sum of items above
		CONSTRUCTION COST				$ 5,707.86	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0040	ACRE	$ 20,600.00	$ 82.76	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 29.17	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 285.39	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 397.89	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 1,426.96	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	27,984	Segment Length (FT)
Repair Length	100%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 210,795,506**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

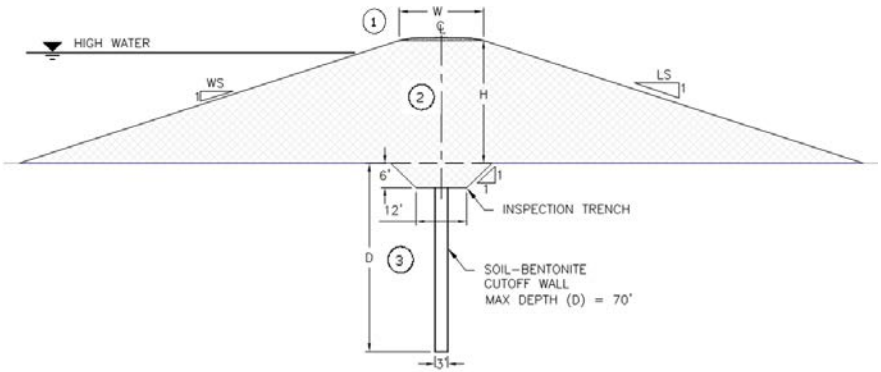
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

		FT Existing ROW

Levee Geometry:

H:	20	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	75	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	180	1	180	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00413	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	152	1	152	SF	Levee footprint
			Length	Length	0.00349	ACRE	
5	02300	FOUNDATION PREPARATION	140	1	140	SF	Levee footprint
			Length	Length	15.55556	SY	
6	02300	SELECT LEVEE FILL	1638	1	1638	CF	Zone 2
			Area	Length	60.66667	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	75	1			Zone 3
			Depth	Length	75.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	148	1	148	SF	Top of levee slope down to disturbed area
			Length	Length	0.00340	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	175	1	175	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00402	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S11
SERIES: a
TOTAL SEGMENT LENGTH (FT): 11,088

S11 - Sutter Bypass and Feather River Confluence Setback Levee

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-SL	New Levee	5,544	$ 28,780,937	$ 5,191	$ 7,195,234	$ 1,935,636	$ 37,911,807
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	5,544	$ 31,805,685	$ 5,737	$ 7,951,421	$ 2,086,873	$ 41,843,980
							$ 79,755,787

LS-SL **New Levee**

LOCATION: S11 - Sutter Bypass and Feather River Confluence Setback Levee

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 190.16	5% of sum Items 2 to 9 and 13 to 16
2	02230	CLEARING AND GRUBBING	0.0045	ACRE	$ 5,000.00	$ 22.38	
3	02230	STRIPPING	0.0038	ACRE	$ 3,000.00	$ 11.50	
4	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
5	02300	FOUNDATION PREPARATION	17.2222	SY	$ 5.00	$ 86.11	
6	02300	SELECT LEVEE FILL	74.3333	CY	$ 43.50	$ 3,233.50	
7	02300	UNSUITABLE MATERIAL DISPOSAL	1.4074	CY	$ 15.00	$ 21.11	
8	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0037	ACRE	$ 3,750.00	$ 14.03	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 345.75	Qty (%) x sum Items 2 to 9 and 14 to 16
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.5926	CY	$ 4.00	$ 10.37	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 1,198.01	30% x sum of items above
		CONSTRUCTION COST				$ 5,191.37	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0044	ACRE	$ 15,080.00	$ 65.78	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 23.22	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 259.57	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 349.14	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 1,297.84	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

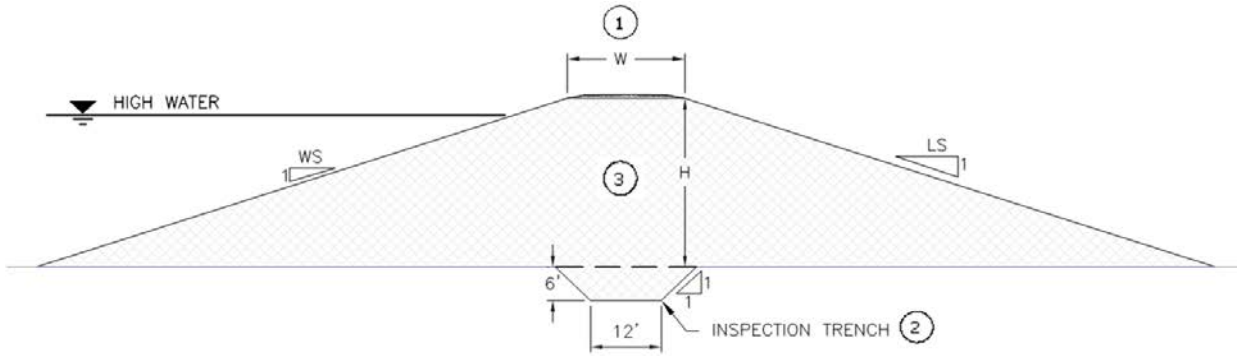
	11,088	Segment Length (FT)
Repair Length	50%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 37,911,807**	For the Specified Repair Length

New Levee

Major Quantity Zone:

1. Levee Road - AB fill area
2. Inspection or cutoff trench - cut and fill area
3. Select Levee Fill - fill area



		FT Existing ROW

Levee Geometry:

H:	22.5	FT Levee Height
W:	20	FT
W_{AC}:		FT Asphalt Concrete Paving Width
W S:	3	:1 Waterside Slope
L S:	3	:1 Landside Slope
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	195	1	195	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00448	ACRE	5' temporary easement
3	02230	STRIPPING	167	1	167	SF	Levee footprint + 12' AB easement road
			Length	Length	0.00383	ACRE	
4	02300	EXCAVATION	108	1	108	CF	Zone 2
			Area	Length	4.00000	CY	
8	02300	FOUNDATION PREPARATION	155	1	155	SF	Levee footprint
			Length	Length	17.22222	SY	
6	02300	SELECT LEVEE FILL	2007	1	2007	CF	Zone 3
			Area	Length	74.33333	CY	
7	02300	UNSUITABLE MATERIAL DISPOSAL	38	1	38	CF	Zone 2 unsuitable material
			Area	Length	1.40741	CY	
8	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON to CY
9	02925	HYDROSEEDING	163	1	163	SF	Top of levee slope down to disturbed area
			Length	Length	0.00374	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	190	1	190	SF	Same footprint as the replaced levee
			Length	Length	0.00436	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70	CF	Zone 2 reusable material
			Area	Length	2.59259	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**

LOCATION: S11 - Sutter Bypass and Feather River Confluence Setback Levee

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 210.14	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0045	ACRE	$ 5,000.00	$ 22.38	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0038	ACRE	$ 3,000.00	$ 11.50	
5	02300	FOUNDATION PREPARATION	17.2222	SY	$ 5.00	$ 86.11	
6	02300	SELECT LEVEE FILL	74.3333	CY	$ 43.50	$ 3,233.50	
7	02260	SOIL-BENTONITE SLURRY WALL	35.00	SF	$ 10.00	$ 350.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0037	ACRE	$ 3,750.00	$ 14.03	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 382.08	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
						-	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 1,323.91	30% x sum of items above
		CONSTRUCTION COST				$ 5,736.96	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0044	ACRE	$ 15,080.00	$ 65.78	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 23.22	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 286.85	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 376.42	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 1,434.24	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	11,088	Segment Length (FT)
Repair Length	50%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 41,843,980**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

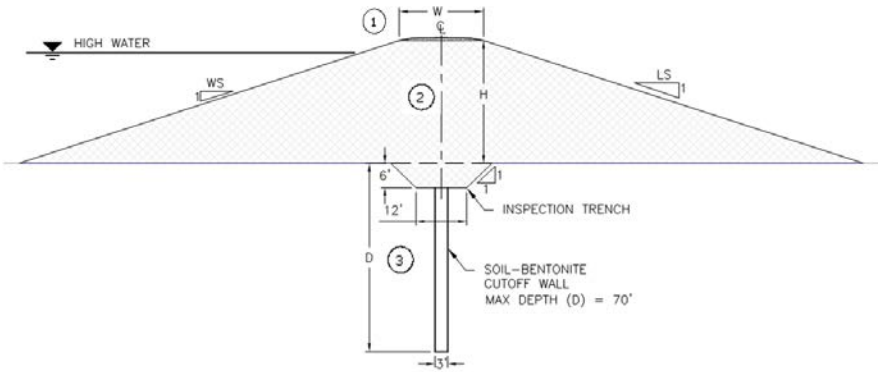
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	22.5	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	35	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	195	1	195	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00448	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	167	1	167	SF	Levee footprint
			Length	Length	0.00383	ACRE	
5	02300	FOUNDATION PREPARATION	155	1	155	SF	Levee footprint
			Length	Length	17.22222	SY	
6	02300	SELECT LEVEE FILL	2007	1	2007	CF	Zone 2
			Area	Length	74.33333	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	35	1			Zone 3
			Depth	Length	35.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	163	1	163	SF	Top of levee slope down to disturbed area
			Length	Length	0.00374	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	190	1	190	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00436	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

Input cell (Variables) | Linked to estimate table | Formula cell

S1: 2 Levee geometry input (Fixed)

100 Length — Cross-section length, area, depth, or width calculation cell

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S12
SERIES: a
TOTAL SEGMENT LENGTH (FT): 4,224

S12 - Star Bend Setback Levee

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
TL-SW-SCBCW-TEF	Centerline Soil-Bentonite	1,056	$ 2,292,390	$ 2,171	$ 573,097	$ 121,067	$ 2,986,554
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	3,168	$ 23,545,006	$ 7,432	$ 5,886,251	$ 1,352,799	$ 30,784,056
							$ 33,770,611

TL-SW-SCBCW- **Centerline Soil-Bentonite**

LOCATION: S12 - Star Bend Setback Levee

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 79.52	5% of sum Items 2 to 9 and 13 to 15
2	02230	CLEARING AND GRUBBING	0.0028	ACRE	$ 5,000.00	$ 14.00	
3	02300	LEVEE DEGRADE	16.6667	CY	$ 4.50	$ 75.00	
4	02300	SELECT LEVEE FILL	6.7037	CY	$ 43.50	$ 291.61	
5	02300	UNSUITABLE MATERIAL DISPOSAL	6.7037	CY	$ 15.00	$ 100.56	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	10.8519	CY	$ 4.00	$ 43.41	
7	02260	SOIL-BENTONITE SLURRY WALL	70.00	SF	$ 12.50	$ 875.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0021	ACRE	$ 3,750.00	$ 7.75	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 144.58	Qty (%) x sum Items 2 to 9 and 14 to 15
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 500.96	30% x sum of items above
		CONSTRUCTION COST				$ 2,170.82	Per Linear Foot
10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0005	ACRE	$ 8,600.00	$ 3.95	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 1.58	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 108.54	
		ROW AND TEMP EASEMENT COST				$ 114.65	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 542.71	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	4,224	Segment Length (FT)
Repair Length	25%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 2,986,554**	For the Specified Repair Length

Centerline Soil-Bentonite

Major Quantity Zone:

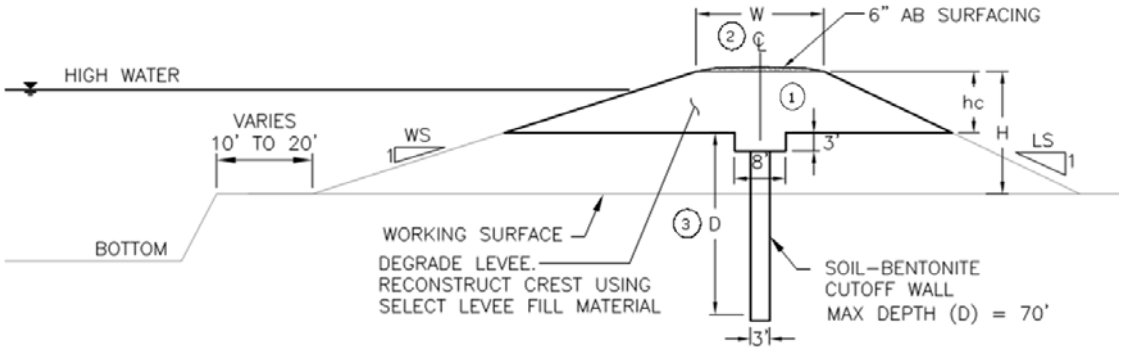
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

		FT Existing ROW

Levee Geometry:

H:	20	FT
W:	20	FT
hc:	10	FT Levee Degrade from Crest to Working Surface
D:	70	FT Cutoff Wall Depth from Working Surface
WS:	3	:1 (Waterside Slope)
LS:	2	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
RM:	65%	% of Reusable Material



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	122	1	122	SF	LS slope length + temporary easement +
			Length	Length	0.00280	ACRE	ROW + W + 1/2 of WS slope length
3	02300	LEVEE DEGRADE	450	1	450	CF	Zone 2
			Area	Length	16.66667	CY	
4	02300	SELECT LEVEE FILL	181	1	181	CF	Zone 2
			Area	Length	6.70370	CY	Imported material
5	02300	UNSUITABLE MATERIAL DISPOSAL	181	1	181	CF	Zone 2 unsuitable material + 3' x 8' trench
			Area	Length	6.70370	CY	
6	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	293	1	293	CF	Zone 2 reusable material
			Area	Length	10.85185	CY	Haul to stockpile for reuse
7	02260	SOIL-BENTONITE SLURRY WALL	70	1			
			Depth	Length	70.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	90	1	90	SF	Top of levee down to disturbed area
			Length	Length	0.00207	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	20	1	20	SF	Permanent Right of Way = ROW
			Length	Length	0.00046	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**
LOCATION: S12 - Star Bend Setback Levee

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 272.24	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0048	ACRE	$ 5,000.00	$ 24.10	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0042	ACRE	$ 3,000.00	$ 12.53	
5	02300	FOUNDATION PREPARATION	18.8889	SY	$ 5.00	$ 94.44	
6	02300	SELECT LEVEE FILL	89.3704	CY	$ 43.50	$ 3,887.61	
7	02260	SOIL-BENTONITE SLURRY WALL	65.00	SF	$ 12.50	$ 812.50	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0041	ACRE	$ 3,750.00	$ 15.32	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 494.98	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
						-	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 1,715.11	30% x sum of items above
		CONSTRUCTION COST				$ 7,432.14	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0047	ACRE	$ 8,600.00	$ 40.47	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 14.37	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 371.61	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 427.02	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 1,858.03	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	4,224	Segment Length (FT)
Repair Length	75%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 30,784,056**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

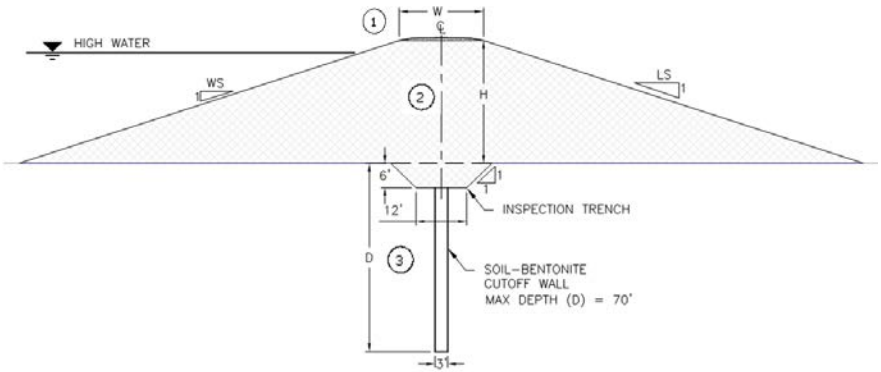
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	25	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	65	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	210	1	210	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00482	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	182	1	182	SF	Levee footprint
			Length	Length	0.00418	ACRE	
5	02300	FOUNDATION PREPARATION	170	1	170	SF	Levee footprint
			Length	Length	18.88889	SY	
6	02300	SELECT LEVEE FILL	2413	1	2413	CF	Zone 2
			Area	Length	89.37037	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	65	1			Zone 3
			Depth	Length	65.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	178	1	178	SF	Top of levee slope down to disturbed area
			Length	Length	0.00409	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	205	1	205	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00471	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

SUTTER BASIN PILOT STUDY

ESTIMATED BY: LOB

DATE: 1/25/2012

PRICE BASIS: 2010

ESCALATION TO: 2011

SEGMENT ID: S24
SERIES: a
TOTAL SEGMENT LENGTH (FT): 32,000

S24 - Gilsizer Cross-Levee

REPAIR ELEMENTS

CODE	DESCRIPTION	REPAIR LENGTH (FT)	CONSTRUCTION COST	CONSTRUCTION COST PER LF	MITIGATION COST	ROW AND TEMP EASEMENT	TOTAL COST ESTIMATED
LS-SL	New Levee	11,200	$ 53,941,787	$ 4,816	$ 13,485,447	$ 3,753,198	$ 71,180,432
TL-SB-SCW	New Levee With Centerline Soil-Bentonite Cutoff Wall	20,800	$ 109,964,305	$ 5,287	$ 27,491,076	$ 7,459,561	$ 144,914,942
							$ 216,095,374

LS-SL **New Levee**
LOCATION: S24 - Gilsizer Cross-Levee

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 176.42	5% of sum Items 2 to 9 and 13 to 16
2	02230	CLEARING AND GRUBBING	0.0043	ACRE	$ 5,000.00	$ 21.69	
3	02230	STRIPPING	0.0037	ACRE	$ 3,000.00	$ 11.09	
4	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
5	02300	FOUNDATION PREPARATION	16.5556	SY	$ 5.00	$ 82.78	
6	02300	SELECT LEVEE FILL	68.7037	CY	$ 43.50	$ 2,988.61	
7	02300	UNSUITABLE MATERIAL DISPOSAL	1.4074	CY	$ 15.00	$ 21.11	
8	02720	AGGREGATE BASE	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0036	ACRE	$ 3,750.00	$ 13.52	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 320.76	Qty (%) x sum Items 2 to 9 and 14 to 16
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.5926	CY	$ 4.00	$ 10.37	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 1,111.44	30% x sum of items above
		CONSTRUCTION COST				$ 4,816.23	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0042	ACRE	$ 16,400.00	$ 69.27	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 24.45	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 240.81	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 335.11	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 1,204.06	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

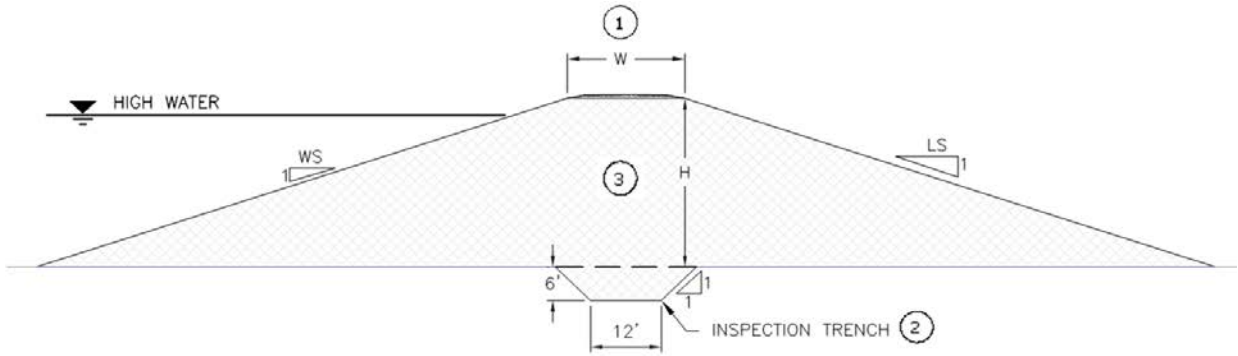
32,000 Segment Length (FT)
Repair Length 35% of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 71,180,432**	For the Specified Repair Length

New Levee

Major Quantity Zone:

1. Levee Road - AB fill area
2. Inspection or cutoff trench - cut and fill area
3. Select Levee Fill - fill area



		FT Existing ROW

Levee Geometry:

H:	21.5	FT Levee Height
W:	20	FT
W_{AC}:		FT Asphalt Concrete Paving Width
W S:	3	:1 Waterside Slope
L S:	3	:1 Landside Slope
RM:	65%	% of Reusable Material

QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
2	02230	CLEARING AND GRUBBING	189	1	189	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00434	ACRE	5' temporary easement
3	02230	STRIPPING	161	1	161	SF	Levee footprint + 12' AB easement road
			Length	Length	0.00370	ACRE	
4	02300	EXCAVATION	108	1	108	CF	Zone 2
			Area	Length	4.00000	CY	
8	02300	FOUNDATION PREPARATION	149	1	149	SF	Levee footprint
			Length	Length	16.55556	SY	
6	02300	SELECT LEVEE FILL	1855	1	1855	CF	Zone 3
			Area	Length	68.70370	CY	
7	02300	UNSUITABLE MATERIAL DISPOSAL	38	1	38	CF	Zone 2 unsuitable material
			Area	Length	1.40741	CY	
8	02720	AGGREGATE BASE	10	1	10	CF	Zone 1: crest width x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON to CY
9	02925	HYDROSEEDING	157	1	157	SF	Top of levee slope down to disturbed area
			Length	Length	0.00360	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	184	1	184	SF	Same footprint as the replaced levee
			Length	Length	0.00422	ACRE	(ROW = 20' CVFPB ROW - existing ROW)
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70	CF	Zone 2 reusable material
			Area	Length	2.59259	CY	Haul to stockpile for reuse

Legend:

	Input cell (Variables)		Linked to estimate table		Formula cell
S1: 2	Levee geometry input (Fixed)	100 Length	Cross-section length, area, depth, or width calculation cell		

TL-SB-SCW **New Levee With Centerline Soil-Bentonite Cutoff Wall**
LOCATION: S24 - Gilsizer Cross-Levee

Item No.	Spec No	Item	Estimated Quantity/LF	Unit	Unit Price $	Total $	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION	5%	LS		$ 193.65	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	0.0043	ACRE	$ 5,000.00	$ 21.69	
3	02300	EXCAVATION	4.0000	CY	$ 5.00	$ 20.00	
4	02230	STRIPPING	0.0037	ACRE	$ 3,000.00	$ 11.09	
5	02300	FOUNDATION PREPARATION	16.5556	SY	$ 5.00	$ 82.78	
6	02300	SELECT LEVEE FILL	68.7037	CY	$ 43.50	$ 2,988.61	
7	02260	SOIL-BENTONITE SLURRY WALL	30.00	SF	$ 10.00	$ 300.00	
8	02720	AGGREGATE BASE LEVEE ROAD	0.6407	TON	$ 37.50	$ 24.03	
9	02925	HYDROSEEDING	0.0036	ACRE	$ 3,750.00	$ 13.52	
13	01090	UNALLOCATED ITEMS - HIGH	10%	LS		$ 352.10	Qty (%) x sum Items 2 to 9 and 14 to 17
14	02720	AGGREGATE BASE EASEMENT ROAD	0.3844	TON	$ 37.50	$ 14.42	
15	02720	ASPHALT CONCRETE PAVING		SY	$ 12.00	$ -	
16	02300	UNSUITABLE MATERIAL DISPOSAL	2.2963	CY	$ 15.00	$ 34.44	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	2.6000	CY	$ 4.00	$ 10.40	
00	01040	CONSTRUCTION CONTINGENCY	30%			$ 1,220.02	30% x sum of items above
		CONSTRUCTION COST				$ 5,286.75	Per Linear Foot

10	01000	PERMANENT RIGHT OF WAY (ROW)	0.0042	ACRE	$ 16,400.00	$ 69.27	
11	01500	TEMPORARY EASEMENT	0.0001	ACRE	$ 5,000.00	$ 0.57	
00	01040	CONTINGENCY ON ROW AND TEMP EASEMENT	35%			$ 24.45	
00	01060	LEGAL/ LAND ACQUISITION	5%			$ 264.34	Does not cover environmental permitting
		ROW AND TEMP EASEMENT COST				$ 358.63	
12	01000	ENVIRONMENTAL MITIGATION - AVERAGE 1	25%	LS		$ 1,321.69	Qty (%) x Construction Cost
00	01010	ESCALATION TO OCTOBER 2011				$ -	
00	01020	MARKET AT BID TIME RESERVE				$ -	
00	01030	CHANGE ORDER RESERVE				$ -	
00	01050	DESIGN AND ENGINEERING				$ -	
00	01070	ENGINEERING DURING CONSTRUCTION				$ -	
00	01080	CONSTRUCTION MANAGEMENT/SITE INSPECTION				$ -	

	32,000	Segment Length (FT)
Repair Length	65%	of Segment Length (enter percent with % sign)

BUDGET AMOUNT	**$ 144,914,942**	For the Specified Repair Length

New Levee With Centerline Soil-Bentonite Cutoff Wall

Major Quantity Zone:

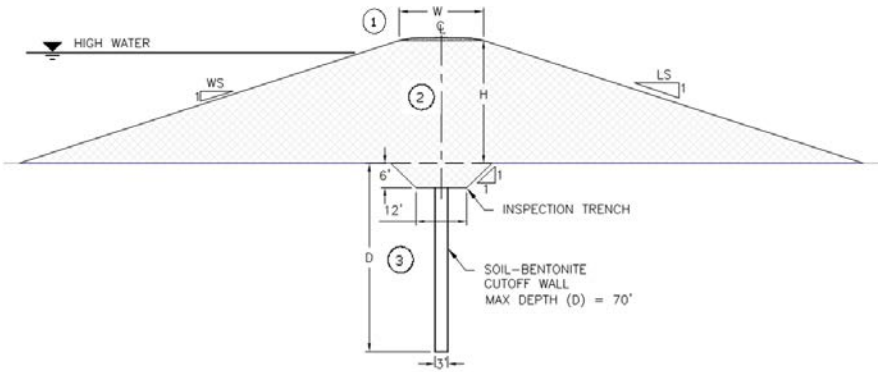
(1) Levee road

(2) Select Levee Fill (3) SB Cutoff Wall

FT Existing ROW

Levee Geometry:

H:	21.5	FT
W:	20	FT
RM:	65%	% Reusable Material
D:	30	FT Cutoff Wall Depth from Working Surface
W S:	3	:1 (Waterside Slope)
L S:	3	:1 (Landside Slope)
W_{AC}:		FT Asphalt Concrete Paving Width
D1	6	FT Inspection Key Depth



QUANTITY PARAMETER INPUT TABLE

			X Section	Plan	Quantity	Unit	Notes and Assumptions
1	02205	MOBILIZATION & DEMOBILIZATION				LS	5% of sum Items 2 to 9 and 13 to 17
2	02230	CLEARING AND GRUBBING	189	1	189	SF	15' WS + levee footprint + 20' LS +
			Length	Length	0.00434	ACRE	5' temporary easement
3	02300	EXCAVATION	108	1	108	CF	
			Area	Length	4.00000	CY	Inspection key
4	02230	STRIPPING	161	1	161	SF	Levee footprint
			Length	Length	0.00370	ACRE	
5	02300	FOUNDATION PREPARATION	149	1	149	SF	Levee footprint
			Length	Length	16.55556	SY	
6	02300	SELECT LEVEE FILL	1855	1	1855	CF	Zone 2
			Area	Length	68.70370	CY	
7	02260	SOIL-BENTONITE SLURRY WALL	30	1			Zone 3
			Depth	Length	30.00000	SF	
8	02720	AGGREGATE BASE LEVEE ROAD	10	1	10	CF	Zone 1: 12' or 20' x 6" AB levee road
			Area	Length	0.64074	TON	1.73 TON/CY
9	02925	HYDROSEEDING	157	1	157	SF	Top of levee slope down to disturbed area
			Length	Length	0.00360	ACRE	
10	01000	PERMANENT RIGHT OF WAY (ROW)	184	1	184	SF	15' WS + levee footprint + 20' LS
			Length	Length	0.00422	ACRE	ROW
11	01500	TEMPORARY EASEMENT	5	1	5	SF	5 feet temporary easement
			Length	Length	0.00011	ACRE	For construction beyond CVFPB ROW
14	02720	AGGREGATE BASE EASEMENT ROAD	6	1	6	CF	12' x 6" AB easement road
			Area	Length	0.38444	TON	1.73 TON/CY
15	02720	ASPHALT CONCRETE PAVING		1		SF	W_{AC} x 1 LF of 3" AC levee road surface
			Width	Length		SY	
16	02300	UNSUITABLE MATERIAL DISPOSAL	62	1	62	CF	Unsuitable material from excavation
			Area	Length	2.29630	CY	
17	02300	STOCKPILE AND REUSE SUITABLE MATERIAL	70	1	70.2	CF	Reusable material from excavation
			Area	Length	2.60000	CY	Haul to stockpile for reuse

Legend:

Input cell (Variables) — Linked to estimate table — Formula cell

S1: 2 Levee geometry input (Fixed)

100 Length — Cross-section length, area, depth, or width calculation cell

CESPK-ED-SC 18 June 2012

(25 Feb 2013 REV)

MEMORANDUM FOR FILE: Sutter Basin Pilot Feasibility Study

SUBJECT: Estimated Project Cost for Draft Array of Alternatives Comparison

1. REFERENCES:

a. Recommendation for Transforming the Current Pre-Authorization Study Process, USACE, January 2011.

2. PURPOSE:

The purpose of this memorandum is to describe and document the method used to calculate the estimated cost of the draft array of alternatives for the Sutter Basin Pilot Feasibility Study.

3. BACKGROUND:

The Sutter Basin Feasibility Study was selected as a planning pilot study to test principles that have been outlined in the *USACE Recommendations for Transforming the Current Pre-Authorization Study Process* (January 2011) and associated presentation materials.

The Pilot Study Re-scoping Plan described an approach to evaluating and comparing alternatives. The beneficial and adverse effects, including monetary and non-monetary benefits and costs, were to be identified for each alternative across a broad array of criteria. The potential criteria to be used included the four P&G criteria (completeness, effectiveness, efficiency, acceptability), national economic development, environmental quality, regional economic development, other social effects (including public safety), environmental justice, sustainability, promotion of wise use of the floodplain in accordance with EO 11988, residual risk, and the consequences of project failure. The beneficial and adverse effects for each alternative in relation to each of the evaluation criteria would be determined based on available information as well as the professional judgment and local knowledge of SMEs and the PDT. The following table presents potential criteria and evaluation methods currently being evaluated for evaluation of the draft array of alternatives.

Criteria	**Evaluation Method For Draft Array of Alternatives**
Net economic benefits	Expected annual damage and costs.
ER benefits	Estimated acreage of habitat based on GIS/aerial photography.
Cost	Estimated cost based on a level 4 estimate (ER 110-2-1302)
Public Safety	Annualized population at risk (PAR).
Wise Use of Floodplain	Potentially developable land within the 0.2% (1/500) Annual Chance Exceedance floodplain.
Non-federal standard	Does alternative meet State's requirement of reducing the risk of flooding to urban and urbanizing areas to less than 0.5% (1/200) Annual Chance of Exceedance.

Critical Infrastructure	Describe number of critical infrastructure items within the 1% ACE floodplain (FEMA type approach).

4. APPROACH:

a. Cost Estimates

In developing the reconnaissance level cost estimates of the various measures and alternatives (combined measures) for the Sutter Basin project, the Cost Engineering team utilized a methodology wherein costs for levee improvements or new levees (sans relocations) were developed using a parametric spreadsheet based on typical cross sections for differing types of levee improvements. Costs for relocations and construction other than that directly related to the levee were compiled based on either 1) historical costs - past levee projects in the vicinity of Sacramento, 2) estimating software MII (MCACES, 2nd Generation) and PACES, or 3) based on a percentage of construction costs. In lieu of the time constraints of the 24-month fast-track pilot study schedule, these methods were used for preparing costs for the purpose of screening alternatives.

A spreadsheet developed by URS Corporation was selected to prepare the parametric level cost estimates for levee improvements and new levees. The parametric spreadsheet utilizes unit costs of certain typical levee design parameters including, for example, stripping vegetation, earthwork, cutoff walls, etc. The spreadsheet is essentially a collection/database of unit cost data from public bid results and projects that URS worked on for the California Department of Water Resources and other various public agencies. The parametric spreadsheet is thus believed to produce an effective and reliable estimate. Input data for followed typical levee designs provided by the Sacramento District (SPK) Geotech/Civil Design sections and the spreadsheet computed the corresponding construction cost. The estimate is based on the manual inputs and output is based solely on the input. The project delivery team (PDT) determined recommended repairs (or new levee design) based on hydraulic models and representative geotechnical data. For each individual reach and cross section, parameters such as the levee height, crest width, levee slopes, cutoff wall depths, etc., were quantified and used to generate the input data. The unit prices used were reviewed by SPK Cost Estimating Section and updated to reflect present day costs. In some cases, these unit costs were updated based on costs developed in MII. (Please refer to the “Parametric Cost Estimating MII Toolbox” pdf file for the parametric cost estimates of alternatives).

Besides levee improvements, other major cost categories including roads, railroads and canals crossing new levees, utility relocations, interior drainage, traffic control, SWPP, cultural resources, mitigation, PED (Planning, Engineering & Design), and Construction Management had to be considered separately. The costs for work relative to obstructions/structures crossing levees (special items) and interior drainage (pump stations) were based on preliminary quantity take-offs, hydrological analysis and existing cost data or similar historic cost estimates. A percentage of the construction cost was used to compute costs for the remaining cost categories.

The cost estimate for each Alternative is the summation of the costs from the parametric spreadsheet output and the costs of each of the other major cost categories.

The Screening Level Estimates were developed based on the initial measures and these were combined to reflect the alternatives developed by the PDT. The estimates were continuously updated to match the current design refinements and the latest information available at the time of the revisions. The costs do not account for life cycle costs.

The estimates follow the Civil Works Work Breakdown Structure (CWWBS) code of accounts. Feature Codes typically involved in this estimate are 01- Lands and Damages, 02-Relocations, 06-Fish and Wildlife Facilities, 11-Levees and Floodwalls, 18-Cultural Resource Preservation, 30-Planning, Engineering and Design, and 31-Construction Management. The 30 and 31 accounts involve any costs associated with USACE staffing on the project. The amounts are based on historical data.

b. Cost Uncertainties

There are inherent uncertainties in the costs at the feasibility level of design since there is no detailed design, plans or specs. There are also inherent uncertainties as the construction contractor(s) are responsible for obtaining most construction materials, accomplishing the work in a timely manner as per the project due date, using overtime and/or multiple crews to accomplish the same, etc. There are also many cost uncertainties relative to risk analysis (see below).

For this project, more than 50% of the costs for this project are directly related to levee improvements or new levee construction. A large percentage of this is obtaining and hauling fill material. For the purposes of the cost estimate, the assumption has been made that materials will come from within 10 miles (one-way haul). The potential contractors are free to obtain borrow from wherever they see fit, as long as it meets specs. Haul costs in general have some uncertainty as material supply locations are up to the contractor, as well as whether the contractor use their own trucks or utilize a subcontractor for hauling.

c. OMRR&R Costs

An investigation into OMRR&R costs was done by the local sponsor by soliciting information from various Levee Districts and State Maintenance Agencies within the Sutter Basin. The costs presented in the attached Table 1 at the end of this section are based on this info. The OMRR&R cost is an estimate of how much effort the local sponsor needs to perform on an annual basis. In the without-project condition, it is assumed that that the locals have carried out the current OMRR&R commitments.

For this exercise, an incremental (Δ) or additional OMRR&R cost was determined. Based on the information provided for the year 2010-2011, there is approximately 63.6 miles of levee maintained by the LDs and MAs (LD1, LD9, MA3, MA7, MA17, and East Levee Sutter Bypass) with an actual expenditure of $980,000. This equates to a unit cost of approximately $15,400 per mile of levee. In the final array of alternatives, only Alternatives SB-3 “Yuba Ring Levee” and SB-4 “Little J Levee” have new levees and therefore would incur additional O&M cost. Alternative SB-3 and SB-4 have 13.5 miles and 10.3 miles of new levee respectively. Multiplying by the unit cost, the additional annual maintenance cost for Alternatives SB-3 and SB-4 is approximately $210,000 and $160,000 respectively. The additional OMRR&R cost can have an influence in the screening of the Alternatives.

d. Total Project Schedule (including Construction)

No formal construction schedule has been developed, but the assumption has been made that the PED portion of the project will occur in FY 13 thru FY 15 with the construction portion commencing FY 16. Construction is assumed to take 3 to 7 years, depending on the alternative.

e. Cost and Schedule Risk Analysis

An initial Cost & Schedule Risk Analysis (CSRA) was performed for the project. The risk analysis process used is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve any desired level of cost confidence. A parallel process was also used to determined the probability of various project schedule duration outcomes and quantify the required schedule contingency (float) needed in the schedule to achieve any desired level of schedule confidence. Risk analysis results are intended to provide project leadership with contingency information in order to support decision making and risk management as the project progresses from planning through implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, budgeting and scheduling.

A meeting was held 25-26 April 2012 with the project manager, most PDT members, and representatives of the local sponsor. The meeting focused primarily on risk factor identification using brainstorming techniques, but also included some discussions based on risk factors common to many civil works projects. The meeting included risk factor assessment and quantification and did result in some revisions to the estimate. Project risks were identified and a risk register developed as a spreadsheet (using Microsoft Excel). After the meeting, the draft risk register was forwarded to the PDT for review.

Risk models were developed for each alternative based on the items with moderate or high risk. Low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as to support follow-on risk studies as the project and its accompanying risks evolve. Some of the moderate/high risk items were mitigated somewhat by further design and additions to the cost estimate. The remaining risks were used to calculate and present the cost and schedule contingencies.

The quantitative impacts of each risk element on costs and schedule were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risks were quantified using probability distributions because risk factors are entered into Crystal Ball software (an add-on to Microsoft Excel) in the form of probability density functions. Quantification involved multiple project team disciplines and functions. This process used an iterative approach to estimate the following parameters for each risk element:

- Maximum possible value for the risk element
- Minimum possible value for the risk element
- Most likely value (the statistical mean), if applicable
- Nature of the probability density function used to approximate risk element uncertainty
- Mathematical correlations between risk elements
- Affected cost estimate and schedule elements

The resulting product risk model therefore reflects the risk register parameters as developed by the PDT.

In simple terms, contingency is an amount added to an estimate and/or schedule that allows for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. Contingency was analyzed using the Crystal Ball software. *Monte Carlo* simulations were performed by applying risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. A simulation calculates multiple trials for the model by repeatedly sampling values from the probability distributions. During each trial, Crystal Ball randomly selects a value from the defined possibilities (based on the range and shape of the probability distribution) for each variable and then recalculates the cost and schedule risk analysis spreadsheet.

Cost variances are calculated by simulating the probable effects of the risk elements to the construction cost estimate. Contingencies are then calculated by applying probability of cost variance occurrence. The sum of the model cost variances is the resultant cost risk for the project. The contingency is calculated based on the difference between the sum of the cost risks and the base cost estimate. Note that cost risks are not always the same as schedule risks.

The Sacramento District has also found that historically, there is a comparative difference between the inflation rates from the Civil Works Construction Cost Index System (CWCCIS) rates and the local Sacramento area historical inflation rate. This has been modeled as an additional risk with added cost contingency based on 1) inflation rates higher than CWCCIS rates and 2) the affect of project delays from the schedule analysis.

For schedule contingency analysis, the potential delays to start of construction or delays during construction are also modeled based on the likelihood of these delays and the possible duration (as determined by the PDT). The effect on schedule is entered into the Crystal Ball model as the potential schedule variance. The sum of the model schedule variances is the resultant schedule risk. The contingency for the schedule is calculated as the difference between the sum of the schedule risks and the base construction schedule.

The amount of contingency used for a project depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that is acceptable, the more contingency that must be applied. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost Engineering MCX guidance for cost and schedule risk analysis generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. The P80 confidence level is the standard normally provided to Congress by USACE and other agencies. Total Project Cost (TPC) being the base costs times the contingency percentage (80% confidence level), there would be an 80% chance of final costs falling at or below the Total Project Cost value. Conversely, there is a 20% chance that the TPC would be above this value.

f. Review

The screening level cost engineering data has been reviewed by senior estimators at the Sacramento District.

g. Screening Level Results

The tables at the conclusion of this section show a brief summary of the screening level results.

5. KEY ASSUMPTIONS:

a. Parametric Estimates

- Cross Sections for the various levee improvements or new levees are representative of the levee reach.
- Unit Costs utilized are fair and reasonable.

b. Haul Distances – Levee Fill Borrow will come from within 10 miles (one-way haul).

c. Real Estate - Real Estate Costs are reasonable.

d. PACES estimates developed for some special items are sufficient for this level of design (screening alternatives).

e. Quantity Uncertainty - Where design is insufficient to produce quantities, the percentage of construction costs assumed and used for unknown utilities, SWPP, mitigation, etc. represent costs adequate to screen alternatives to the point of determining a tentatively selected plan.

f. Project Schedule - PED portion of the project will occur from FY 13 thru FY 15 with the construction portion commencing FY 16. Construction is assumed to take 3 to 7 years

g. Cultural Resources – Costs will be approximately 1% of the Federal Construction Costs

h. PED Costs – the assumed 18% of Construction Costs used in recent years by the Sacramento District is fair and reasonable

i. Construction Management Costs – the assumed 8.5% of Construction Costs used in recent years by the Sacramento District is fair and reasonable

6. RESULTS

Table 1
Estimated Cost Without Contingincy for Draft Array of Alternatives

Item	COST ($1000)							
	SB-1	SB-2	SB-3	SB-4	SB-5	SB-6	SB-7	SB-8
	No Action	Minimal Fix In Place with Non Structural	Yuba City Ring Levee	Little J-Levee	Fix-In-Place Feather River, Thermalito to Star Bend	Fix-In-Place Feather River, Sutter Bypass, Wadsworth Canal	Fix-In-Place Feather River, Sunset Weir to Laurel Ave	Fix-In-Place Feather River, Thermalito to Laurel Ave
6 Fish & Wildlife Fac		16,590	22,804	40,014	31,225	57,310	21,966	36,601
11 Levees & Floodwalls		149,604	190,469	353,095	284,203	502,953	200,207	334,806
18 Cult. Resrc. Preserv.		1,627	2,252	3,978	3,004	5,512	2,160	3,537
1 Lands & Damages (FED)		3,865	3,850	9,775	5,500	9,175	4,895	6,500
30 PED (FED)		29,915	38,389	70,760	56,777	100,847	39,991	66,853
31 Construction Mngt (FED)		14,126	18,128	33,414	26,811	47,622	19.994	31,569
1 Lands & Damages (NF)		13,076	21,746	39,261	17,536	32.886	18,381	22,841
2 Relocations (NF)		16,297	37,580	47,045	28,051	70,150	19,450	31,204
30 PED (NF)		2,933	6,764	8,468	5,049	12,627	3,501	5,617
31 Construction Mngt (NF)		1,385	3,194	3,999	2,384	5,963	1,653	2,652
TOTAL (FED & NF)		249,448	345,176	609,809	460,540	845,045	331,088	542,180
	COST ($1000/YR)							
Δ OMRR&R		0	210	160	0	0	0	0

* OMRR&R cost is based on 2010-2011 actual expenditures provided by local Levee Districts and the State Maintenance Areas.

Table 2
Estimated Contingency for Draft Array of Alternatives

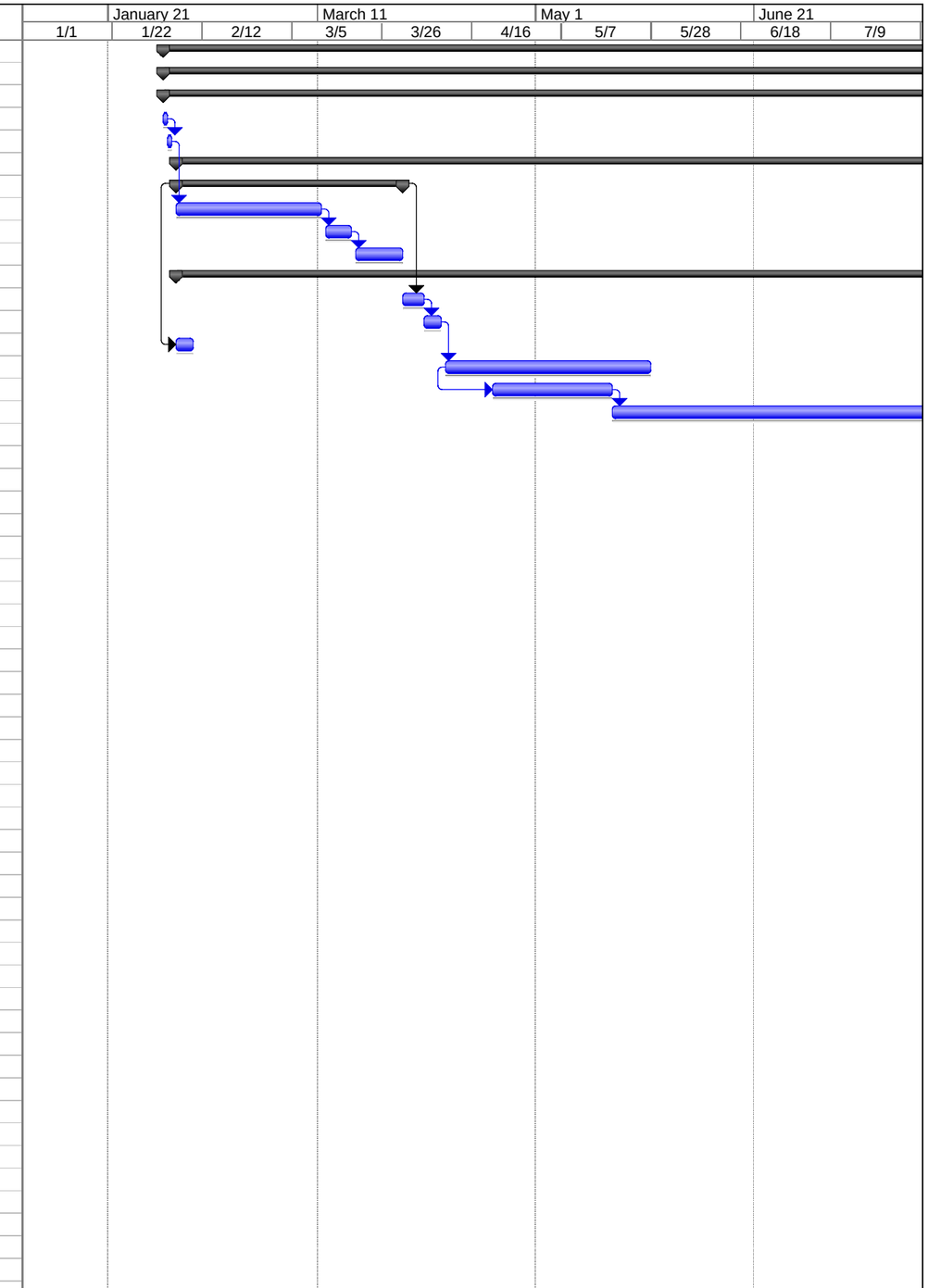
Percent Chance Cost will be lower than stated amount	Contingency (%)							
	SB-1	SB-2	SB-3	SB-4	SB-5	SB-6	SB-7	SB-8
	No Action	Minimal Fix In Place with Non Structural	Yuba City Ring Levee	Little J-Levee	Fix-In-Place Feather River, Thermalito to Star Bend	Fix-In-Place Feather River, Sutter Bypass, Wadsworth Canal	Fix-In-Place Feather River, Sunset Weir to Laurel Ave	Fix-In-Place Feather River, Thermalito to Laurel Ave
0.01		-1.22	-3.02	1.05	-1.15	-1.95	-1.32	-1.24
10%		11.76	14.31	14.86	13.96	14.88	12.18	14.27
20%		16.45	19.08	19.49	19.30	20.48	17.09	19.79
25%		18.34	21.02	21.49	21.43	22.72	19.05	21.99
30%		20.22	22.97	23.49	23.56	24.95	21.02	24.19
40%		23.80	26.62	26.98	27.56	29.17	24.76	28.32
50%		27.71	30.52	30.83	31.99	33.80	28.87	32.90
60%		32.28	34.96	35.31	37.03	39.11	33.67	38.13
70%		37.58	40.12	40.53	42.88	45.38	39.19	44.21
75%		41.07	43.52	43.96	46.74	49.44	42.85	48.20
80%		44.55	46.92	47.38	50.59	53.50	46.51	52.20
90%		54.09	56.79	57.20	61.41	64.90	56.49	63.40
99%		89.28	94.58	95.61	101.55	106.62	93.44	104.87

Table 3
Estimated Total Project Cost for Draft Array of Alternatives

Percent Chance Cost will be lower than stated amount	Project Cost ($1000)							
	SB-1	SB-2	SB-3	SB-4	SB-5	SB-6	SB-7	SB-8
	No Action	Minimal Fix In Place with Non Structural	Yuba City Ring Levee	Little J-Levee	Fix-In-Place Feather River, Thermalito to Star Bend	Fix-In-Place Feather River, Sutter Bypass, Wadsworth Canal	Fix-In-Place Feather River, Sunset Weir to Laurel Ave	Fix-In-Place Feather River, Thermalito to Laurel Ave
0.01		246,405	334,752	616,212	455,244	828,567	326,718	535,457
10%		278,784	394,571	700,427	524,832	970,788	371,415	619,549
20%		290,483	411,036	728,661	549,425	1,018,111	387,671	649,477
25%		295,197	417,732	740,857	559,234	1,037,040	394,160	661,405
30%		299,887	424,463	753,054	569,044	1,055,884	400,683	673,333
40%		308,817	437,062	774,336	587,465	1,091,545	413,065	695,725
50%		318,571	450,524	797,814	607,867	1,130,671	426,673	720,557
60%		329,970	465,850	825,133	631,078	1,175,543	442,565	748,913
70%		343,191	483,661	856,965	658,020	1,228,527	460,841	781,878
75%		351,897	495,397	877,882	675,797	1,262,836	472,959	803,511
80%		360,578	507,133	898,737	693,528	1,297,145	485,077	825,198
90%		384,375	541,202	958,620	743,358	1,393,480	518,120	885,922
99%		472,156	671,664	1,192,848	928,219	1,746,032	640,457	1,110,764

NOTE: All costs are considered preliminary and are only to be used to compare the relative cost between the draft array of alternatives. Focus on the Cost Engineering data has been on the alternatives. The costs for the possible options will be updated following determination of the tentatively selected plan (TSP). Once the PDT has selected the TSP and any locally preferred plan (if different from the TSP), Feasibility Level Details and Cost Engineering data must be developed. This includes creation of the initial designs, civil design plans, a materials balance, development of an MII estimate, Project and Construction Schedules, PDT estimates for Planning, Engineering and Design and Construction Management, an updated Cost and Schedule Risk Analysis and a Total Project Cost Estimate extending costs out through the life of the Project. The MII estimate must be detailed indicating labor, equipment and materials with accompanying production rates.

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1	**Sutter Basin SB-7**	**1445 days?**	**Fri 2/3/17**	**Wed 9/15/21**		
2	**Contract C (13-21)**	**802 days?**	**Fri 2/3/17**	**Tue 8/27/19**		
3	**Contract C1 (13-18)**	**539 days?**	**Fri 2/3/17**	**Wed 10/24/18**		
4	Contract Award	1 day	Fri 2/3/17	Fri 2/3/17		
5	NTP	1 day	Sat 2/4/17	Sat 2/4/17	4	
6	**Construction Year 1**	**279 days?**	**Mon 2/6/17**	**Wed 12/27/17**		
7	**Mob, Demob & Preparatory Work**	**46 days**	**Mon 2/6/17**	**Thu 3/30/17**		
8	Submittals	30 days	Mon 2/6/17	Sat 3/11/17	5	
9	Mobilization	6 days	Mon 3/13/17	Sat 3/18/17	8	
10	Staging Areas Setup	10 days	Mon 3/20/17	Thu 3/30/17	9	
11	**Levees & Floodwalls Reach 13 - 18:**	**279 days?**	**Mon 2/6/17**	**Wed 12/27/17**		
12	Top Soil Stripping	4 days	Fri 3/31/17	Tue 4/4/17	7	
13	Clearing & Grubbing	4 days	Wed 4/5/17	Sat 4/8/17	12	
14	Remove AB Surfacing	4 days	Mon 2/6/17	Thu 2/9/17	7SS	
15	Degrade Exisiting Levees	42 days	Mon 4/10/17	Sat 5/27/17	13	
16	SB Cutoff Wall Conventional	24 days	Fri 4/21/17	Thu 5/18/17	15SS+10 days	
17	SB Cutoff Wall DSM	87 days	Fri 5/19/17	Mon 8/28/17	16	
18	Jet Grouting	18 days	Tue 8/29/17	Mon 9/18/17	17	
19	Levee Embankment Fill	76 days	Sat 9/30/17	Wed 12/27/17	18SS+28 days	
20	Top Soil Replacment	4 days	Sat 12/23/17	Wed 12/27/17	19FF	
21	AB Surfacing Levee Crown	1 day	Wed 12/27/17	Wed 12/27/17	19FF	
22	Relief Well Conveyance Ditch	1 day?	Wed 12/27/17	Wed 12/27/17	19FF	
23	**Construction Year 2**	**191 days**	**Fri 3/16/18**	**Wed 10/24/18**		
24	**Mob, Demob & Preparatory Work**	**16 days**	**Fri 3/16/18**	**Tue 4/3/18**		
25	Mobilization	6 days	Fri 3/16/18	Thu 3/22/18		
26	Staging Areas Setup	10 days	Fri 3/23/18	Tue 4/3/18	25	
27	**Levees & Floodwalls Reach 13 - 18:**	**191 days**	**Fri 3/16/18**	**Wed 10/24/18**		
28	Top Soil Stripping	4 days	Wed 4/4/18	Sat 4/7/18	24	
29	Clearing & Grubbing	4 days	Mon 4/9/18	Thu 4/12/18	28	
30	Remove AB Surfacing	4 days	Fri 3/16/18	Tue 3/20/18	24SS	
31	Degrade Exisiting Levees	42 days	Fri 4/13/18	Thu 5/31/18	29	
32	SB Cutoff Wall Conventional	24 days	Wed 4/25/18	Tue 5/22/18	31SS+10 days	
33	SB Cutoff Wall DSM	87 days	Wed 5/23/18	Fri 8/31/18	32	
34	Jet Grouting	18 days	Sat 9/1/18	Fri 9/21/18	33	
35	Levee Embankment Fill	76 days	Sat 7/28/18	Wed 10/24/18	34FF+28 days	
36	Top Soil Replacment	4 days	Sat 10/20/18	Wed 10/24/18	35FF	
37	AB Surfacing Levee Crown	1 day	Wed 10/24/18	Wed 10/24/18	36FF	
38	**Contract C2 (19-21)**	**490 days**	**Fri 2/2/18**	**Tue 8/27/19**		
39	Contract Award	1 day	Fri 2/2/18	Fri 2/2/18		
40	NTP	1 day	Sat 2/3/18	Sat 2/3/18	39	
41	**Construction Year 1**	**155 days**	**Mon 2/5/18**	**Fri 8/3/18**		
42	**Mob, Demob & Preparatory Work**	**46 days**	**Mon 2/5/18**	**Thu 3/29/18**		
43	Submittals	30 days	Mon 2/5/18	Sat 3/10/18	40	
44	Mobilization	6 days	Mon 3/12/18	Sat 3/17/18	43	
45	Staging Areas Setup	10 days	Mon 3/19/18	Thu 3/29/18	44	
46	**Levees & Floodwalls Reach 19-21:**	**155 days**	**Mon 2/5/18**	**Fri 8/3/18**		
47	Top Soil Stripping	3 days	Fri 3/30/18	Mon 4/2/18	42	
48	Clearing & Grubbing	2 days	Tue 4/3/18	Wed 4/4/18	47	
49	Remove AB Surfacing	2 days	Mon 2/5/18	Tue 2/6/18	42SS	
50	Degrade Exisiting Levees	16 days	Thu 4/5/18	Mon 4/23/18	48	
51	Excavate Cutoff Trench	2 days	Tue 4/17/18	Wed 4/18/18	50SS+10 days	
52	SB Cutoff Wall Conventional	37 days	Tue 4/17/18	Tue 5/29/18	50SS+10 days	
53	SB Cutoff Wall DSM	34 days	Wed 5/30/18	Sat 7/7/18	52	
54	Levee Embankment Fill	27 days	Mon 7/2/18	Wed 8/1/18	53SS+28 days	
55	AB Surfacing Levee Crown	2 days	Thu 8/2/18	Fri 8/3/18	54	
56	Top Soil Replacment	6 days	Sat 7/28/18	Fri 8/3/18	55FF	



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Task | Progress | Summary | External Tasks | Deadline
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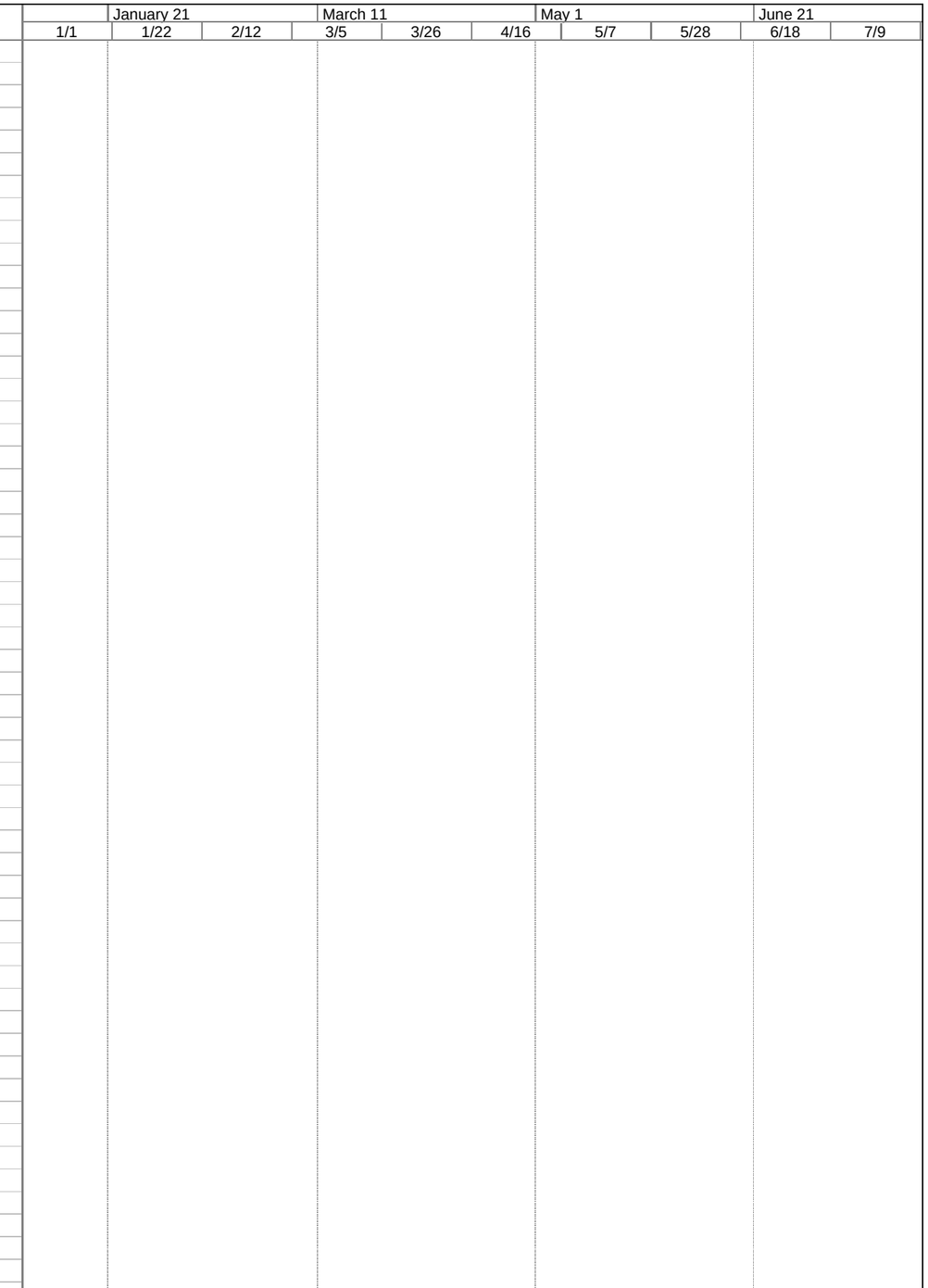
ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
57	**Construction Year 2**	**155 days**	**Thu 2/28/19**	**Tue 8/27/19**		
58	**Mob, Demob & Preparatory Work**	**46 days**	**Thu 2/28/19**	**Mon 4/22/19**		
59	Submittals	30 days	Thu 2/28/19	Wed 4/3/19		
60	Mobilization	6 days	Thu 4/4/19	Wed 4/10/19	59	
61	Staging Areas Setup	10 days	Thu 4/11/19	Mon 4/22/19	60	
62	**Levees & Floodwalls Reach 19-21:**	**109 days**	**Tue 4/23/19**	**Tue 8/27/19**		
63	Top Soil Stripping	3 days	Tue 4/23/19	Thu 4/25/19	58	
64	Clearing & Grubbing	2 days	Fri 4/26/19	Sat 4/27/19	63	
65	Remove AB Surfacing	2 days	Tue 4/23/19	Wed 4/24/19	58	
66	Degrade Exisiting Levees	16 days	Mon 4/29/19	Thu 5/16/19	64	
67	Excavate Cutoff Trench	2 days	Fri 5/10/19	Sat 5/11/19	66SS+10 days	
68	SB Cutoff Wall Conventional	37 days	Fri 5/10/19	Fri 6/21/19	66SS+10 days	
69	SB Cutoff Wall DSM	34 days	Sat 6/22/19	Wed 7/31/19	68	
70	Levee Embankment Fill	27 days	Thu 7/25/19	Sat 8/24/19	69SS+28 days	
71	AB Surfacing Levee Crown	2 days	Mon 8/26/19	Tue 8/27/19	70	
72	Top Soil Replacment	6 days	Wed 8/21/19	Tue 8/27/19	71FF	
73	**Contract B (7-12)**	**504 days?**	**Tue 2/5/19**	**Mon 9/14/20**		
74	**Contract B (7-12)**	**504 days?**	**Tue 2/5/19**	**Mon 9/14/20**		
75	Contract Award	1 day	Tue 2/5/19	Tue 2/5/19		
76	NTP	1 day	Wed 2/6/19	Wed 2/6/19	75	
77	**Construction Year 1**	**187 days?**	**Thu 2/7/19**	**Thu 9/12/19**		
78	**Mob, Demob & Preparatory Work**	**46 days**	**Thu 2/7/19**	**Mon 4/1/19**		
79	Submittals	30 days	Thu 2/7/19	Wed 3/13/19	76	
80	Mobilization	6 days	Thu 3/14/19	Wed 3/20/19	79	
81	Staging Areas Setup	10 days	Thu 3/21/19	Mon 4/1/19	80	
82	**Levees & Floodwalls Reach 7-12**	**141 days?**	**Tue 4/2/19**	**Thu 9/12/19**		
83	Top Soil Stripping	6 days	Tue 4/2/19	Mon 4/8/19	78	
84	Clearing & Grubbing	5 days	Tue 4/9/19	Sat 4/13/19	83	
85	Remove AB Surfacing	3 days	Fri 6/7/19	Mon 6/10/19	78,86FF	
86	Degrade Exisiting Levees	49 days	Mon 4/15/19	Mon 6/10/19	84	
87	Excavate Cutoff Trench	4 days	Fri 4/26/19	Tue 4/30/19	86SS+10 days	
88	Excavate Inspection/Key Trench	1 day?	Wed 5/8/19	Wed 5/8/19	87SS+10 days	
89	SB Cutoff Wall Conventional	83 days	Fri 4/26/19	Wed 7/31/19	86SS+10 days	
90	Levee Embankment Fill	83 days	Wed 5/29/19	Mon 9/2/19	89SS+28 days	
91	AB Surfacing Levee Crown	9 days	Tue 9/3/19	Thu 9/12/19	90	
92	Top Soil Replacment	12 days	Fri 8/30/19	Thu 9/12/19	91FF	
93	**Construction Year 2**	**157 days?**	**Mon 3/16/20**	**Mon 9/14/20**		
94	**Mob, Demob & Preparatory Work**	**16 days**	**Mon 3/16/20**	**Thu 4/2/20**		
95	Mobilization	6 days	Mon 3/16/20	Sat 3/21/20		
96	Staging Areas Setup	10 days	Mon 3/23/20	Thu 4/2/20	95	
97	**Levees & Floodwalls Reach 7-12**	**141 days?**	**Fri 4/3/20**	**Mon 9/14/20**		
98	Top Soil Stripping	6 days	Fri 4/3/20	Thu 4/9/20	94	
99	Clearing & Grubbing	5 days	Fri 4/10/20	Wed 4/15/20	98	
100	Remove AB Surfacing	3 days	Tue 6/9/20	Thu 6/11/20	94,101FF	
101	Degrade Exisiting Levees	49 days	Thu 4/16/20	Thu 6/11/20	99	
102	Excavate Cutoff Trench	4 days	Tue 4/28/20	Fri 5/1/20	101SS+10 days	
103	Excavate Inspection/Key Trench	1 day?	Sat 5/9/20	Sat 5/9/20	102SS+10 days	
104	SB Cutoff Wall Conventional	83 days	Tue 4/28/20	Sat 8/1/20	101SS+10 days	
105	Levee Embankment Fill	83 days	Sat 5/30/20	Thu 9/3/20	104SS+28 days	
106	AB Surfacing Levee Crown	9 days	Fri 9/4/20	Mon 9/14/20	105	
107	Top Soil Replacment	12 days	Tue 9/1/20	Mon 9/14/20	106FF	
108	**Star Bend FIP (6)**	**425 days?**	**Tue 2/5/19**	**Sat 6/13/20**		
109	**Star Bend FIP (6)**	**425 days?**	**Tue 2/5/19**	**Sat 6/13/20**		
110	Contract Award	1 day	Tue 2/5/19	Tue 2/5/19		
111	NTP	1 day	Wed 2/6/19	Wed 2/6/19	110	
112	**Construction Year 1**	**108 days**	**Thu 2/7/19**	**Wed 6/12/19**		



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Task | Progress | Summary | External Tasks | Deadline
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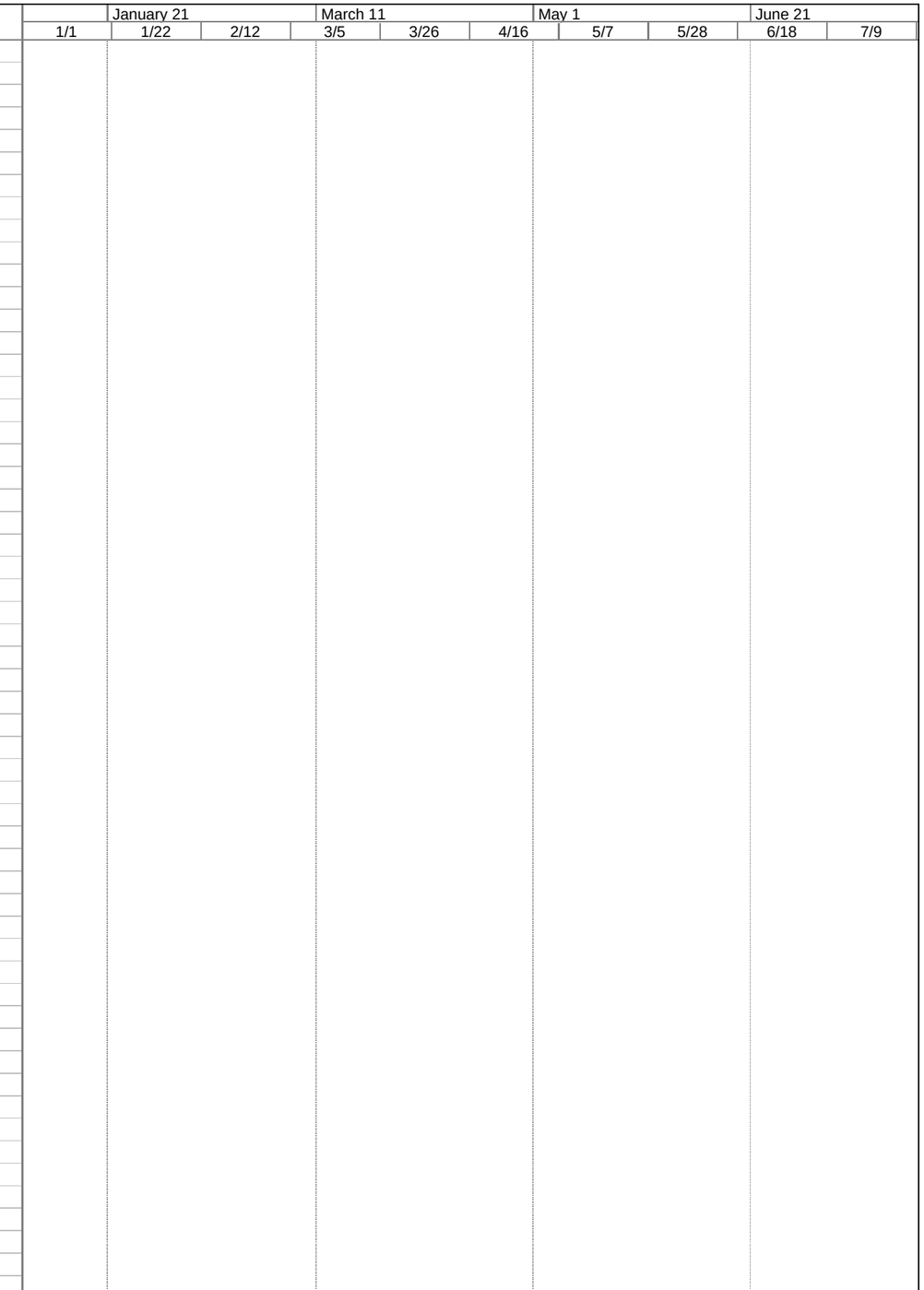
ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
113	**Mob, Demob & Preparatory Work**	**46 days**	**Thu 2/7/19**	**Mon 4/1/19**		
114	Submittals	30 days	Thu 2/7/19	Wed 3/13/19	111	
115	Mobilization	6 days	Thu 3/14/19	Wed 3/20/19	114	
116	Staging Areas Setup	10 days	Thu 3/21/19	Mon 4/1/19	115	
117	**Levees & Floodwalls Reach 6**	**62 days**	**Tue 4/2/19**	**Wed 6/12/19**		
118	Top Soil Stripping	2 days	Tue 4/2/19	Wed 4/3/19	113	
119	Clearing & Grubbing	2 days	Thu 4/4/19	Fri 4/5/19	118	
120	Degrade Exisiting Levees	10 days	Sat 4/6/19	Wed 4/17/19	119	
121	Excavate Cutoff Trench	1 day	Thu 4/18/19	Thu 4/18/19	120SS+10 days	
122	SB Cutoff Wall Conventional	29 days	Thu 4/18/19	Tue 5/21/19	120SS+10 days	
123	Levee Embankment Fill	18 days	Tue 5/21/19	Mon 6/10/19	122SS+28 days	
124	AB Surfacing Levee Crown	2 days	Tue 6/11/19	Wed 6/12/19	123	
125	Top Soil Replacment	3 days	Mon 6/10/19	Wed 6/12/19	124FF	
126	**Construction Year 2**	**78 days?**	**Mon 3/16/20**	**Sat 6/13/20**		
127	**Mob, Demob & Preparatory Work**	**16 days**	**Mon 3/16/20**	**Thu 4/2/20**		
128	Mobilization	6 days	Mon 3/16/20	Sat 3/21/20		
129	Staging Areas Setup	10 days	Mon 3/23/20	Thu 4/2/20	128	
130	**Levees & Floodwalls Reach 6**	**62 days?**	**Fri 4/3/20**	**Sat 6/13/20**		
131	Top Soil Stripping	2 days	Fri 4/3/20	Sat 4/4/20	127	
132	Clearing & Grubbing	2 days	Mon 4/6/20	Tue 4/7/20	131	
133	Degrade Exisiting Levees	10 days	Wed 4/8/20	Sat 4/18/20	132	
134	Excavate Cutoff Trench	1 day	Mon 4/20/20	Mon 4/20/20	133SS+10 days	
135	Excavate Inspection/Key Trench	1 day?	Fri 5/1/20	Fri 5/1/20	134SS+10 days	
136	SB Cutoff Wall Conventional	29 days	Mon 4/20/20	Fri 5/22/20	133SS+10 days	
137	Levee Embankment Fill	18 days	Fri 5/22/20	Thu 6/11/20	136SS+28 days	
138	AB Surfacing Levee Crown	2 days	Fri 6/12/20	Sat 6/13/20	137	
139	Top Soil Replacment	3 days	Thu 6/11/20	Sat 6/13/20	138FF	
140	**Contract A (2-5)**	**506 days**	**Tue 2/4/20**	**Wed 9/15/21**		
141	**Contract A (2-5)**	**506 days**	**Tue 2/4/20**	**Wed 9/15/21**		
142	Contract Award	1 day	Tue 2/4/20	Tue 2/4/20		
143	NTP	1 day	Wed 2/5/20	Wed 2/5/20	142	
144	**Construction Year 1**	**188 days**	**Thu 2/6/20**	**Fri 9/11/20**		
145	**Mob, Demob & Preparatory Work**	**46 days**	**Thu 2/6/20**	**Mon 3/30/20**		
146	Submittals	30 days	Thu 2/6/20	Wed 3/11/20	143	
147	Mobilization	6 days	Thu 3/12/20	Wed 3/18/20	146	
148	Staging Areas Setup	10 days	Thu 3/19/20	Mon 3/30/20	147	
149	**Levees & Floodwalls Reach 2-5:**	**142 days**	**Tue 3/31/20**	**Fri 9/11/20**		
150	Top Soil Stripping	8 days	Tue 3/31/20	Wed 4/8/20	145	
151	Clearing & Grubbing	6 days	Thu 4/9/20	Wed 4/15/20	150	
152	Remove AB Surfacing	3 days	Tue 3/31/20	Thu 4/2/20	145	
153	Degrade Exisiting Levees	46 days	Thu 4/16/20	Mon 6/8/20	151	
154	Excavate Cutoff Trench	4 days	Tue 4/28/20	Fri 5/1/20	153SS+10 days	
155	Excavate Inspection/Key Trench	4 days	Sat 5/9/20	Wed 5/13/20	154SS+10 days	
156	SB Cutoff Wall Conventional	51 days	Tue 4/28/20	Thu 6/25/20	153SS+10 days	
157	SB Cutoff Wall DSM	67 days	Fri 6/26/20	Fri 9/11/20	156	
158	Levee Embankment Fill	82 days	Sat 5/30/20	Wed 9/2/20	156SS+28 days	
159	AB Surfacing Levee Crown	5 days	Thu 9/3/20	Tue 9/8/20	158	
160	Top Soil Replacment	8 days	Mon 8/31/20	Tue 9/8/20	159FF	
161	**Construction Year 2**	**158 days**	**Tue 3/16/21**	**Wed 9/15/21**		
162	**Mob, Demob & Preparatory Work**	**16 days**	**Tue 3/16/21**	**Fri 4/2/21**		
163	Mobilization	6 days	Tue 3/16/21	Mon 3/22/21		
164	Staging Areas Setup	10 days	Tue 3/23/21	Fri 4/2/21	163	
165	**Levees & Floodwalls Reach 2-5**	**142 days**	**Sat 4/3/21**	**Wed 9/15/21**		
166	Top Soil Stripping	8 days	Sat 4/3/21	Mon 4/12/21	162	
167	Clearing & Grubbing	6 days	Tue 4/13/21	Mon 4/19/21	166	
168	Remove AB Surfacing	3 days	Sat 4/3/21	Tue 4/6/21	162	



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Task | Progress | Summary | External Tasks | Deadline
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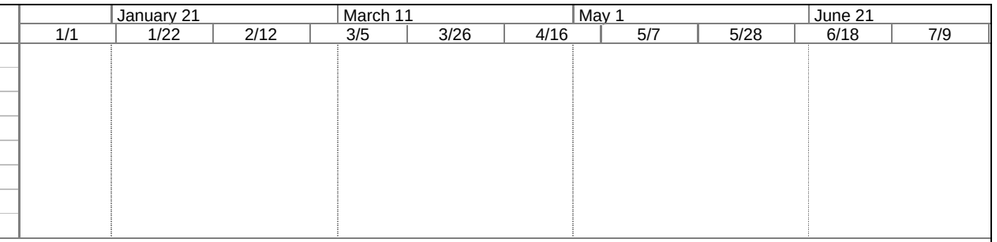
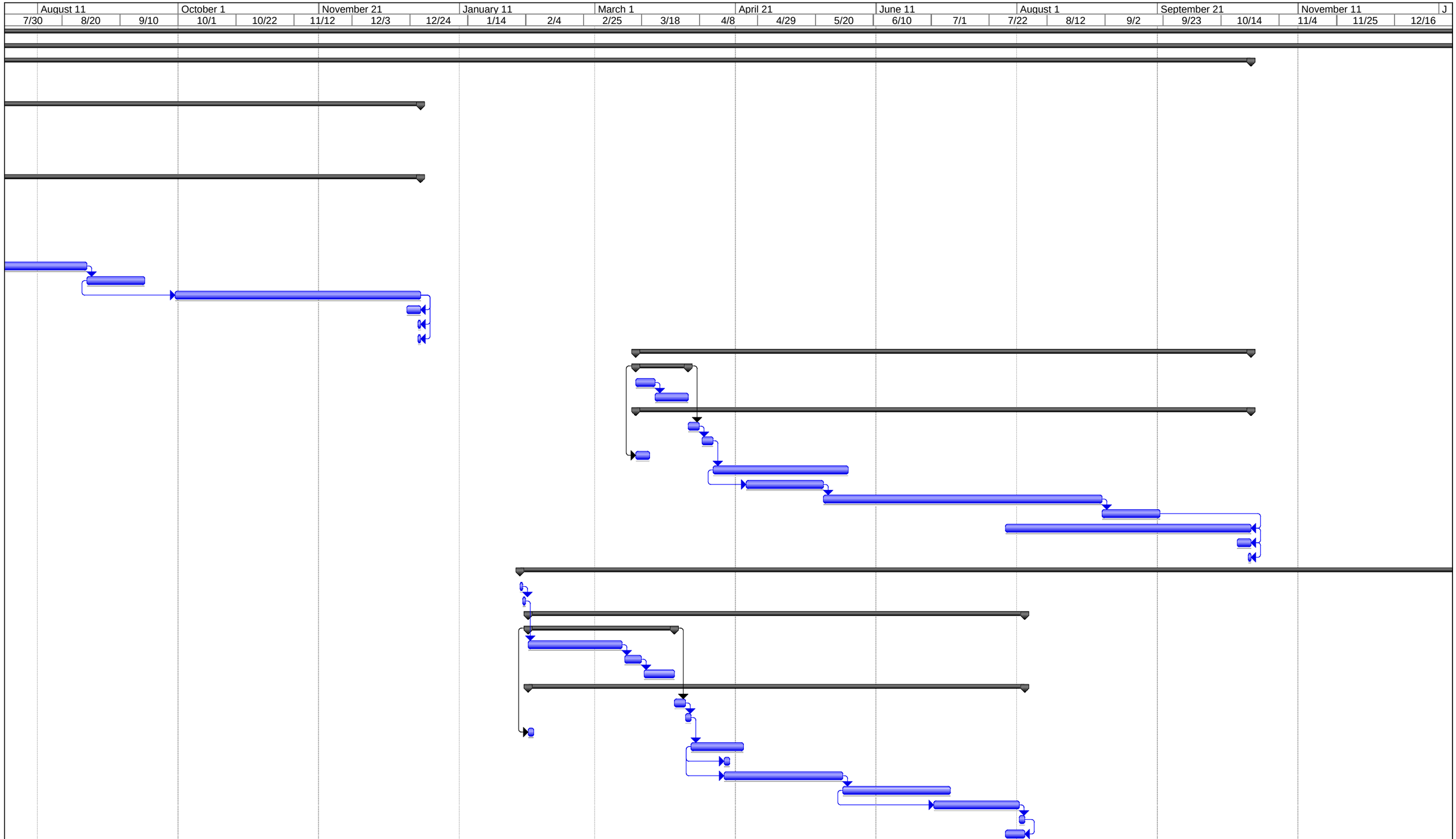
ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
169	Degrade Exisiting Levees	46 days	Tue 4/20/21	Fri 6/11/21	167	
170	Excavate Cutoff Trench	4 days	Sat 5/1/21	Wed 5/5/21	169SS+10 days	
171	Excavate Inspection/Key Trench	4 days	Thu 5/13/21	Mon 5/17/21	170SS+10 days	
172	SB Cutoff Wall Conventional	51 days	Sat 5/1/21	Tue 6/29/21	169SS+10 days	
173	SB Cutoff Wall DSM	67 days	Wed 6/30/21	Wed 9/15/21	172	
174	Levee Embankment Fill	82 days	Thu 6/3/21	Mon 9/6/21	172SS+28 days	
175	AB Surfacing Levee Crown	5 days	Tue 9/7/21	Sat 9/11/21	174	
176	Top Soil Replacment	8 days	Fri 9/3/21	Sat 9/11/21	175FF	



Project: Sutter Basin Rev 1
Date: Thu 3/14/13

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone



Project: Sutter Basin Rev 1
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Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

	August 11		October 1		November 21		January 11		March 1		April 21		June 11		August 1		September 21		November 11		J
7/30	8/20	9/10	10/1	10/22	11/12	12/3	12/24	1/14	2/4	2/25	3/18	4/8	4/29	5/20	6/10	7/1	7/22	8/12	9/2	9/23	10/14	11/4	11/25	12/16

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Date: Thu 3/14/13

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

	August 11		October 1		November 21		January 11		March 1		April 21		June 11		August 1		September 21		November 11		J
7/30	8/20	9/10	10/1	10/22	11/12	12/3	12/24	1/14	2/4	2/25	3/18	4/8	4/29	5/20	6/10	7/1	7/22	8/12	9/2	9/23	10/14	11/4	11/25	12/16

Project: Sutter Basin Rev 1
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Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

	August 11		October 1		November 21			January 11		March 1			April 21		June 11		August 1			September 21		November 11		J
7/30	8/20	9/10	10/1	10/22	11/12	12/3	12/24	1/14	2/4	2/25	3/18	4/8	4/29	5/20	6/10	7/1	7/22	8/12	9/2	9/23	10/14	11/4	11/25	12/16

Project: Sutter Basin Rev 1
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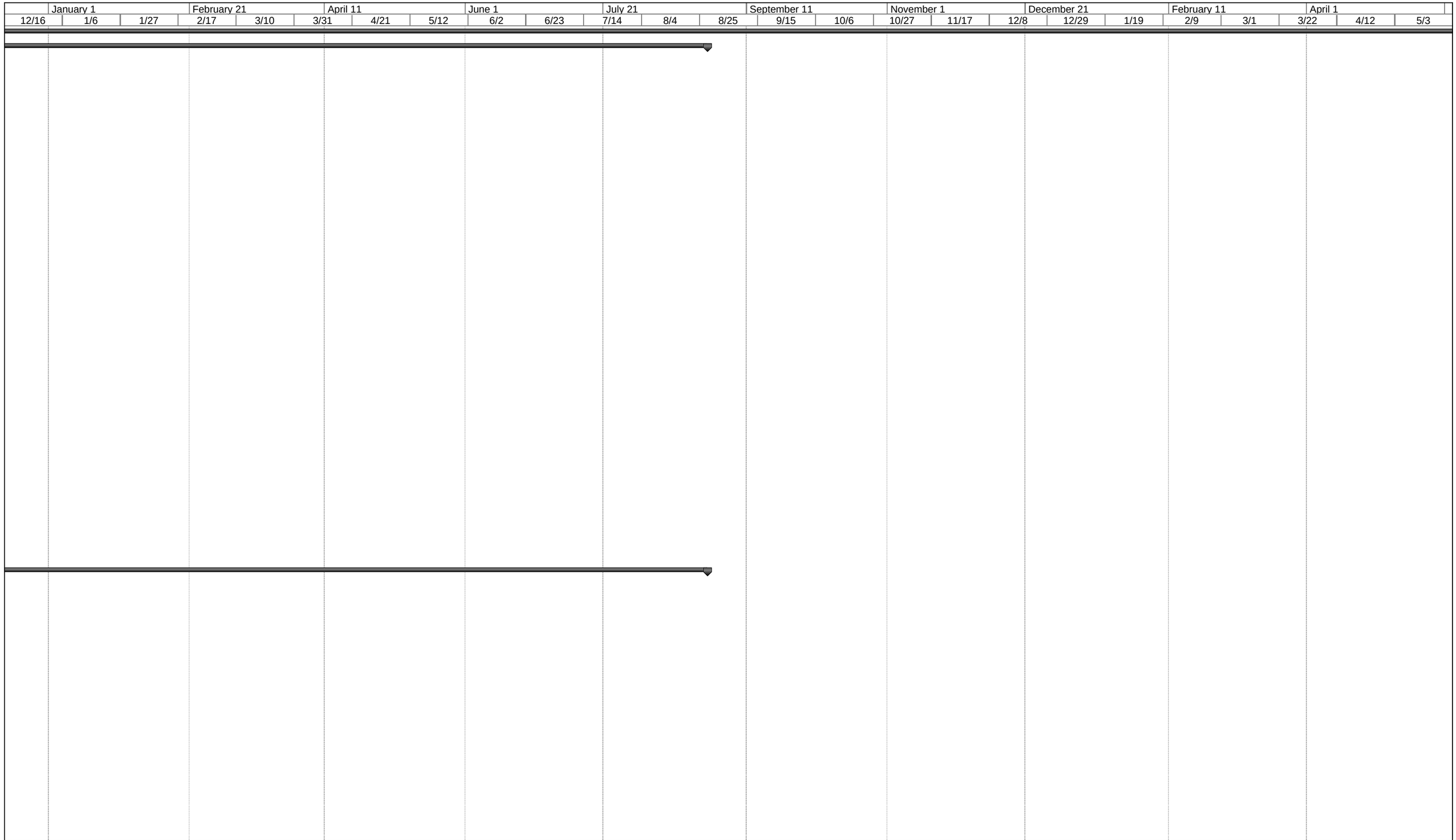
Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			



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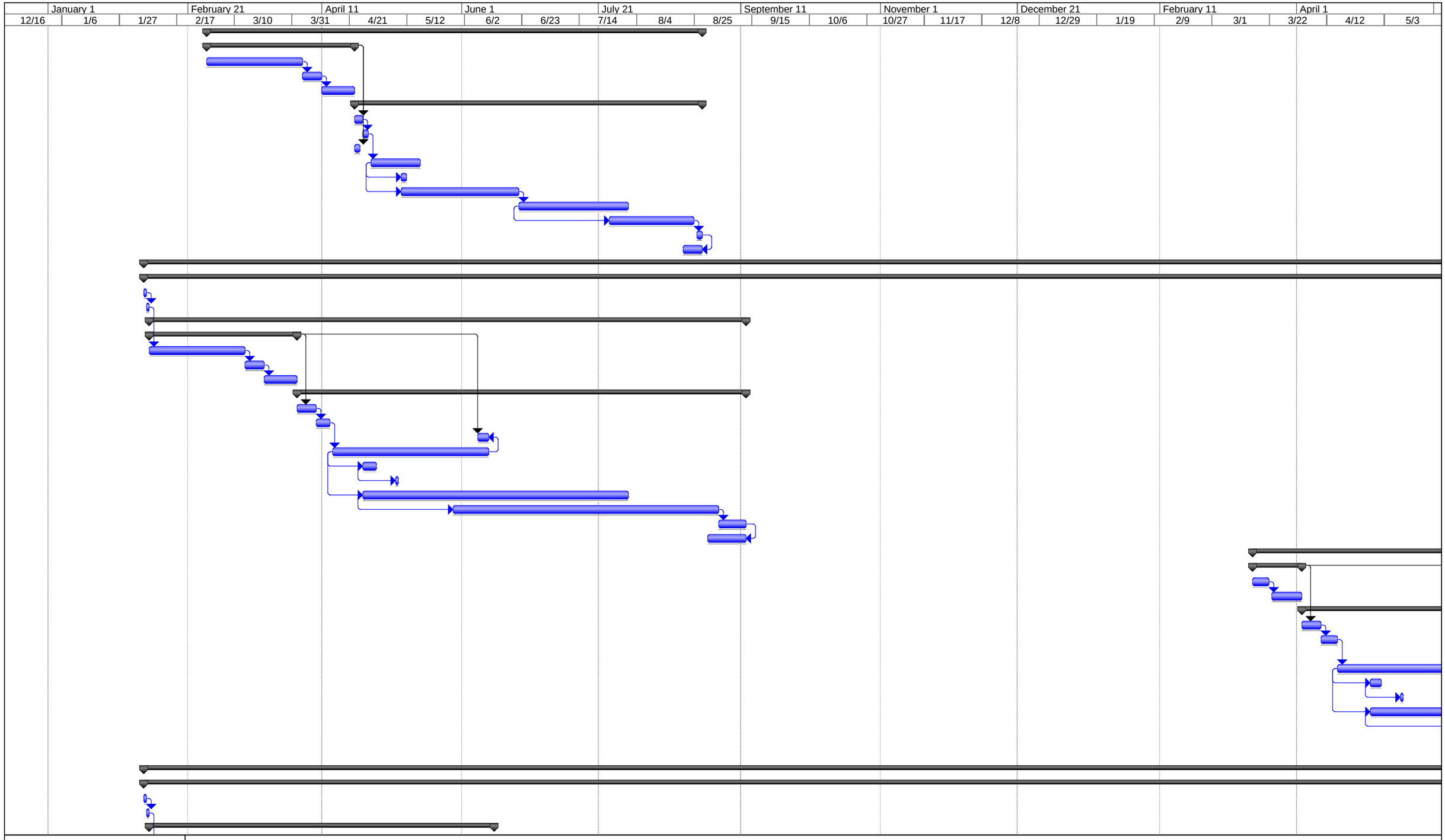
Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			



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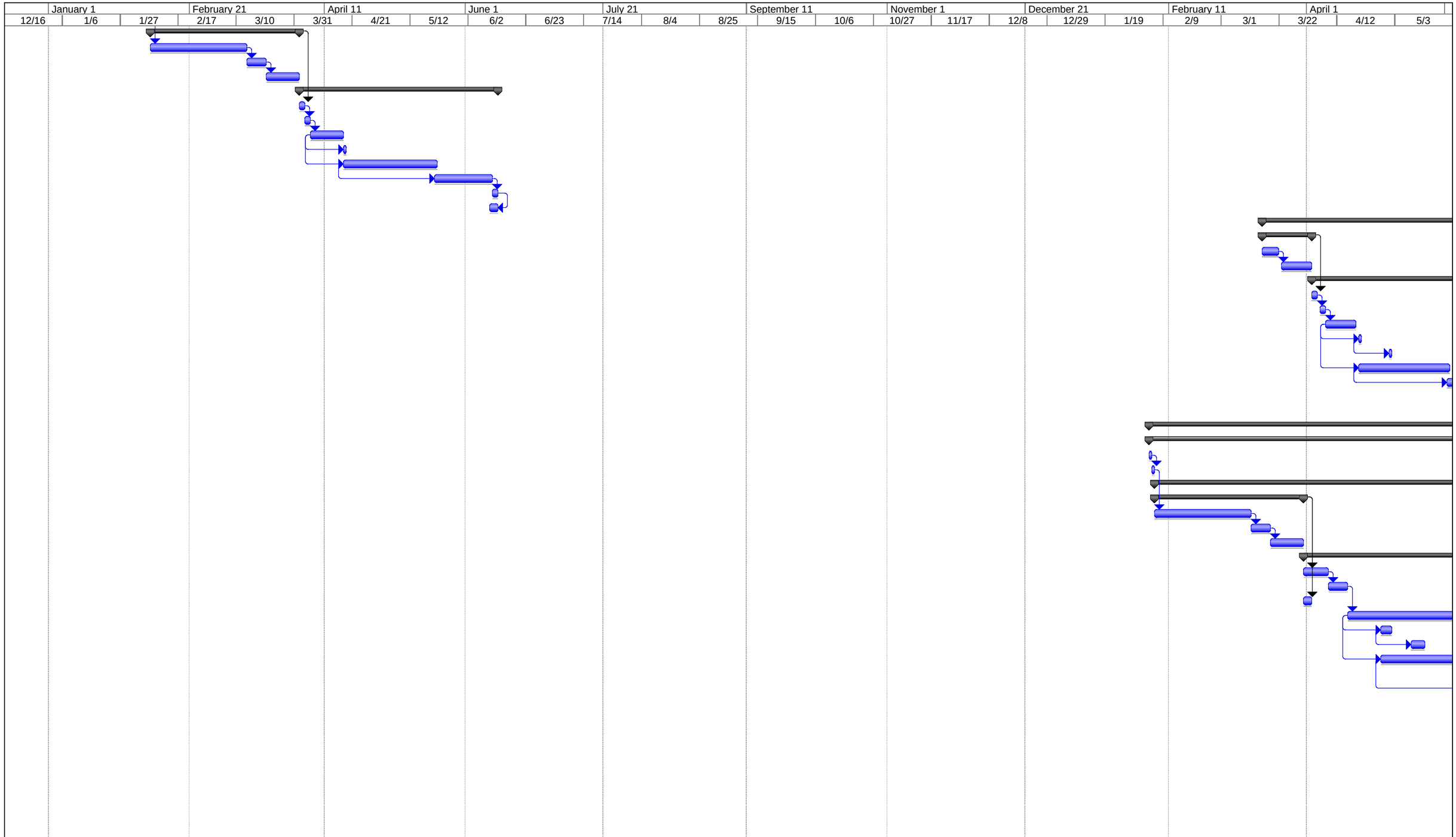
Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			



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Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

	January 1		February 21			April 11		June 1		July 21			September 11		November 1			December 21		February 11			April 1		
12/16	1/6	1/27	2/17	3/10	3/31	4/21	5/12	6/2	6/23	7/14	8/4	8/25	9/15	10/6	10/27	11/17	12/8	12/29	1/19	2/9	3/1	3/22	4/12	5/3

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Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

	May 21		July 11			September 1		October 21			December 11		February 1		March 21			May 11		July 1			August 21	
5/3	5/24	6/14	7/5	7/26	8/16	9/6	9/27	10/18	11/8	11/29	12/20	1/10	1/31	2/21	3/14	4/4	4/25	5/16	6/6	6/27	7/18	8/8	8/29	9/19

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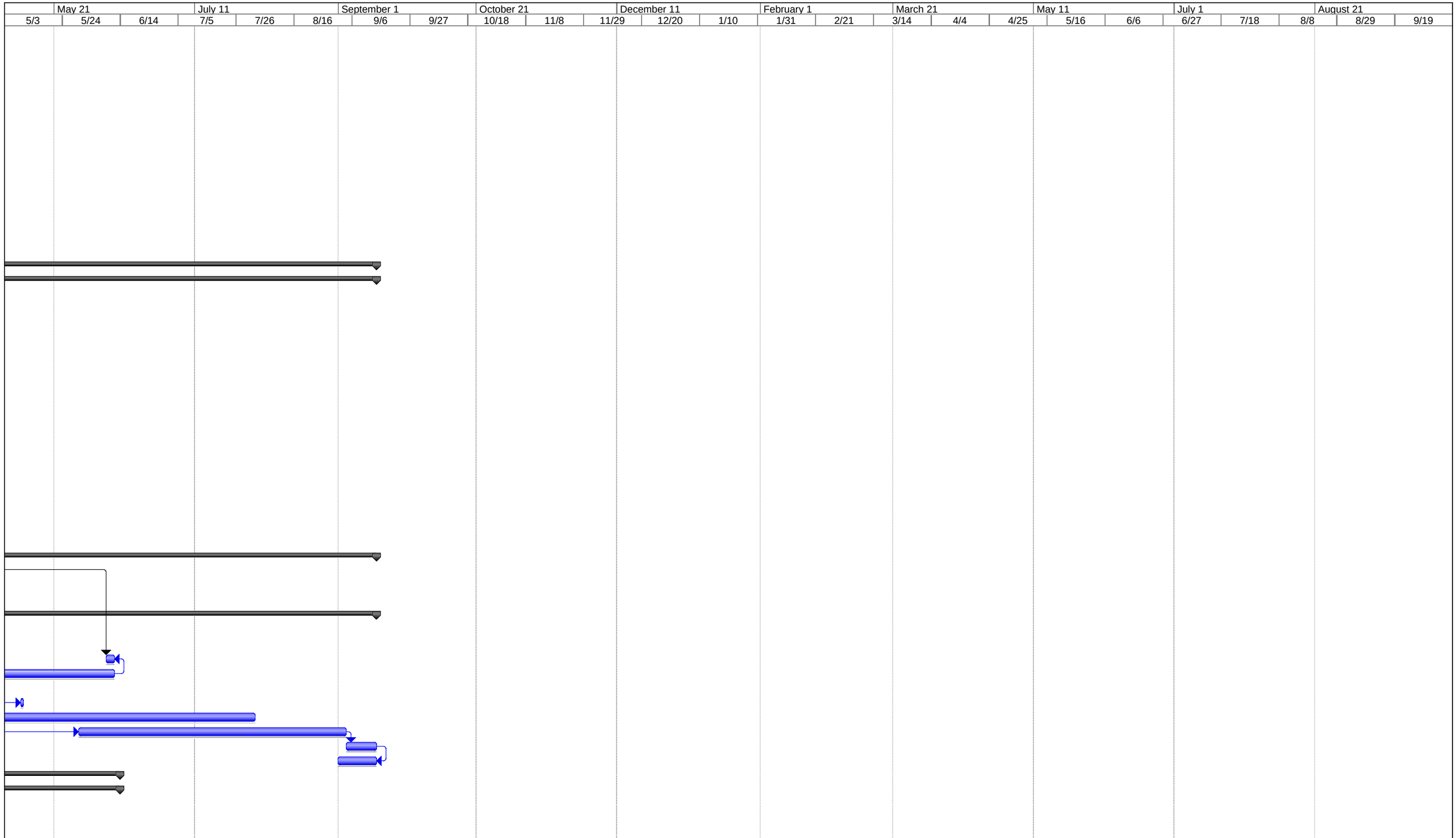
Task		Progress		Summary		External Tasks		Deadline
Split		Milestone		Project Summary		External Milestone	



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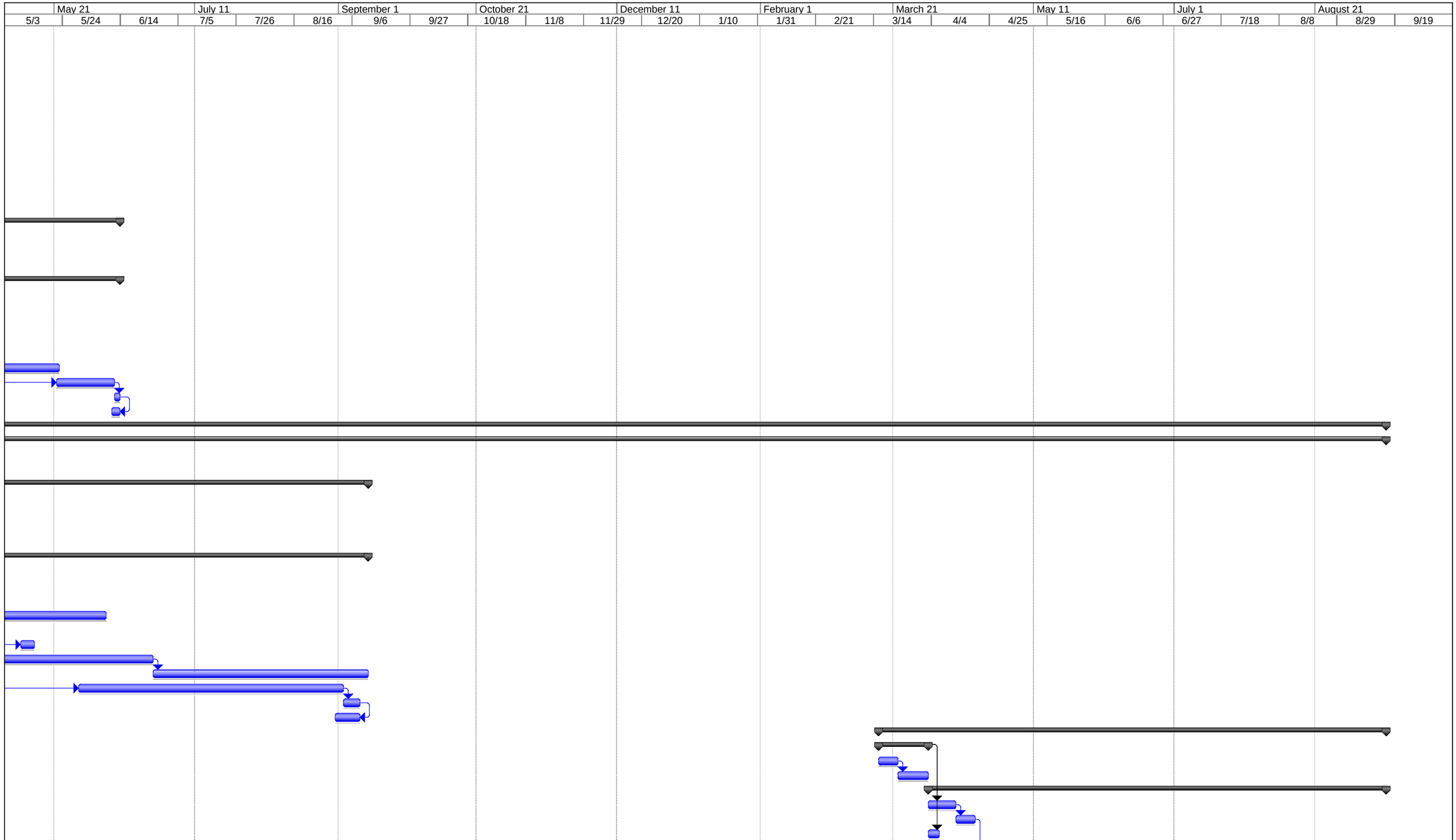
Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			



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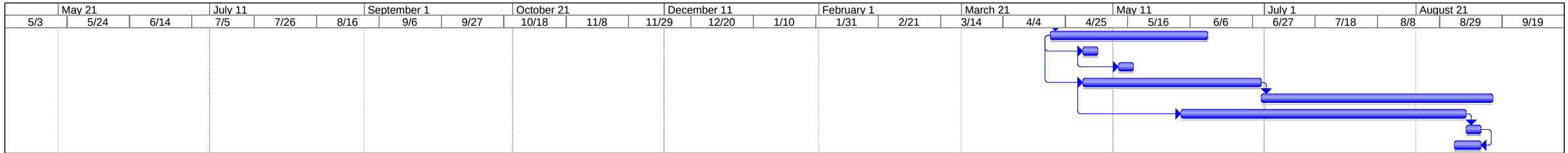
Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			



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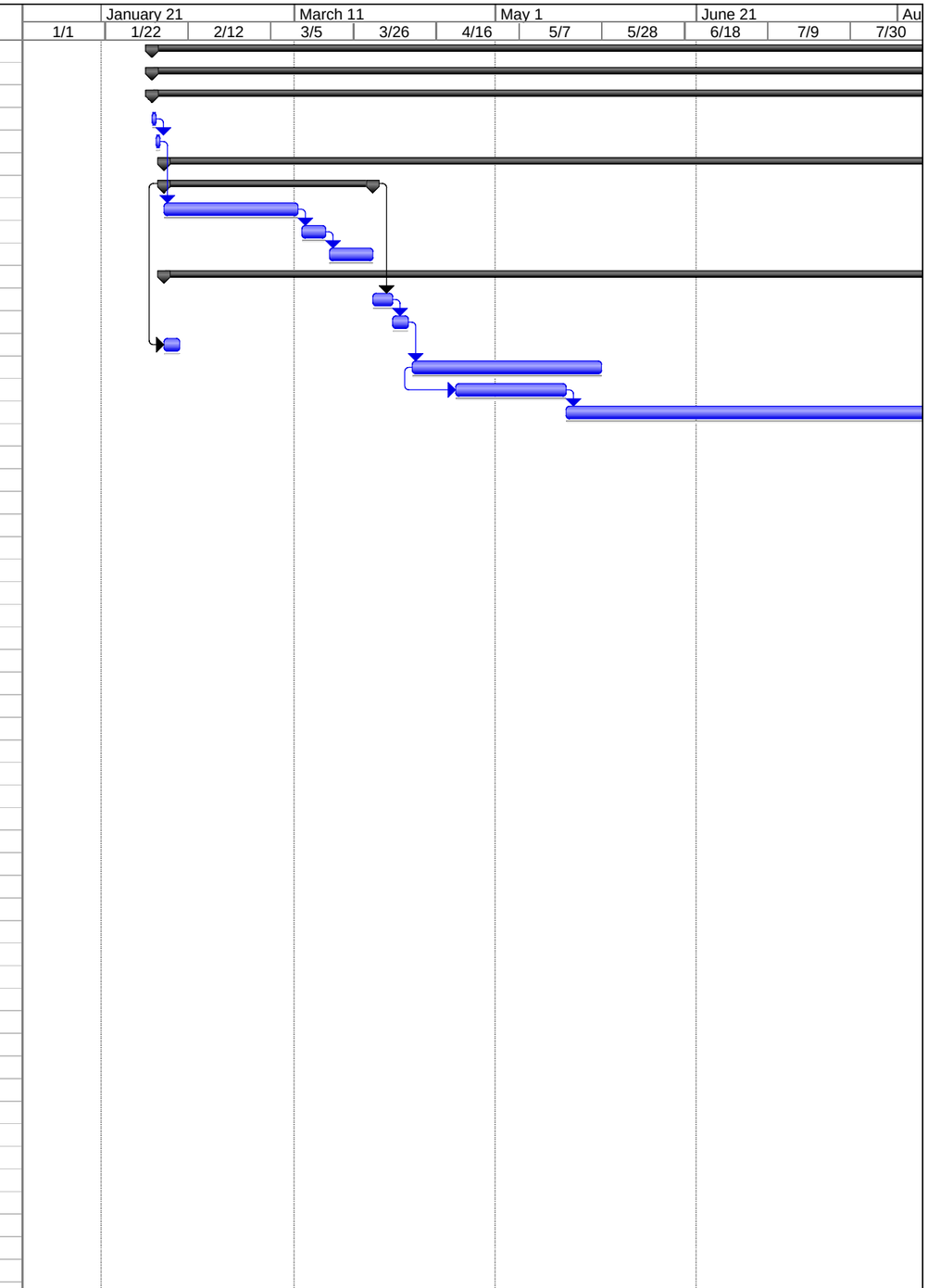
Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1	**Sutter Basin SB-8**	**2071 days?**	**Fri 2/3/17**	**Fri 9/15/23**		
2	**Contract C (13-25)**	**865 days?**	**Fri 2/3/17**	**Fri 11/8/19**		
3	**Contract C1 (13-18)**	**539 days?**	**Fri 2/3/17**	**Wed 10/24/18**		
4	Contract Award	1 day	Fri 2/3/17	Fri 2/3/17		
5	NTP	1 day	Sat 2/4/17	Sat 2/4/17	4	
6	**Construction Year 1**	**279 days?**	**Mon 2/6/17**	**Wed 12/27/17**		
7	**Mob, Demob & Preparatory Work**	**46 days**	**Mon 2/6/17**	**Thu 3/30/17**		
8	Submittals	30 days	Mon 2/6/17	Sat 3/11/17	5	
9	Mobilization	6 days	Mon 3/13/17	Sat 3/18/17	8	
10	Staging Areas Setup	10 days	Mon 3/20/17	Thu 3/30/17	9	
11	**Levees & Floodwalls Reach 13 - 18:**	**279 days?**	**Mon 2/6/17**	**Wed 12/27/17**		
12	Top Soil Stripping	4 days	Fri 3/31/17	Tue 4/4/17	7	
13	Clearing & Grubbing	4 days	Wed 4/5/17	Sat 4/8/17	12	
14	Remove AB Surfacing	4 days	Mon 2/6/17	Thu 2/9/17	7SS	
15	Degrade Exisiting Levees	42 days	Mon 4/10/17	Sat 5/27/17	13	
16	SB Cutoff Wall Conventional	24 days	Fri 4/21/17	Thu 5/18/17	15SS+10 days	
17	SB Cutoff Wall DSM	87 days	Fri 5/19/17	Mon 8/28/17	16	
18	Jet Grouting	18 days	Tue 8/29/17	Mon 9/18/17	17	
19	Levee Embankment Fill	76 days	Sat 9/30/17	Wed 12/27/17	18SS+28 days	
20	Top Soil Replacment	4 days	Sat 12/23/17	Wed 12/27/17	19FF	
21	AB Surfacing Levee Crown	1 day	Wed 12/27/17	Wed 12/27/17	19FF	
22	Relief Well Conveyance Ditch	1 day?	Wed 12/27/17	Wed 12/27/17	19FF	
23	**Construction Year 2**	**191 days**	**Fri 3/16/18**	**Wed 10/24/18**		
24	**Mob, Demob & Preparatory Work**	**16 days**	**Fri 3/16/18**	**Tue 4/3/18**		
25	Mobilization	6 days	Fri 3/16/18	Thu 3/22/18		
26	Staging Areas Setup	10 days	Fri 3/23/18	Tue 4/3/18	25	
27	**Levees & Floodwalls Reach 13 - 18:**	**191 days**	**Fri 3/16/18**	**Wed 10/24/18**		
28	Top Soil Stripping	4 days	Wed 4/4/18	Sat 4/7/18	24	
29	Clearing & Grubbing	4 days	Mon 4/9/18	Thu 4/12/18	28	
30	Remove AB Surfacing	4 days	Fri 3/16/18	Tue 3/20/18	24SS	
31	Degrade Exisiting Levees	42 days	Fri 4/13/18	Thu 5/31/18	29	
32	SB Cutoff Wall Conventional	24 days	Wed 4/25/18	Tue 5/22/18	31SS+10 days	
33	SB Cutoff Wall DSM	87 days	Wed 5/23/18	Fri 8/31/18	32	
34	Jet Grouting	18 days	Sat 9/1/18	Fri 9/21/18	33	
35	Levee Embankment Fill	76 days	Sat 7/28/18	Wed 10/24/18	34FF+28 days	
36	Top Soil Replacment	4 days	Sat 10/20/18	Wed 10/24/18	35FF	
37	AB Surfacing Levee Crown	1 day	Wed 10/24/18	Wed 10/24/18	36FF	
38	**Contract C2 (19-25)**	**553 days**	**Fri 2/2/18**	**Fri 11/8/19**		
39	Contract Award	1 day	Fri 2/2/18	Fri 2/2/18		
40	NTP	1 day	Sat 2/3/18	Sat 2/3/18	39	
41	**Construction Year 1**	**218 days**	**Mon 2/5/18**	**Tue 10/16/18**		
42	**Mob, Demob & Preparatory Work**	**46 days**	**Mon 2/5/18**	**Thu 3/29/18**		
43	Submittals	30 days	Mon 2/5/18	Sat 3/10/18	40	
44	Mobilization	6 days	Mon 3/12/18	Sat 3/17/18	43	
45	Staging Areas Setup	10 days	Mon 3/19/18	Thu 3/29/18	44	
46	**Levees & Floodwalls Reach 19-25:**	**218 days**	**Mon 2/5/18**	**Tue 10/16/18**		
47	Top Soil Stripping	5 days	Fri 3/30/18	Wed 4/4/18	42	
48	Clearing & Grubbing	4 days	Thu 4/5/18	Mon 4/9/18	47	
49	Remove AB Surfacing	4 days	Mon 2/5/18	Thu 2/8/18	42SS	
50	Degrade Exisiting Levees	26 days	Tue 4/10/18	Wed 5/9/18	48	
51	Excavate Cutoff Trench	5 days	Sat 4/21/18	Thu 4/26/18	50SS+10 days	
52	Excavate Inspection/Key Trench	3 days	Thu 5/3/18	Sat 5/5/18	51SS+10 days	
53	SB Cutoff Wall Conventional	67 days	Sat 4/21/18	Sat 7/7/18	50SS+10 days	
54	SB Cutoff Wall DSM	34 days	Mon 7/9/18	Thu 8/16/18	53	
55	Levee Embankment Fill	53 days	Fri 8/10/18	Wed 10/10/18	54SS+28 days	
56	AB Surfacing Levee Crown	5 days	Thu 10/11/18	Tue 10/16/18	55	



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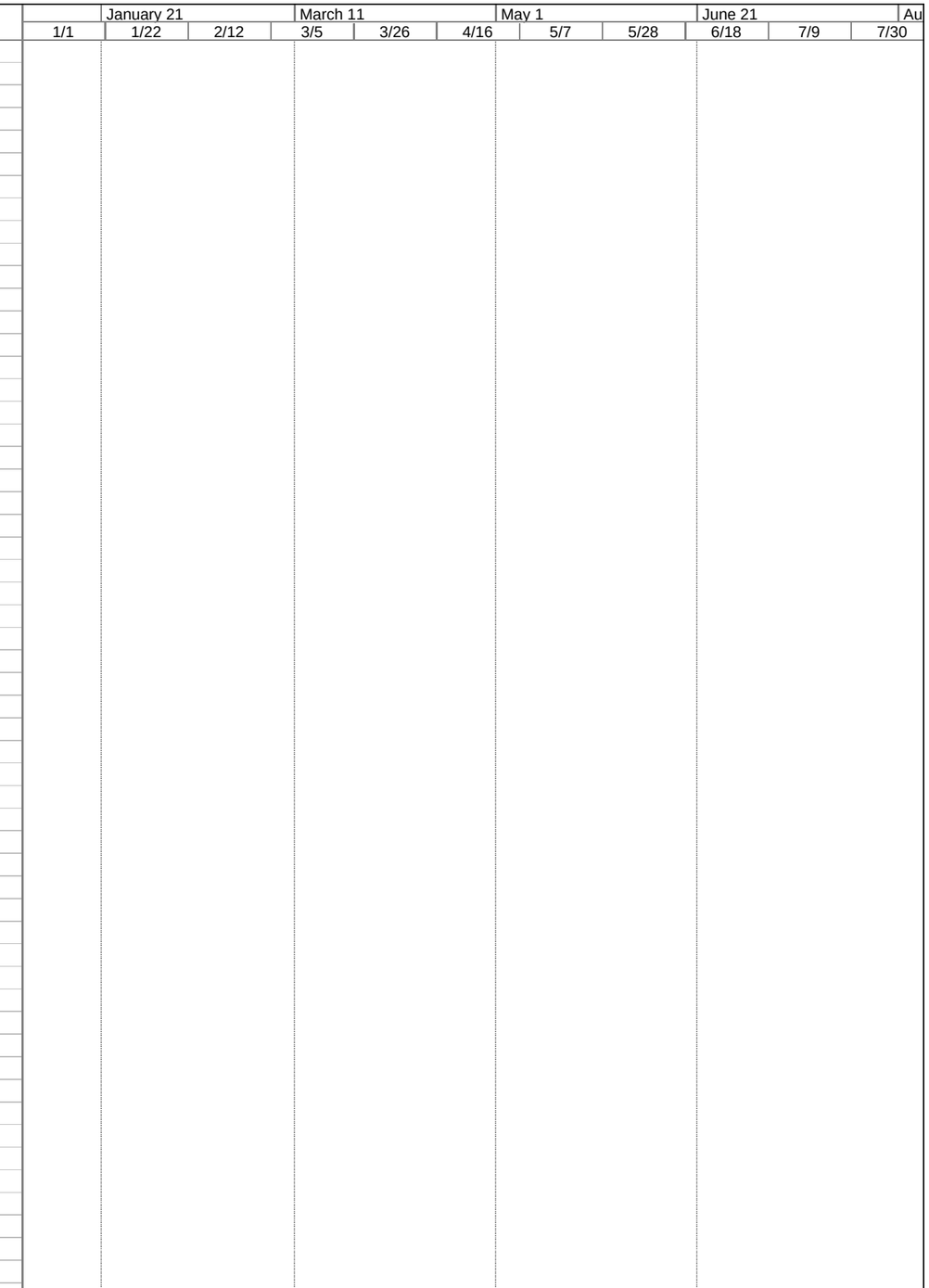
Date: Thu 3/14/13

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
57	Top Soil Replacment	10 days	Fri 10/5/18	Tue 10/16/18	56FF	
58	**Construction Year 2**	**218 days**	**Thu 2/28/19**	**Fri 11/8/19**		
59	**Mob, Demob & Preparatory Work**	**46 days**	**Thu 2/28/19**	**Mon 4/22/19**		
60	Submittals	30 days	Thu 2/28/19	Wed 4/3/19		
61	Mobilization	6 days	Thu 4/4/19	Wed 4/10/19	60	
62	Staging Areas Setup	10 days	Thu 4/11/19	Mon 4/22/19	61	
63	**Levees & Floodwalls Reach 19-25:**	**172 days**	**Tue 4/23/19**	**Fri 11/8/19**		
64	Top Soil Stripping	5 days	Tue 4/23/19	Sat 4/27/19	59	
65	Clearing & Grubbing	4 days	Mon 4/29/19	Thu 5/2/19	64	
66	Remove AB Surfacing	4 days	Tue 4/23/19	Fri 4/26/19	59	
67	Degrade Exisiting Levees	26 days	Fri 5/3/19	Sat 6/1/19	65	
68	Excavate Cutoff Trench	5 days	Wed 5/15/19	Mon 5/20/19	67SS+10 days	
69	Excavate Inspection/Key Trench	5 days	Mon 5/27/19	Fri 5/31/19	68SS+10 days	
70	SB Cutoff Wall Conventional	67 days	Wed 5/15/19	Wed 7/31/19	67SS+10 days	
71	SB Cutoff Wall DSM	34 days	Thu 8/1/19	Mon 9/9/19	70	
72	Levee Embankment Fill	53 days	Tue 9/3/19	Sat 11/2/19	71SS+28 days	
73	AB Surfacing Levee Crown	5 days	Mon 11/4/19	Fri 11/8/19	72	
74	Top Soil Replacment	10 days	Tue 10/29/19	Fri 11/8/19	73FF	
75	**Contract D (26-41)**	**793 days**	**Mon 2/4/19**	**Mon 8/16/21**		
76	**Contract D1 (26-33)**	**541 days**	**Mon 2/4/19**	**Mon 10/26/20**		
77	Contract Award	1 day	Mon 2/4/19	Mon 2/4/19		
78	NTP	1 day	Tue 2/5/19	Tue 2/5/19	77	
79	**Construction Year 1**	**228 days**	**Wed 2/6/19**	**Tue 10/29/19**		
80	**Mob, Demob & Preparatory Work**	**46 days**	**Wed 2/6/19**	**Sat 3/30/19**		
81	Submittals	30 days	Wed 2/6/19	Tue 3/12/19	78	
82	Mobilization	6 days	Wed 3/13/19	Tue 3/19/19	81	
83	Staging Areas Setup	10 days	Wed 3/20/19	Sat 3/30/19	82	
84	**Levees & Floodwalls Reach 26-33:**	**228 days**	**Wed 2/6/19**	**Tue 10/29/19**		
85	Top Soil Stripping	4 days	Mon 4/1/19	Thu 4/4/19	80	
86	Clearing & Grubbing	3 days	Fri 4/5/19	Mon 4/8/19	85	
87	Remove AB Surfacing	3 days	Wed 2/6/19	Fri 2/8/19	80SS	
88	Degrade Exisiting Levees	17 days	Tue 4/9/19	Sat 4/27/19	86	
89	Excavate Cutoff Trench	4 days	Sat 4/20/19	Wed 4/24/19	88SS+10 days	
90	Excavate Inspection/Key Trench	5 days	Thu 5/2/19	Tue 5/7/19	89SS+10 days	
91	SB Cutoff Wall Conventional	68 days	Sat 4/20/19	Mon 7/8/19	88SS+10 days	
92	SB Cutoff Wall DSM	60 days	Tue 7/9/19	Mon 9/16/19	91	
93	Jet Grouting	20 days	Sat 8/24/19	Mon 9/16/19	92FF	
94	Levee Embankment Fill	61 days	Fri 8/9/19	Fri 10/18/19	91SS+28 days,93I	
95	AB Surfacing Levee Crown	4 days	Sat 10/19/19	Wed 10/23/19	94	
96	Top Soil Replacment	7 days	Wed 10/16/19	Wed 10/23/19	95FF	
97	**Canal @ STA 1753+00**	**17 days**	**Thu 10/10/19**	**Tue 10/29/19**		
98	Construction New Canal	8 days	Thu 10/10/19	Fri 10/18/19	86,94FF	
99	Backfill Old Canal	9 days	Sat 10/19/19	Tue 10/29/19	98	
100	**Construction Year 2**	**193 days**	**Mon 3/16/20**	**Mon 10/26/20**		
101	**Mob, Demob & Preparatory Work**	**16 days**	**Mon 3/16/20**	**Thu 4/2/20**		
102	Mobilization	6 days	Mon 3/16/20	Sat 3/21/20		
103	Staging Areas Setup	10 days	Mon 3/23/20	Thu 4/2/20	102	
104	**Levees & Floodwalls Reach 26-33**	**193 days**	**Mon 3/16/20**	**Mon 10/26/20**		
105	Top Soil Stripping	4 days	Fri 4/3/20	Tue 4/7/20	101	
106	Clearing & Grubbing	3 days	Wed 4/8/20	Fri 4/10/20	105	
107	Remove AB Surfacing	3 days	Mon 3/16/20	Wed 3/18/20	101SS	
108	Degrade Exisiting Levees	17 days	Sat 4/11/20	Thu 4/30/20	106	
109	Excavate Cutoff Trench	4 days	Thu 4/23/20	Mon 4/27/20	108SS+10 days	
110	Excavate Inspection/Key Trench	5 days	Tue 5/5/20	Sat 5/9/20	109SS+10 days	
111	SB Cutoff Wall Conventional	68 days	Thu 4/23/20	Fri 7/10/20	108SS+10 days	
112	SB Cutoff Wall DSM	60 days	Sat 7/11/20	Fri 9/18/20	111	



Project: Sutter Basin Rev 1
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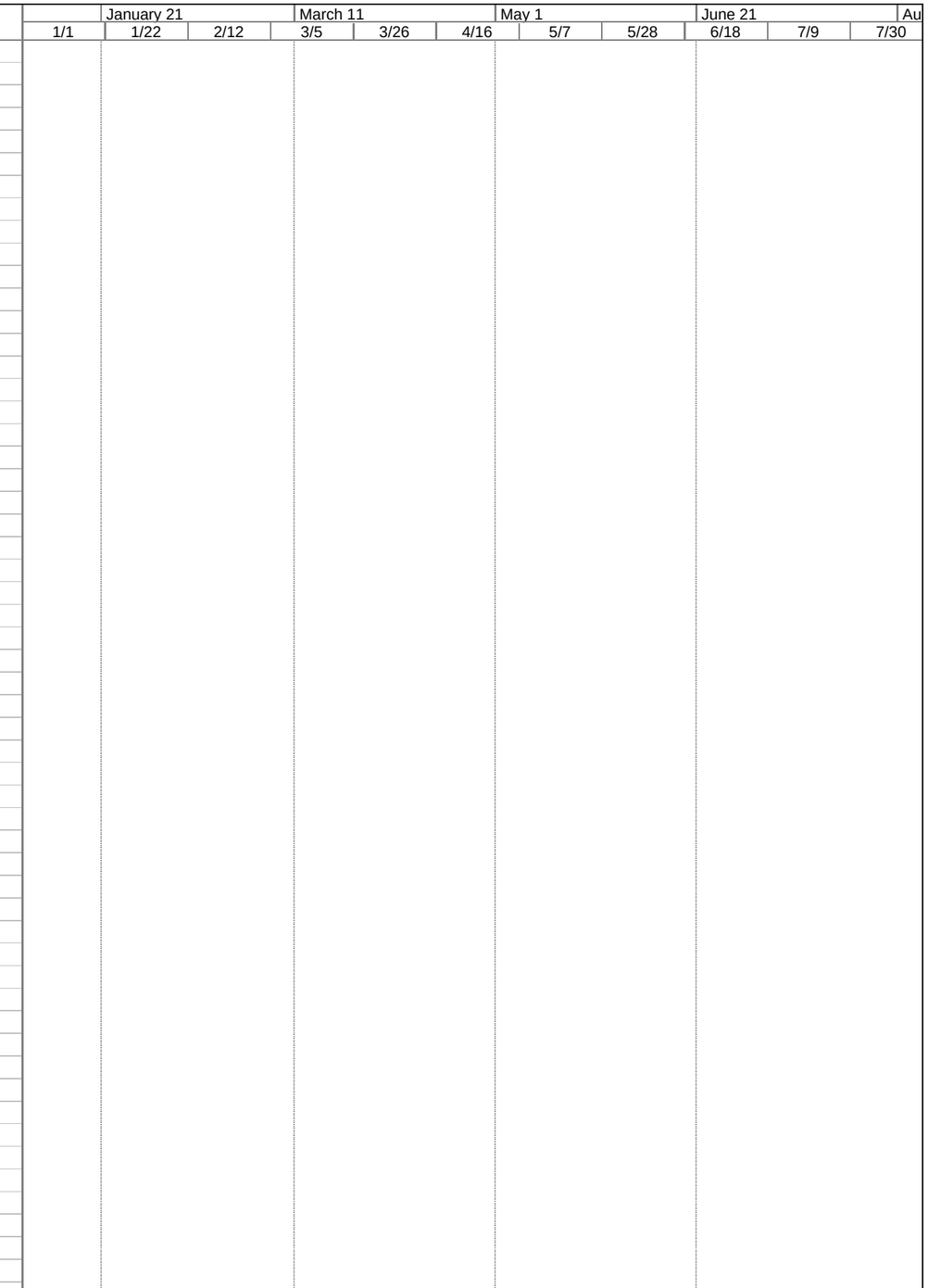
Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

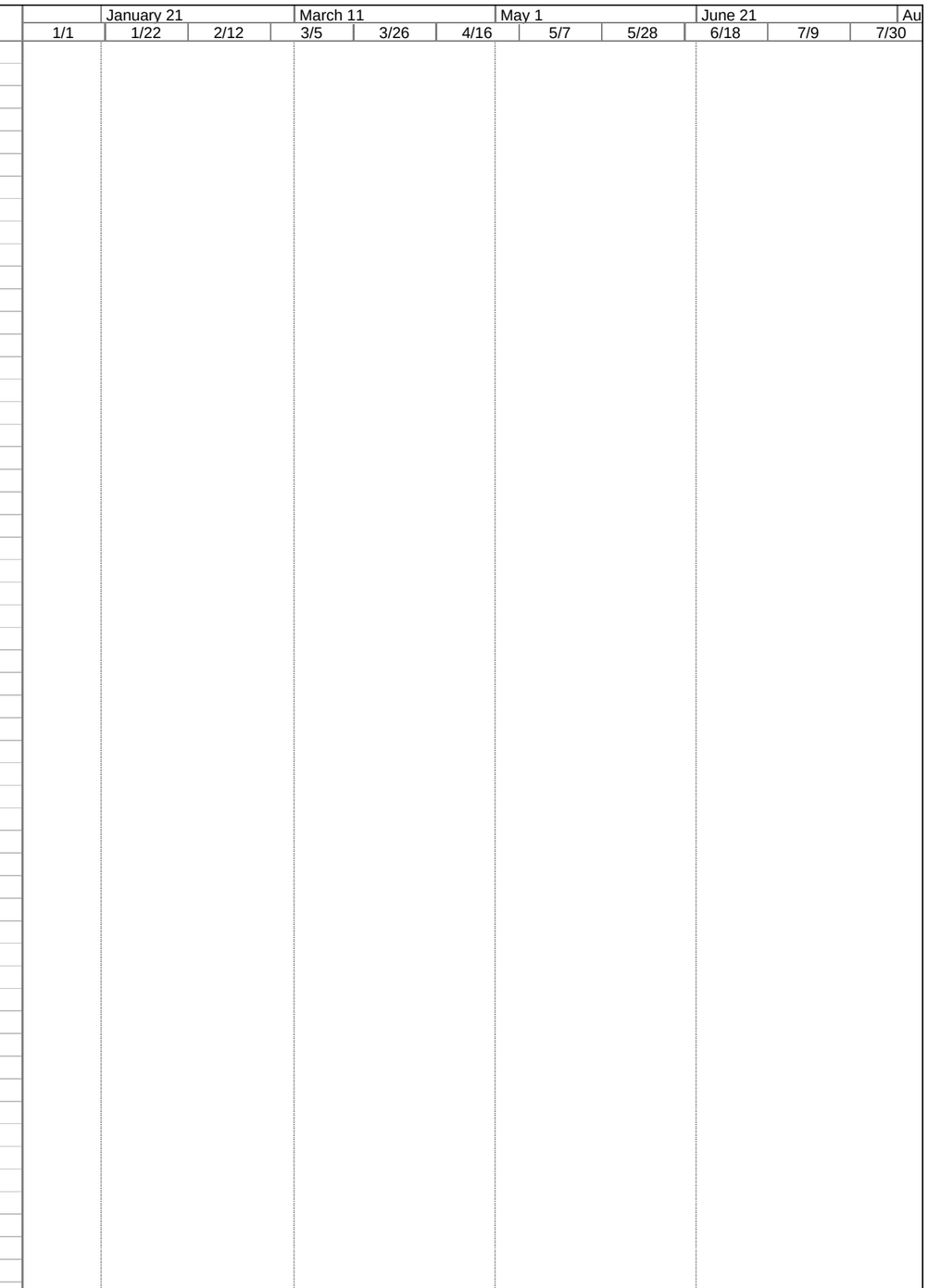
ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
113	Jet Grouting	20 days	Thu 8/27/20	Fri 9/18/20	112FF	
114	Levee Embankment Fill	61 days	Wed 8/12/20	Wed 10/21/20	111SS+28 days,1:	
115	AB Surfacing Levee Crown	4 days	Thu 10/22/20	Mon 10/26/20	114	
116	Top Soil Replacment	7 days	Mon 10/19/20	Mon 10/26/20	115FF	
117	**Contract D2 (34-41)**	**481 days**	**Mon 2/3/20**	**Mon 8/16/21**		
118	Contract Award	1 day	Mon 2/3/20	Mon 2/3/20		
119	NTP	1 day	Tue 2/4/20	Tue 2/4/20	118	
120	**Construction Year 1**	**163 days**	**Wed 2/5/20**	**Wed 8/12/20**		
121	**Mob, Demob & Preparatory Work**	**46 days**	**Wed 2/5/20**	**Sat 3/28/20**		
122	Submittals	30 days	Wed 2/5/20	Tue 3/10/20	119	
123	Mobilization	6 days	Wed 3/11/20	Tue 3/17/20	122	
124	Staging Areas Setup	10 days	Wed 3/18/20	Sat 3/28/20	123	
125	**Levees & Floodwalls Reach 34-41**	**117 days**	**Mon 3/30/20**	**Wed 8/12/20**		
126	Top Soil Stripping	4 days	Mon 3/30/20	Thu 4/2/20	121	
127	Clearing & Grubbing	5 days	Fri 4/3/20	Wed 4/8/20	126	
128	Remove AB Surfacing	2 days	Sat 5/2/20	Mon 5/4/20	121,129FF	
129	Degrade Exisiting Levees	22 days	Thu 4/9/20	Mon 5/4/20	127	
130	Excavate Cutoff Trench	3 days	Tue 4/21/20	Thu 4/23/20	129SS+10 days	
131	SB Cutoff Wall Conventional	31 days	Tue 4/21/20	Tue 5/26/20	129SS+10 days	
132	SB Cutoff Wall DSM	67 days	Wed 5/27/20	Wed 8/12/20	131	
133	Levee Embankment Fill	23 days	Sat 5/23/20	Thu 6/18/20	131SS+28 days	
134	AB Surfacing Levee Crown	3 days	Fri 6/19/20	Mon 6/22/20	133	
135	Top Soil Replacment	7 days	Mon 6/15/20	Mon 6/22/20	134FF	
136	**Construction Year 2**	**133 days**	**Mon 3/15/21**	**Mon 8/16/21**		
137	**Mob, Demob & Preparatory Work**	**16 days**	**Mon 3/15/21**	**Thu 4/1/21**		
138	Mobilization	6 days	Mon 3/15/21	Sat 3/20/21		
139	Staging Areas Setup	10 days	Mon 3/22/21	Thu 4/1/21	138	
140	**Levees & Floodwalls Reach 34-41**	**117 days**	**Fri 4/2/21**	**Mon 8/16/21**		
141	Top Soil Stripping	4 days	Fri 4/2/21	Tue 4/6/21	137	
142	Clearing & Grubbing	5 days	Wed 4/7/21	Mon 4/12/21	141	
143	Remove AB Surfacing	2 days	Thu 5/6/21	Fri 5/7/21	137,144FF	
144	Degrade Exisiting Levees	22 days	Tue 4/13/21	Fri 5/7/21	142	
145	Excavate Cutoff Trench	3 days	Sat 4/24/21	Tue 4/27/21	144SS+10 days	
146	SB Cutoff Wall Conventional	31 days	Sat 4/24/21	Sat 5/29/21	144SS+10 days	
147	SB Cutoff Wall DSM	67 days	Mon 5/31/21	Mon 8/16/21	146	
148	Levee Embankment Fill	23 days	Thu 5/27/21	Tue 6/22/21	146SS+28 days	
149	AB Surfacing Levee Crown	3 days	Wed 6/23/21	Fri 6/25/21	148	
150	Top Soil Replacment	7 days	Fri 6/18/21	Fri 6/25/21	149FF	
151	**Contract B (7-12)**	**503 days?**	**Fri 2/5/21**	**Wed 9/14/22**		
152	**Contract B (7-12)**	**503 days?**	**Fri 2/5/21**	**Wed 9/14/22**		
153	Contract Award	1 day	Fri 2/5/21	Fri 2/5/21		
154	NTP	1 day	Sat 2/6/21	Sat 2/6/21	153	
155	**Construction Year 1**	**187 days?**	**Mon 2/8/21**	**Mon 9/13/21**		
156	**Mob, Demob & Preparatory Work**	**46 days**	**Mon 2/8/21**	**Thu 4/1/21**		
157	Submittals	30 days	Mon 2/8/21	Sat 3/13/21	154	
158	Mobilization	6 days	Mon 3/15/21	Sat 3/20/21	157	
159	Staging Areas Setup	10 days	Mon 3/22/21	Thu 4/1/21	158	
160	**Levees & Floodwalls Reach 7-12**	**141 days?**	**Fri 4/2/21**	**Mon 9/13/21**		
161	Top Soil Stripping	6 days	Fri 4/2/21	Thu 4/8/21	156	
162	Clearing & Grubbing	5 days	Fri 4/9/21	Wed 4/14/21	161	
163	Remove AB Surfacing	3 days	Tue 6/8/21	Thu 6/10/21	156,164FF	
164	Degrade Exisiting Levees	49 days	Thu 4/15/21	Thu 6/10/21	162	
165	Excavate Cutoff Trench	4 days	Tue 4/27/21	Fri 4/30/21	164SS+10 days	
166	Excavate Inspection/Key Trench	1 day?	Sat 5/8/21	Sat 5/8/21	165SS+10 days	
167	SB Cutoff Wall Conventional	83 days	Tue 4/27/21	Sat 7/31/21	164SS+10 days	
168	Levee Embankment Fill	83 days	Sat 5/29/21	Thu 9/2/21	167SS+28 days	



Project: Sutter Basin Rev 1
Date: Thu 3/14/13

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

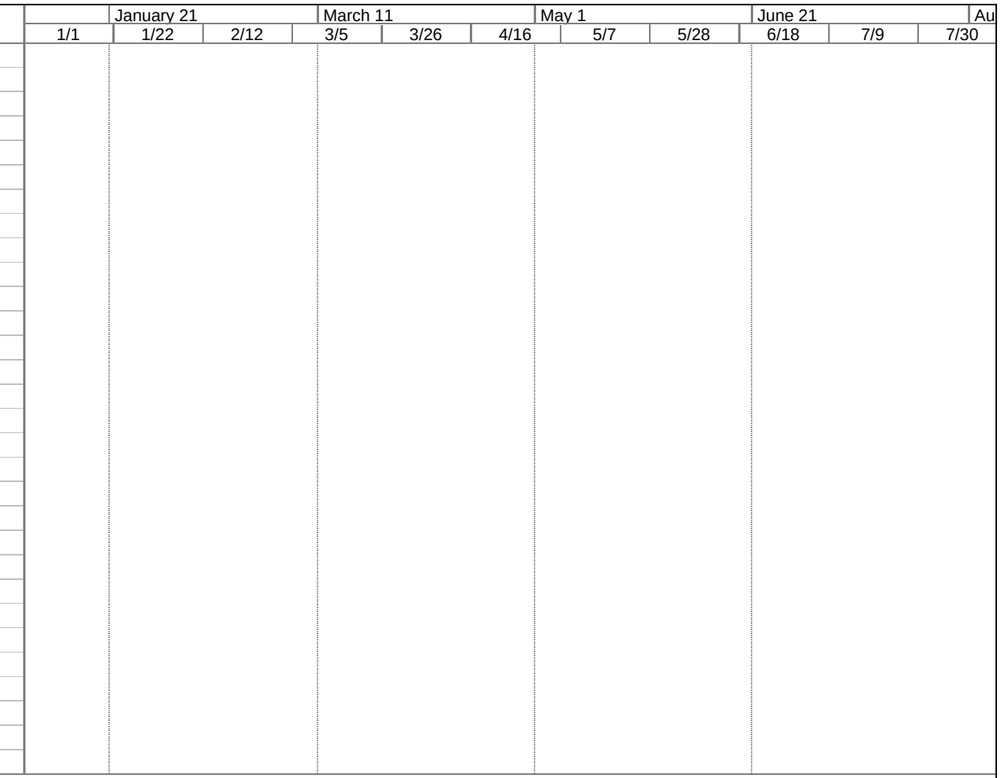
ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
169	AB Surfacing Levee Crown	9 days	Fri 9/3/21	Mon 9/13/21	168	
170	Top Soil Replacment	12 days	Tue 8/31/21	Mon 9/13/21	169FF	
171	**Construction Year 2**	**157 days?**	**Wed 3/16/22**	**Wed 9/14/22**		
172	**Mob, Demob & Preparatory Work**	**16 days**	**Wed 3/16/22**	**Sat 4/2/22**		
173	Mobilization	6 days	Wed 3/16/22	Tue 3/22/22		
174	Staging Areas Setup	10 days	Wed 3/23/22	Sat 4/2/22	173	
175	**Levees & Floodwalls Reach 7-12**	**141 days?**	**Mon 4/4/22**	**Wed 9/14/22**		
176	Top Soil Stripping	6 days	Mon 4/4/22	Sat 4/9/22	172	
177	Clearing & Grubbing	5 days	Mon 4/11/22	Fri 4/15/22	176	
178	Remove AB Surfacing	3 days	Thu 6/9/22	Sat 6/11/22	172,179FF	
179	Degrade Exisiting Levees	49 days	Sat 4/16/22	Sat 6/11/22	177	
180	Excavate Cutoff Trench	4 days	Thu 4/28/22	Mon 5/2/22	179SS+10 days	
181	Excavate Inspection/Key Trench	1 day?	Tue 5/10/22	Tue 5/10/22	180SS+10 days	
182	SB Cutoff Wall Conventional	83 days	Thu 4/28/22	Tue 8/2/22	179SS+10 days	
183	Levee Embankment Fill	83 days	Tue 5/31/22	Sat 9/3/22	182SS+28 days	
184	AB Surfacing Levee Crown	9 days	Mon 9/5/22	Wed 9/14/22	183	
185	Top Soil Replacment	12 days	Thu 9/1/22	Wed 9/14/22	184FF	
186	**Star Bend FIP (6)**	**424 days?**	**Fri 2/5/21**	**Tue 6/14/22**		
187	**Star Bend FIP (6)**	**424 days?**	**Fri 2/5/21**	**Tue 6/14/22**		
188	Contract Award	1 day	Fri 2/5/21	Fri 2/5/21		
189	NTP	1 day	Sat 2/6/21	Sat 2/6/21	188	
190	**Construction Year 1**	**108 days**	**Mon 2/8/21**	**Sat 6/12/21**		
191	**Mob, Demob & Preparatory Work**	**46 days**	**Mon 2/8/21**	**Thu 4/1/21**		
192	Submittals	30 days	Mon 2/8/21	Sat 3/13/21	189	
193	Mobilization	6 days	Mon 3/15/21	Sat 3/20/21	192	
194	Staging Areas Setup	10 days	Mon 3/22/21	Thu 4/1/21	193	
195	**Levees & Floodwalls Reach 6**	**62 days**	**Fri 4/2/21**	**Sat 6/12/21**		
196	Top Soil Stripping	2 days	Fri 4/2/21	Sat 4/3/21	191	
197	Clearing & Grubbing	2 days	Mon 4/5/21	Tue 4/6/21	196	
198	Degrade Exisiting Levees	10 days	Wed 4/7/21	Sat 4/17/21	197	
199	Excavate Cutoff Trench	1 day	Mon 4/19/21	Mon 4/19/21	198SS+10 days	
200	SB Cutoff Wall Conventional	29 days	Mon 4/19/21	Fri 5/21/21	198SS+10 days	
201	Levee Embankment Fill	18 days	Fri 5/21/21	Thu 6/10/21	200SS+28 days	
202	AB Surfacing Levee Crown	2 days	Fri 6/11/21	Sat 6/12/21	201	
203	Top Soil Replacment	3 days	Thu 6/10/21	Sat 6/12/21	202FF	
204	**Construction Year 2**	**78 days?**	**Wed 3/16/22**	**Tue 6/14/22**		
205	**Mob, Demob & Preparatory Work**	**16 days**	**Wed 3/16/22**	**Sat 4/2/22**		
206	Mobilization	6 days	Wed 3/16/22	Tue 3/22/22		
207	Staging Areas Setup	10 days	Wed 3/23/22	Sat 4/2/22	206	
208	**Levees & Floodwalls Reach 6**	**62 days?**	**Mon 4/4/22**	**Tue 6/14/22**		
209	Top Soil Stripping	2 days	Mon 4/4/22	Tue 4/5/22	205	
210	Clearing & Grubbing	2 days	Wed 4/6/22	Thu 4/7/22	209	
211	Degrade Exisiting Levees	10 days	Fri 4/8/22	Tue 4/19/22	210	
212	Excavate Cutoff Trench	1 day	Wed 4/20/22	Wed 4/20/22	211SS+10 days	
213	Excavate Inspection/Key Trench	1 day?	Mon 5/2/22	Mon 5/2/22	212SS+10 days	
214	SB Cutoff Wall Conventional	29 days	Wed 4/20/22	Mon 5/23/22	211SS+10 days	
215	Levee Embankment Fill	18 days	Mon 5/23/22	Sat 6/11/22	214SS+28 days	
216	AB Surfacing Levee Crown	2 days	Mon 6/13/22	Tue 6/14/22	215	
217	Top Soil Replacment	3 days	Sat 6/11/22	Tue 6/14/22	216FF	
218	**Contract A (2-5)**	**505 days**	**Fri 2/4/22**	**Fri 9/15/23**		
219	**Contract A (2-5)**	**505 days**	**Fri 2/4/22**	**Fri 9/15/23**		
220	Contract Award	1 day	Fri 2/4/22	Fri 2/4/22		
221	NTP	1 day	Sat 2/5/22	Sat 2/5/22	220	
222	**Construction Year 1**	**188 days**	**Mon 2/7/22**	**Tue 9/13/22**		
223	**Mob, Demob & Preparatory Work**	**46 days**	**Mon 2/7/22**	**Thu 3/31/22**		
224	Submittals	30 days	Mon 2/7/22	Sat 3/12/22	221	



Project: Sutter Basin Rev 1
Date: Thu 3/14/13

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

ID		Task Name	Duration	Start	Finish	Predecessors	Resource Names
225		Mobilization	6 days	Mon 3/14/22	Sat 3/19/22	224	
226		Staging Areas Setup	10 days	Mon 3/21/22	Thu 3/31/22	225	
227		**Levees & Floodwalls Reach 2-5:**	**142 days**	**Fri 4/1/22**	**Tue 9/13/22**		
228		Top Soil Stripping	8 days	Fri 4/1/22	Sat 4/9/22	223	
229		Clearing & Grubbing	6 days	Mon 4/11/22	Sat 4/16/22	228	
230		Remove AB Surfacing	3 days	Fri 4/1/22	Mon 4/4/22	223	
231		Degrade Exisiting Levees	46 days	Mon 4/18/22	Thu 6/9/22	229	
232		Excavate Cutoff Trench	4 days	Fri 4/29/22	Tue 5/3/22	231SS+10 days	
233		Excavate Inspection/Key Trench	4 days	Wed 5/11/22	Sat 5/14/22	232SS+10 days	
234		SB Cutoff Wall Conventional	51 days	Fri 4/29/22	Mon 6/27/22	231SS+10 days	
235		SB Cutoff Wall DSM	67 days	Tue 6/28/22	Tue 9/13/22	234	
236		Levee Embankment Fill	82 days	Wed 6/1/22	Sat 9/3/22	234SS+28 days	
237		AB Surfacing Levee Crown	5 days	Mon 9/5/22	Fri 9/9/22	236	
238		Top Soil Replacment	8 days	Thu 9/1/22	Fri 9/9/22	237FF	
239		**Construction Year 2**	**158 days**	**Thu 3/16/23**	**Fri 9/15/23**		
240		**Mob, Demob & Preparatory Work**	**16 days**	**Thu 3/16/23**	**Mon 4/3/23**		
241		Mobilization	6 days	Thu 3/16/23	Wed 3/22/23		
242		Staging Areas Setup	10 days	Thu 3/23/23	Mon 4/3/23	241	
243		**Levees & Floodwalls Reach 2-5**	**142 days**	**Tue 4/4/23**	**Fri 9/15/23**		
244		Top Soil Stripping	8 days	Tue 4/4/23	Wed 4/12/23	240	
245		Clearing & Grubbing	6 days	Thu 4/13/23	Wed 4/19/23	244	
246		Remove AB Surfacing	3 days	Tue 4/4/23	Thu 4/6/23	240	
247		Degrade Exisiting Levees	46 days	Thu 4/20/23	Mon 6/12/23	245	
248		Excavate Cutoff Trench	4 days	Tue 5/2/23	Fri 5/5/23	247SS+10 days	
249		Excavate Inspection/Key Trench	4 days	Sat 5/13/23	Wed 5/17/23	248SS+10 days	
250		SB Cutoff Wall Conventional	51 days	Tue 5/2/23	Thu 6/29/23	247SS+10 days	
251		SB Cutoff Wall DSM	67 days	Fri 6/30/23	Fri 9/15/23	250	
252		Levee Embankment Fill	82 days	Sat 6/3/23	Wed 9/6/23	250SS+28 days	
253		AB Surfacing Levee Crown	5 days	Thu 9/7/23	Tue 9/12/23	252	
254		Top Soil Replacment	8 days	Mon 9/4/23	Tue 9/12/23	253FF	



Project: Sutter Basin Rev 1
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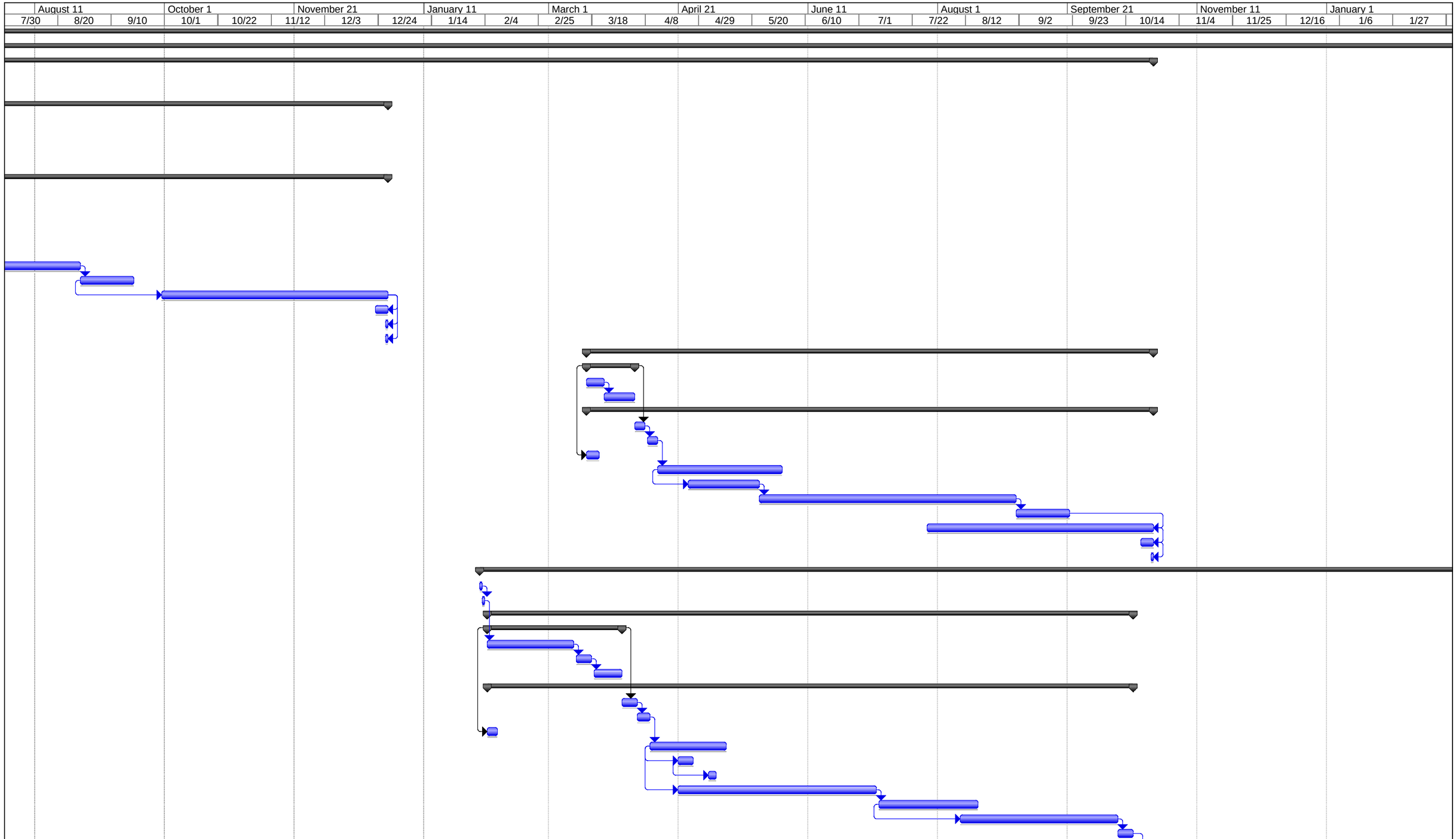
Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone



Project: Sutter Basin Rev 1
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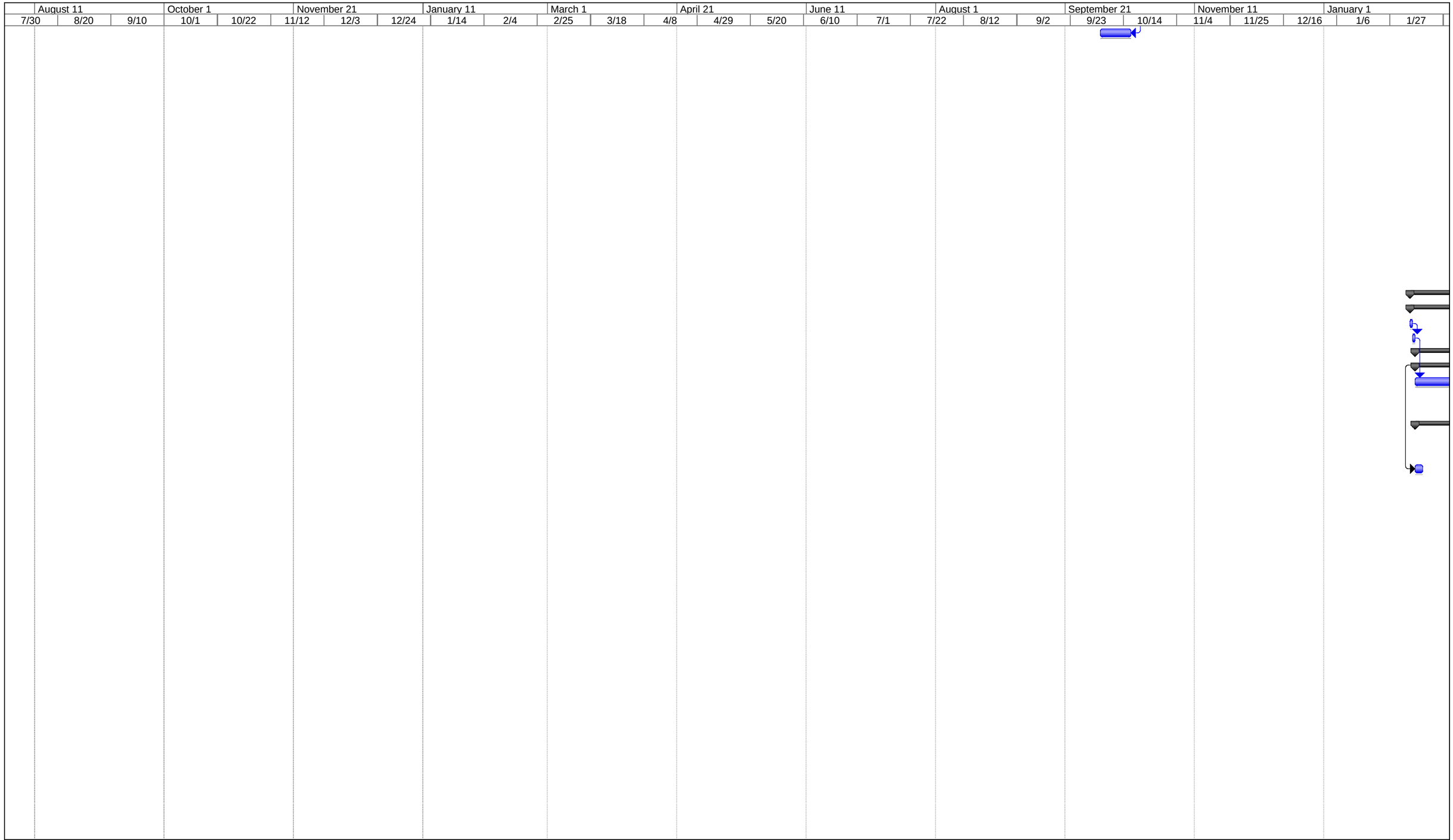
Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			



Project: Sutter Basin Rev 1
Date: Thu 3/14/13

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

	August 11		October 1		November 21		January 11		March 1		April 21		June 11		August 1		September 21		November 11		January 1	
7/30	8/20	9/10	10/1	10/22	11/12	12/3	12/24	1/14	2/4	2/25	3/18	4/8	4/29	5/20	6/10	7/1	7/22	8/12	9/2	9/23	10/14	11/4	11/25	12/16	1/6	1/27

Project: Sutter Basin Rev 1
Date: Thu 3/14/13

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

August 11			October 1		November 21			January 11		March 1			April 21		June 11		August 1			September 21		November 11			January 1	
7/30	8/20	9/10	10/1	10/22	11/12	12/3	12/24	1/14	2/4	2/25	3/18	4/8	4/29	5/20	6/10	7/1	7/22	8/12	9/2	9/23	10/14	11/4	11/25	12/16	1/6	1/27

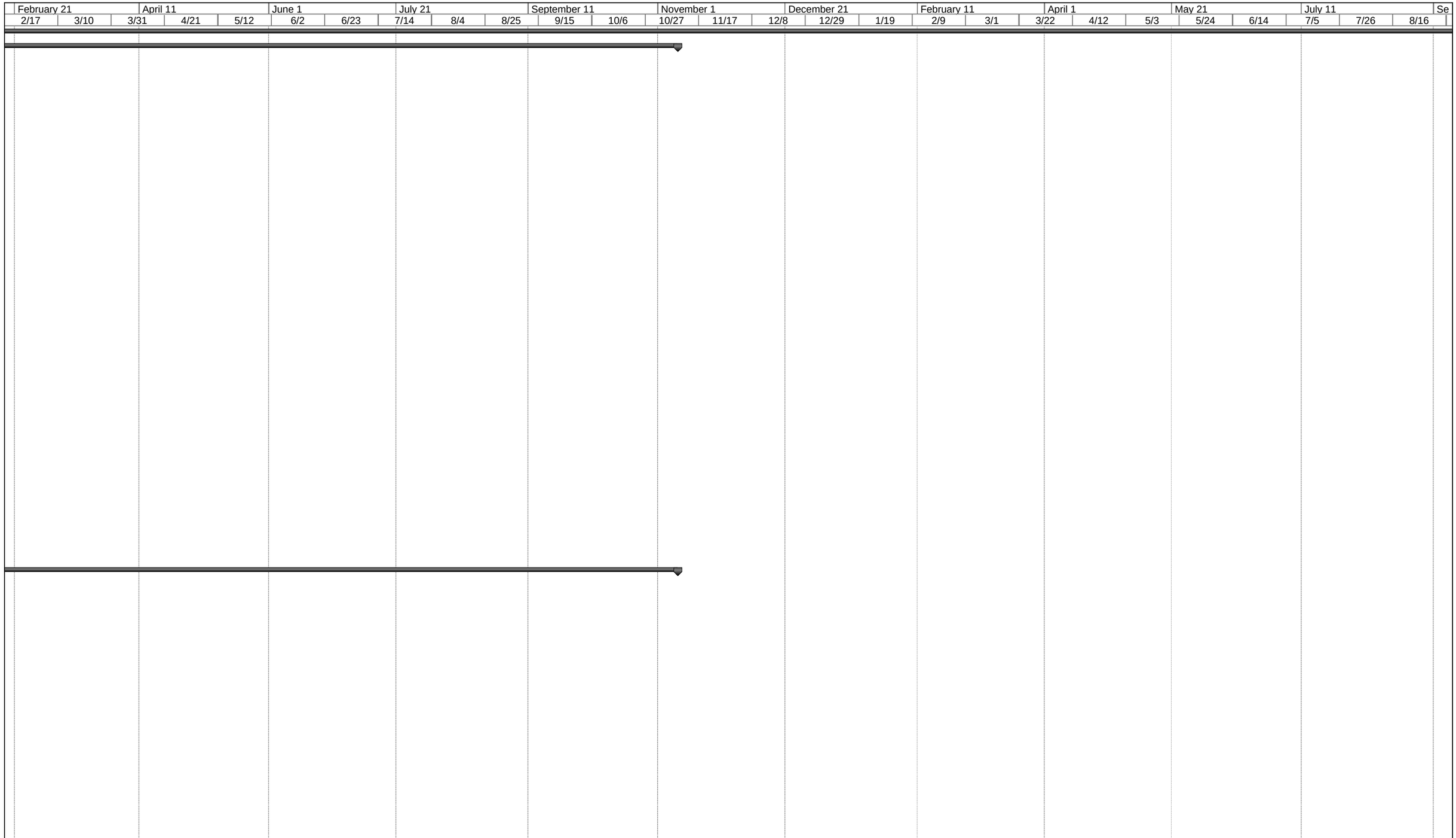
Project: Sutter Basin Rev 1
Date: Thu 3/14/13

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

	August 11		October 1		November 21		January 11		March 1		April 21		June 11		August 1		September 21		November 11		January 1	
7/30	8/20	9/10	10/1	10/22	11/12	12/3	12/24	1/14	2/4	2/25	3/18	4/8	4/29	5/20	6/10	7/1	7/22	8/12	9/2	9/23	10/14	11/4	11/25	12/16	1/6	1/27

Project: Sutter Basin Rev 1
Date: Thu 3/14/13

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			



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Task		Progress		Summary		External Tasks		Deadline	
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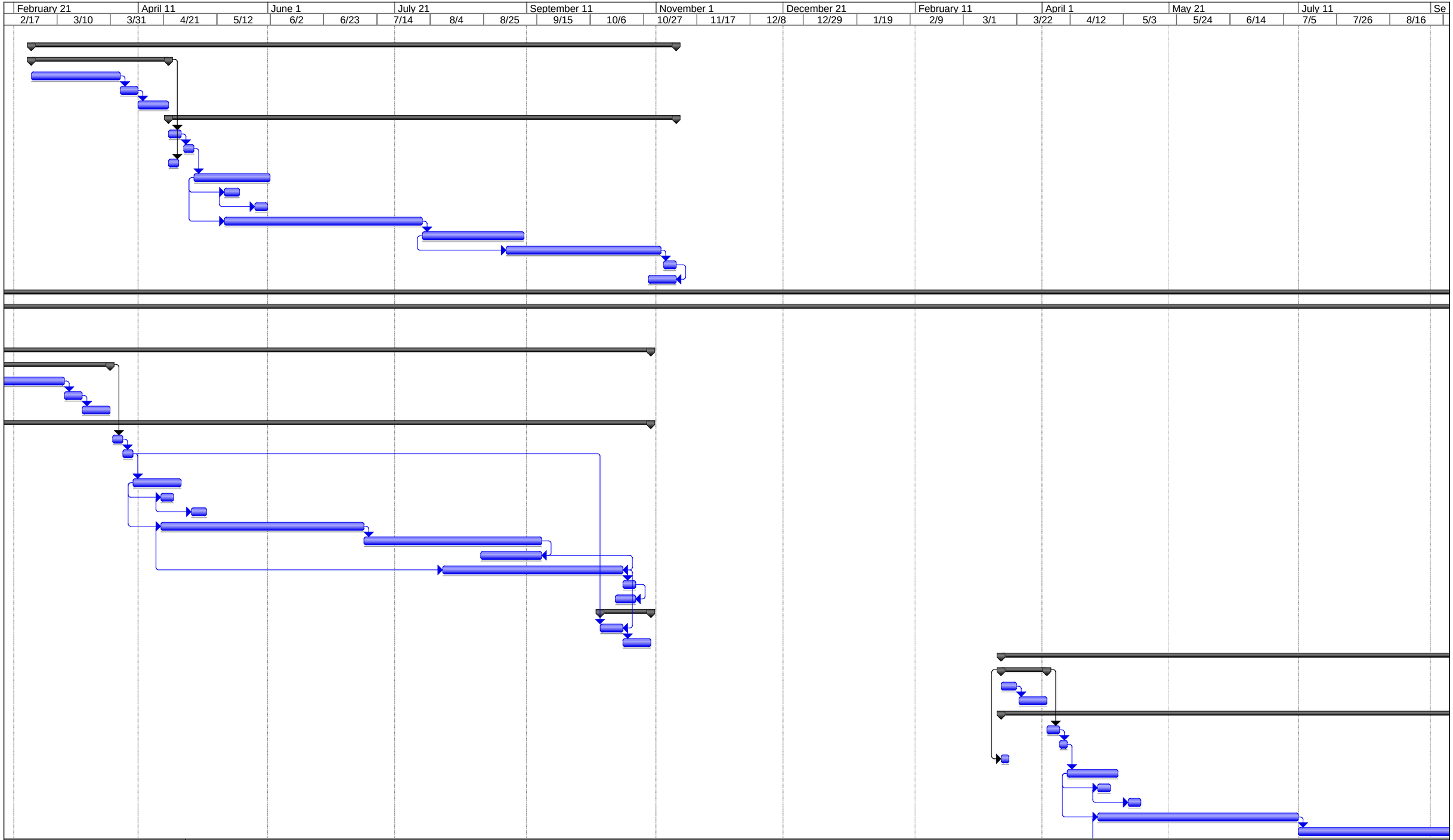

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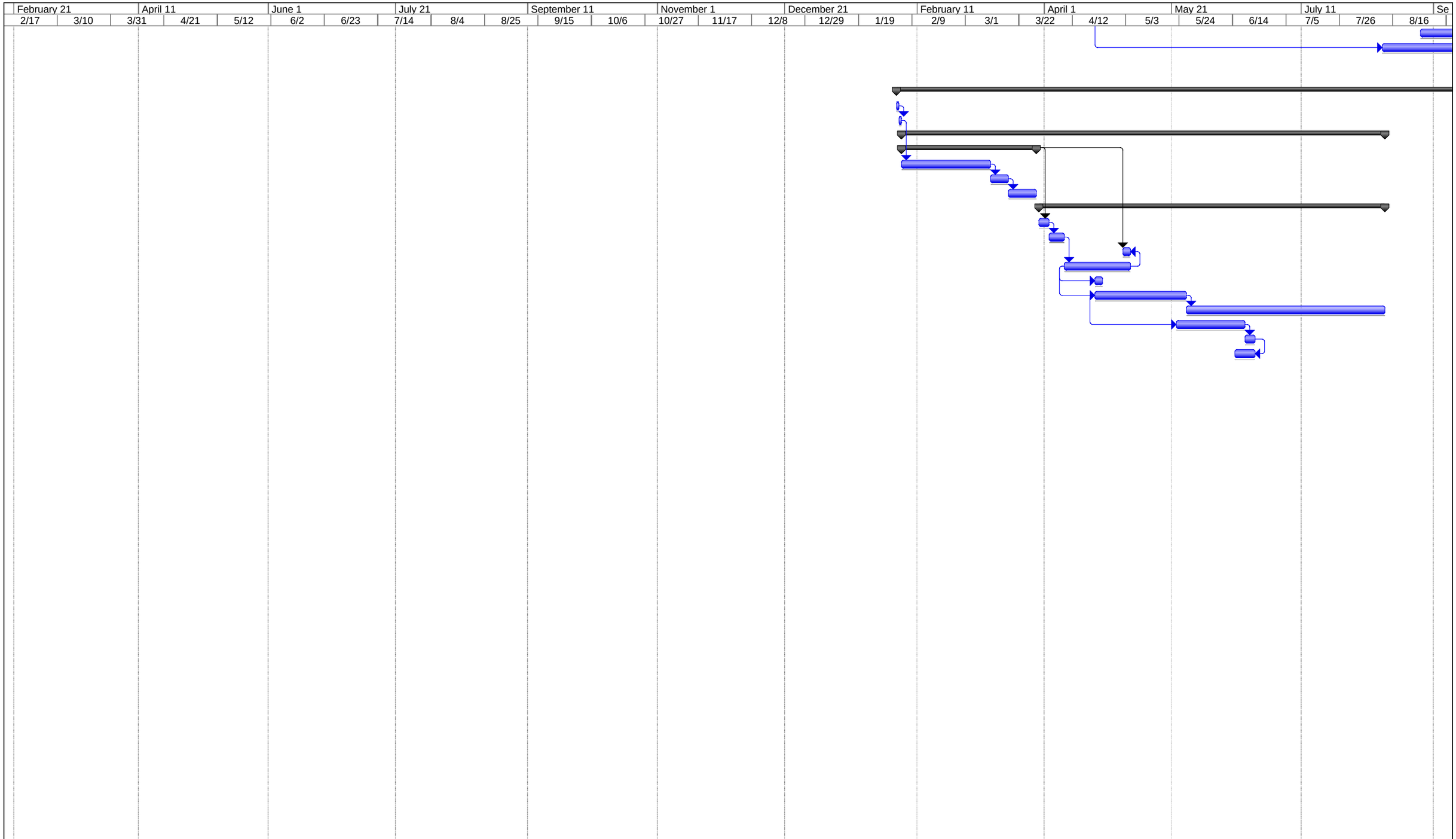
Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			



Project: Sutter Basin Rev 1
Date: Thu 3/14/13

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

February 21			April 11		June 1		July 21			September 11		November 1			December 21		February 11		April 1			May 21		July 11			Se
2/17	3/10	3/31	4/21	5/12	6/2	6/23	7/14	8/4	8/25	9/15	10/6	10/27	11/17	12/8	12/29	1/19	2/9	3/1	3/22	4/12	5/3	5/24	6/14	7/5	7/26	8/16	

Project: Sutter Basin Rev 1
Date: Thu 3/14/13

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

February 21			April 11		June 1		July 21			September 11		November 1			December 21		February 11		April 1			May 21		July 11			Se
2/17	3/10	3/31	4/21	5/12	6/2	6/23	7/14	8/4	8/25	9/15	10/6	10/27	11/17	12/8	12/29	1/19	2/9	3/1	3/22	4/12	5/3	5/24	6/14	7/5	7/26	8/16	

Project: Sutter Basin Rev 1
Date: Thu 3/14/13

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

ptember 1		October 21			December 11		February 1		March 21			May 11		July 1			August 21		October 11			December 1		January 21		March 11
9/6	9/27	10/18	11/8	11/29	12/20	1/10	1/31	2/21	3/14	4/4	4/25	5/16	6/6	6/27	7/18	8/8	8/29	9/19	10/10	10/31	11/21	12/12	1/2	1/23	2/13	3/6

Project: Sutter Basin Rev 1
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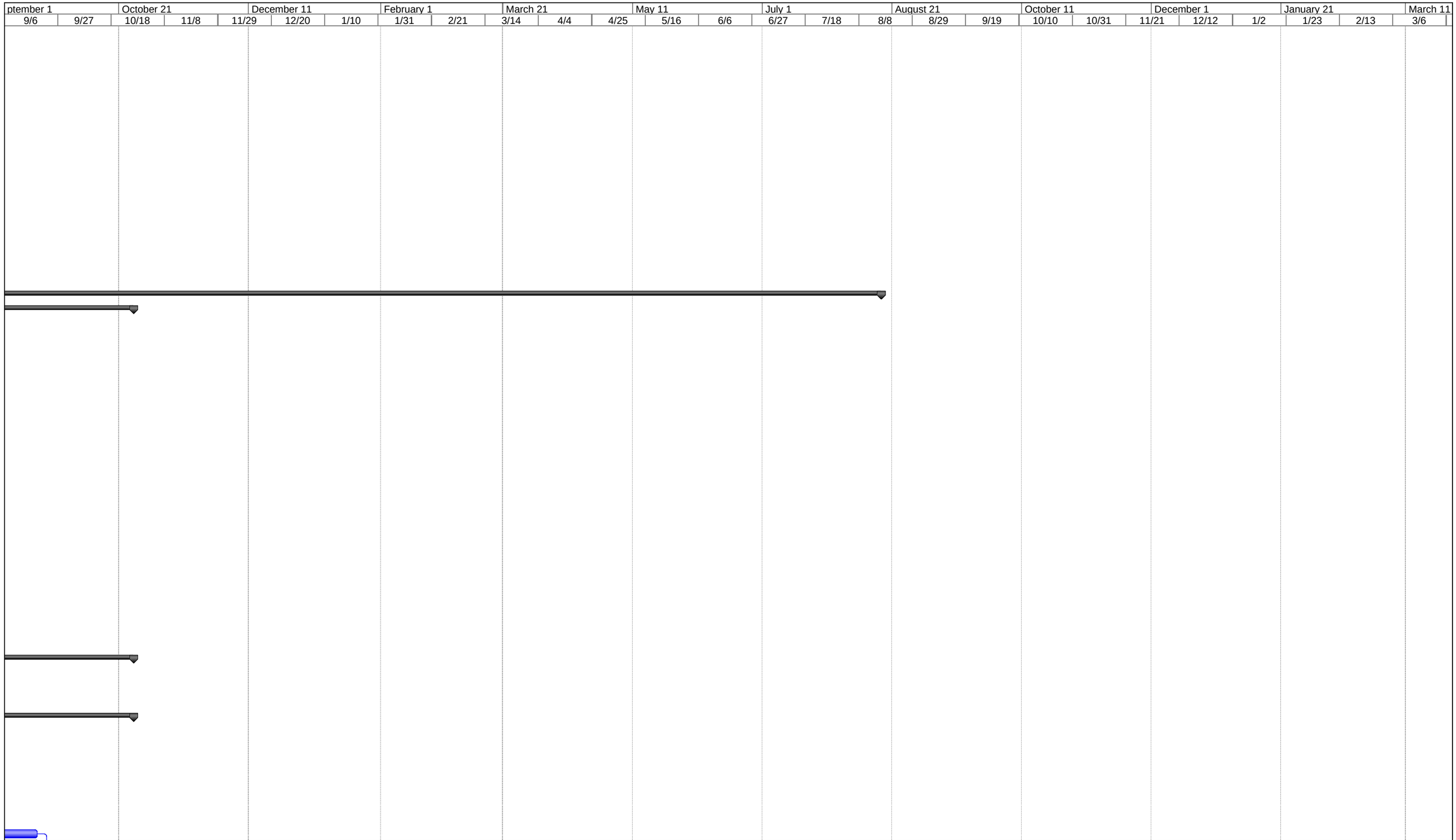
Task		Progress		Summary		External Tasks		Deadline
Split		Milestone		Project Summary		External Milestone	



Project: Sutter Basin Rev 1
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Task		Progress		Summary		External Tasks		Deadline	
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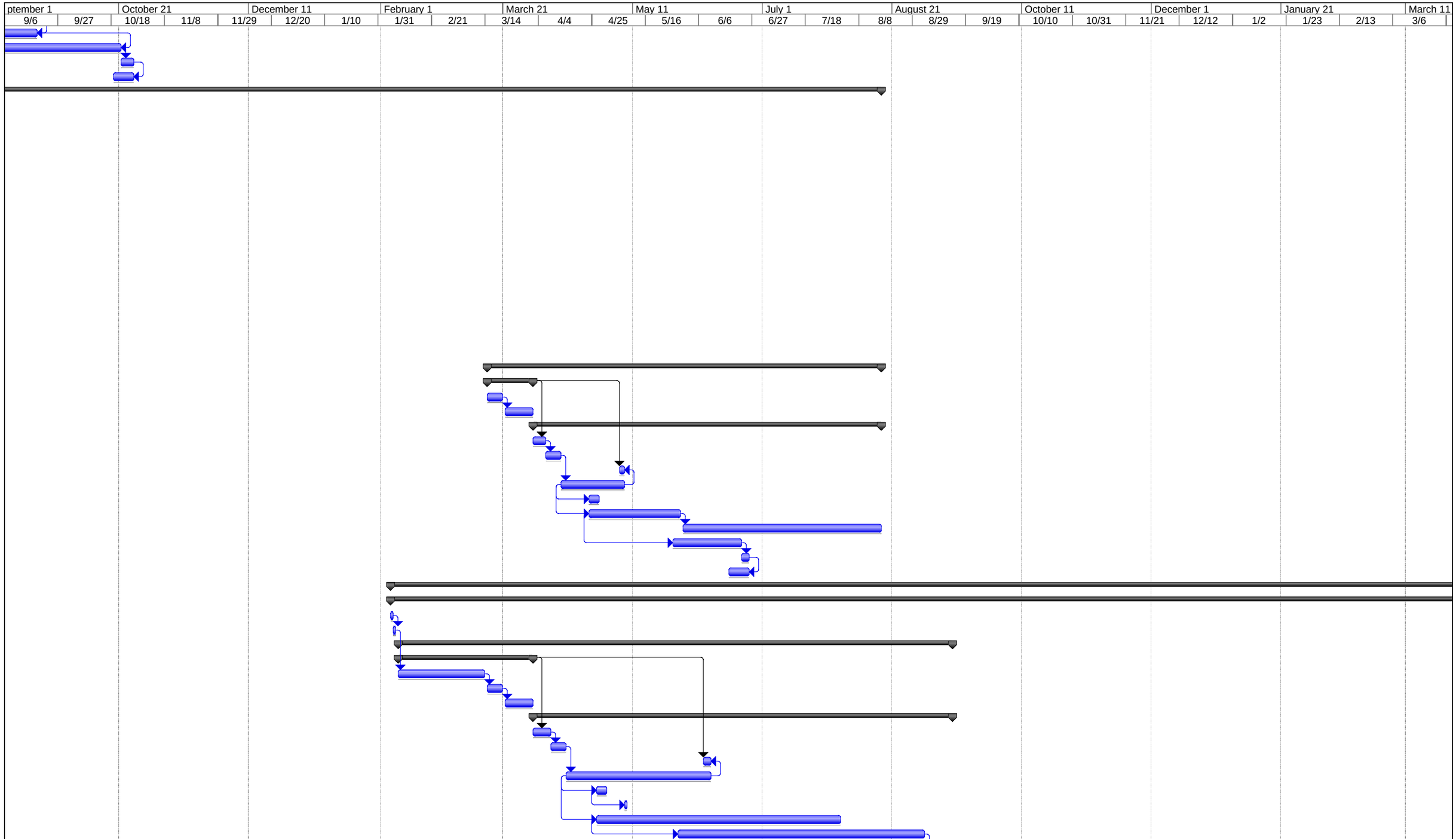

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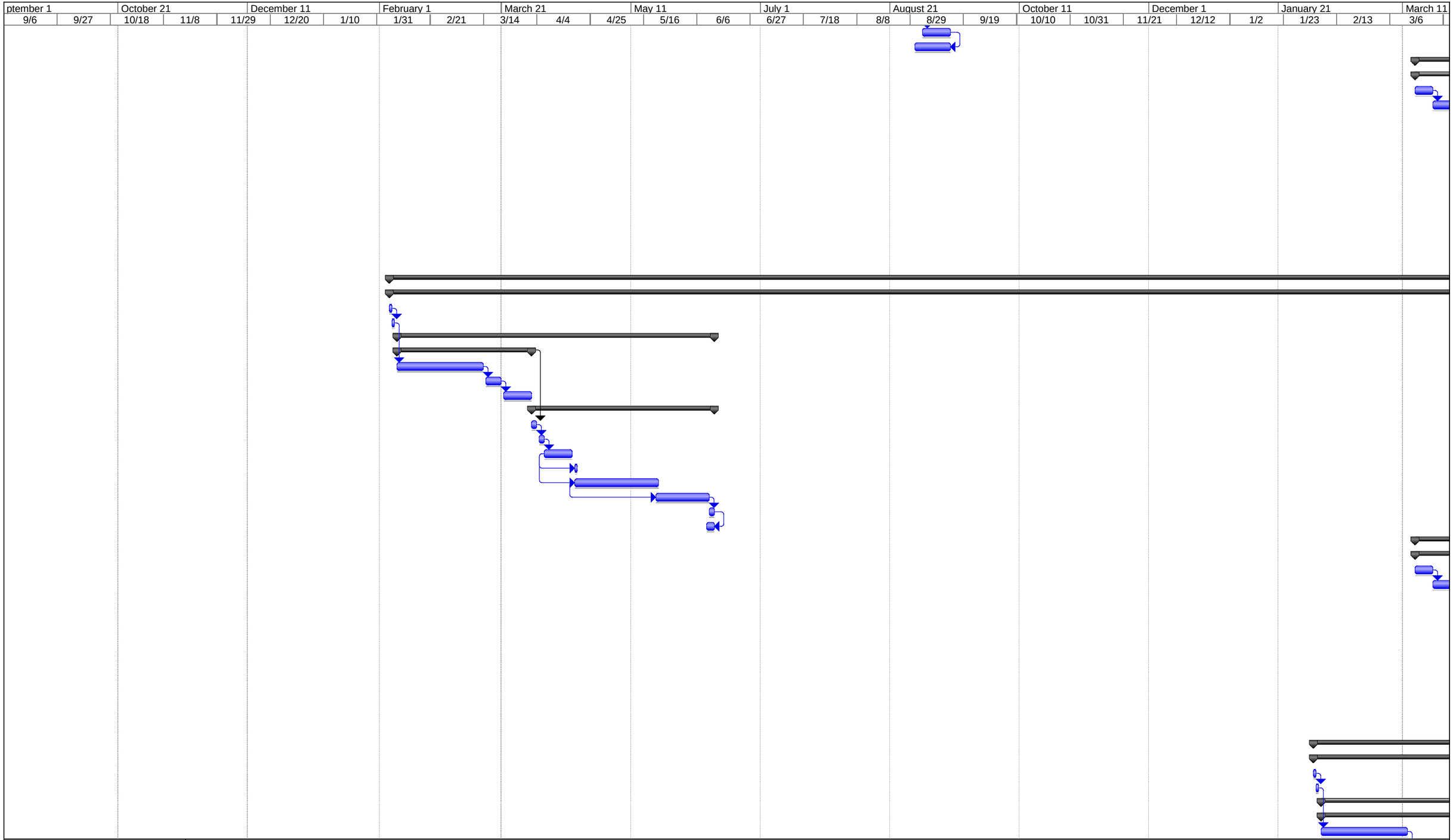

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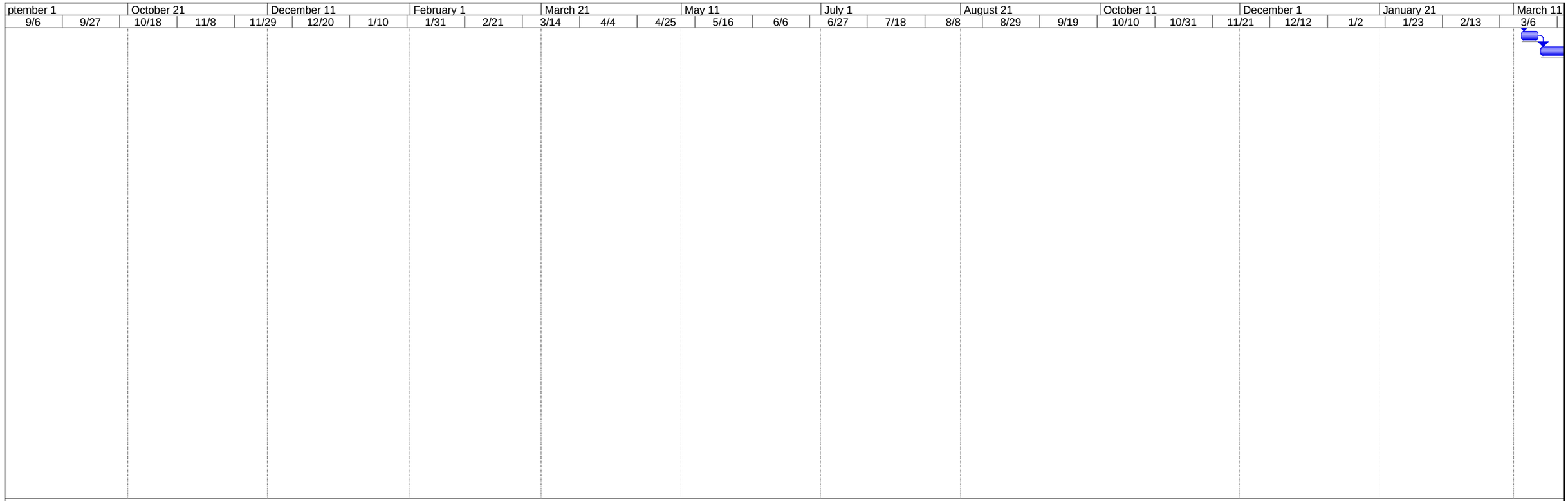

Project: Sutter Basin Rev 1
Date: Thu 3/14/13

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

		May 1		June 21		August 11		October 1		November 21		January 11		March 1		April 21		June 11		August 1		September 21	
3/27	4/17	5/8	5/29	6/19	7/10	7/31	8/21	9/11	10/2	10/23	11/13	12/4	12/25	1/15	2/5	2/26	3/19	4/9	4/30	5/21	6/11	7/2	7/23	8/13	9/3	9/24

Project: Sutter Basin Rev 1
Date: Thu 3/14/13

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

		May 1			June 21			August 11			October 1			November 21			January 11			March 1			April 21			June 11			August 1			September 21
3/27	4/17	5/8	5/29	6/19	7/10	7/31	8/21	9/11	10/2	10/23	11/13	12/4	12/25	1/15	2/5	2/26	3/19	4/9	4/30	5/21	6/11	7/2	7/23	8/13	9/3	9/24	

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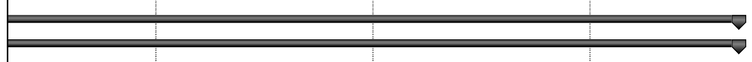
Split		Milestone		Project Summary		External Milestone			

		May 1			June 21			August 11			October 1			November 21			January 11			March 1			April 21			June 11			August 1			September 21
3/27	4/17	5/8	5/29	6/19	7/10	7/31	8/21	9/11	10/2	10/23	11/13	12/4	12/25	1/15	2/5	2/26	3/19	4/9	4/30	5/21	6/11	7/2	7/23	8/13	9/3	9/24	



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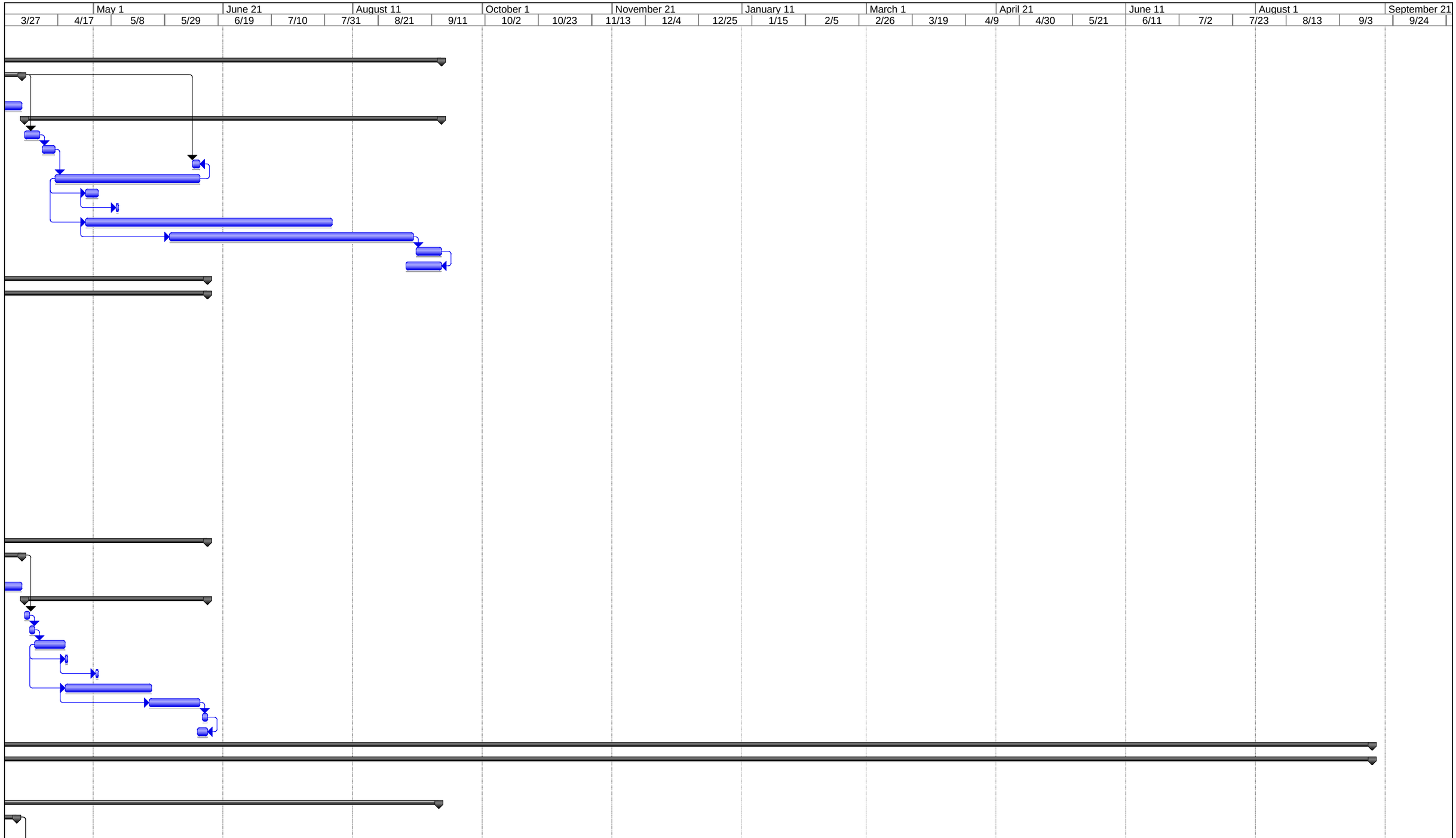

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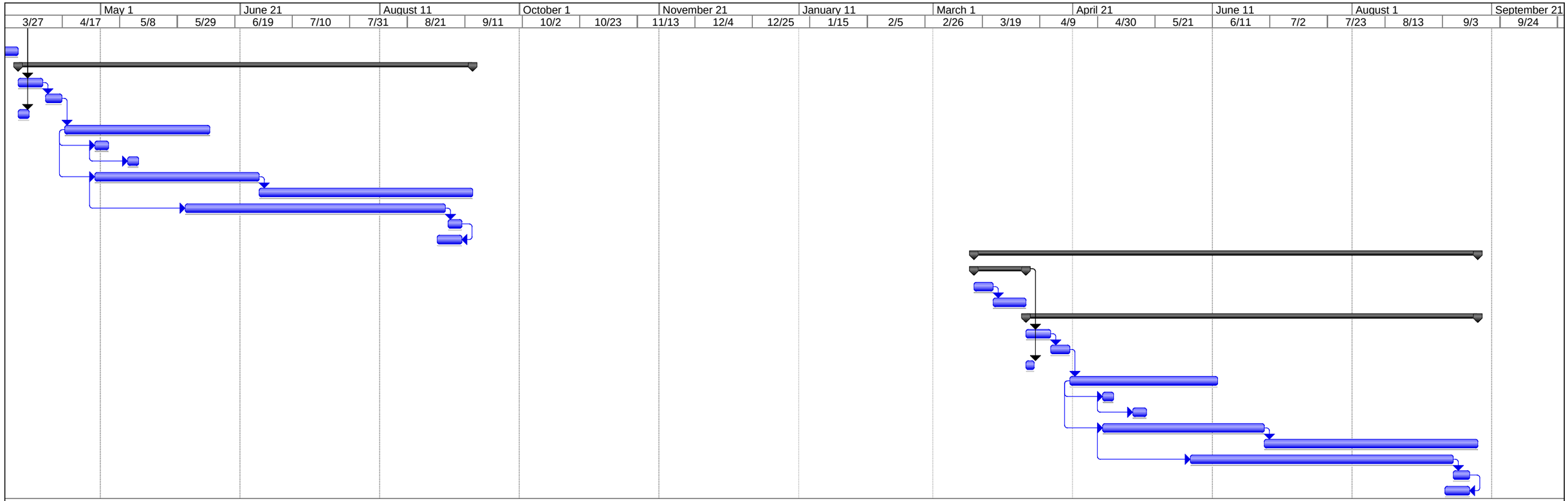

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Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

US Army Corps
of Engineers®

Sutter Basin Feasibility Study
Alternative Selection Plans
Project Cost and Schedule Risk Analysis Report

Prepared for:

U.S. Army Corps of Engineers,
Sacramento District

Prepared by:

U.S. Army Corps of Engineers
Cost Engineering Directory of Expertise, Walla Walla

March 5, 2013

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EXECUTIVE SUMMARY

Under the auspices of the U.S. Army Corps of Engineers (USACE), Sacramento District, this report presents a recommendation for the total project cost and schedule contingencies for the Sutter Basin Feasibility Study Alternatives (SB7 and SB8). In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis study was conducted for the development of contingency on the total project cost. The purpose of this risk analysis study was to establish project contingencies for both alternatives by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated total project costs.

Specific to the Sutter Basin project, the base case construction cost for SB7 (excluding Accounts 01 Lands and Damages, 30 Planning, Engineering and Design and 31 Construction Management) is estimated at approximately $232 Million and for SB8 is estimated at approximately $418 Million. Based on the results of the analysis, the Cost Engineering Mandatory Center of Expertise for Civil Works (Walla Walla District) recommends a contingency value of approximately $54.8 Million, or 31% for Alternative SB7 and approximately $96.1 Million, or 30% for Alternative SB8.

Walla Walla Cost MCX performed risk analysis using the *Monte Carlo* technique, producing the aforementioned contingencies and identifying key risk drivers.

The following tables ES-1, ES-2, and ES-3 portray the development of contingencies (30% overall). The contingency is based on an 80% confidence level, as per USACE Civil Works guidance.

Table ES-1A. Contingency Analysis Table – SB7

Base Cost Estimate	**$232,136,000**	
Confidence Level	**Value ($$)**	**Contingency (%)**
5%	$25,226,761	10.87%
50%	$54,903,347	23.65%
80%	**$72,460,184**	**31.21%**
95%	$88,905,272	38.30%

Table ES-1B. Contingency Analysis Table – SB8

Base Cost Estimate	**$418,285,000**	
Confidence Level	**Value ($$)**	**Contingency (%)**
5%	$41,103,162	9.83%
50%	$92,972,697	22.23%
80%	**$123,579,556**	**29.54%**
95%	$151,931,222	36.32%

The following table ES-2 portrays the full project costs of the SB7 and SB8. The costs are intended to address the congressional request of estimates to implement the project. The contingency is based on an 80% confidence level, as per accepted USACE Civil Works guidance.

Table ES-2A. Cost Summary – SB7

SUTTER BASIN FEATURE ACCOUNTS		COST ($1,000)	CNTG ($1,000)	TOTAL ($1,000)
01	LANDS AND DAMAGES	31,135	15,567	46,702
02	RELOCATIONS	47,416	14,699	62,115
06	FISH AND WILDLIFE FACILITIES	4,552	910	5,462
08	ROADS, RAILROADS & BRIDGES	1,790	555	2,345
11	LEVEES & FLOODWALLS	176,268	54,643	230,911
18	CULTURAL	2,110	654	2,764
30	PLANNING, ENGINEERING, AND DESIGN	41,791	12,865	54,656
31	CONSTRUCTION MANAGEMENT	19,733	6,075	25,808
	TOTAL PROJECT COSTS	**324,795**	**105,969**	**430,763**

Notes: 1) Costs include the recommended contingency of 31%.
2) Costs exclude O&M and Life Cycle Cost estimates.

Table ES-2B. Cost Summary – SB8

SUTTER BASIN FEATURE ACCOUNTS		COST ($1,000)	CNTG ($1,000)	TOTAL ($1,000)
01	LANDS AND DAMAGES	42,621	21,310	63,931
02	RELOCATIONS	138,900	41,670	180,570
06	FISH AND WILDLIFE FACILITIES	9,286	1,857	11,143
08	ROADS, RAILROADS & BRIDGES	2,526	758	3,284
11	LEVEES & FLOODWALLS	263,858	79,157	343,015
18	CULTURAL	3,715	1,115	4,830
30	PLANNING, ENGINEERING, AND DESIGN	75,288	22,419	97,707
31	CONSTRUCTION MANAGEMENT	35,555	10,588	46,143
	TOTAL PROJECT COSTS	**571,749**	**178,874**	**750,623**

Notes: 1) Costs include the recommended contingency of 30%.
2) Costs exclude O&M and Life Cycle Cost estimates.

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The key cost risk drivers identified through sensitivity analysis for both Alternatives SB7 and SB8 are CA-3 (Availability of Qualified Contractors) and CA-1 (Multiple Construction Contracts), which together contribute some 69 percent of the statistical cost variance.

> Availability of Qualified Contractors captures the risk of limited competition. Multiple other contracts with similar seepage cutoff wall construction could be ongoing at time of contract award, potentially limiting the pool of contractors available to perform the work, impacting the ultimate contract costs. Multiple Construction Contracts captures the risk funding constraints will require multiple construction contracts, resulting in construction inefficiencies (multiple mob/demobs) and increasing contract oversight and administration costs.

The key schedule risk drivers identified through sensitivity analysis both Alternatives SB7 and SB8 are CA-1 (Multiple Construction Contracts) and PPM-2 (Vertical Team Review and Approval), which together contribute some 72 percent of the statistical schedule variance.

> Multiple Construction Contracts captures the risk funding constraints will require multiple non-concurrent construction contracts, extending the time required to complete the total project. Vertical Team Review and Approval captures the risk high time demands on vertical teams have created a backlog of projects and resulting in the potential for delays in the approval process and subsequent schedule slips.

Recommendations, as detailed within the main report, include the implementation of cost and schedule contingencies, further iterative study of risks throughout the project life-cycle, potential mitigation throughout the PED phase, and proactive monitoring and control of risk identified in this study.

MAIN REPORT

1.0 PURPOSE

Under the auspices of the US Army Corps of Engineers (USACE), Sacramento District, this report presents a recommendation for the total project cost and schedule contingencies for alternatives for the Sutter Basin Study Project.

2.0 BACKGROUND

The Sutter Basin Study consists of levee remediation necessary to reduce flood risk to the Sutter Basin. The vast majority of levee remediation consists of seepage prevention by constructing a soil-bentonite slurry cutoff wall through the centerline of the levee and rebuild the levee to pre-project geometry. At some locations, seepage berm, relief wells, deep-soil-mixing, jet grout cutoff wall, canal relocation, and slight levee relocation to provide O&M access roads are included but they are minor relative to the soil-bentonite cutoff wall construction.

The Sutter Basin Feasibility Study considers three (3) Alternatives; Do Nothing; SB7, a Fix-in-Place alternative running for the Feather River West Levee from Sunset Weir to Laurel Avenue; and SB8, a Fix-in-Place alternative for the Feather River West Levee running from Thermalito Afterbay to Laurel Avenue (essentially SB7 plus the additional length from Thermalito Afterbay to Sunset Weir).

The primary project sponsors are the Sutter Butte Flood Control Agency (SBFCA). and the California Department of Water Resources (DWR).The work will likely be complete in 5-7 phases due to funding increment limitations. It is likely that the contracts will be acquired using a RFP procurement. The current construction schedule is approximately 24 months in duration. Construction of the first phase (Star Bend) has been started by the Sponsor with additional phases to begin construction in late FY 3013.

As a part of study effort, Sacramento District has requested that the USACE Cost Engineering Mandatory Center of Expertise for Civil Works (Cost Engineering MCX) provide a risk analysis study to establish the resulting contingencies.

3.0 REPORT SCOPE

The scope of the risk analysis report is to calculate and present the cost and schedule contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating

Guide for Civil Works. The report presents the contingency results for cost risks for all project features. The study and presentation does not include consideration for life cycle costs.

3.1 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the base case Micro Computer Aided Cost Estimating System (MCACES) cost estimate, schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

The project technical scope, estimates and schedules were developed and presented by the Sacramento District. Consequently, these documents serve as the basis for the risk analysis.

The scope of this study addresses the identification of problems, needs, opportunities and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering MCX. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, this risk analysis was performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering MCX.

- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.

- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.0 METHODOLOGY / PROCESS

The Walla Walla Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Sacramento District staff to provide information gathering. The Walla Walla Cost Engineering MCX facilitated an on-site risk identification meeting on January 24, 2013 with the Jacksonville District PDT to produce a risk register that served as the framework for the risk analysis. Participants in risk identification meeting included the following:

Name	Organization	Title
Peter Blodgett	USACE - SPK	Hydraulic Engineer
William Bolte	USACE - NWW	Cost Engineer (Risk Facilitator)
Jane Bolton	USACE - SPK	Geotechnical Engineer
Matt Davis	USACE - SPK	Environmental Engineer
Tri Duong	USACE - SPK	Cost Engineer
Mark Ellis	USACE - SPK	Project Manager
Miki Fujitsubo	USACE - SPK	Planner
Erik Gomez	USACE - SPK	Economist
S. Joe Griffin	USACE - SPK	Cultural Resources
Richard Kristof	USACE - SPK	Civil Engineer
Tung Le	USACE - SPK	Structural Engineer
Michael Musto	DWR	Sponsor Representative
Laurie Parker	USACE – SPK	Real Estate
David Peterson	PBI	Sponsor Representative

The first cost risk model was completed February 14, 2013. However, when final estimates were provided, the final results were completed and reported to Jacksonville on February 25, 2013.

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve the desired level of cost confidence. Per regulation and guidance, the P80 confidence level (80% confidence level) is the normal and accepted cost confidence level. District Management has the prerogative to select different confidence levels, pending approval from Headquarters, USACE.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost MCX guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

A formal PDT meeting was held with the Sacramento District office for the purposes of identifying and assessing risk factors. The meeting included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, design, environmental compliance, and real estate

The initial formal meetings focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Subsequent meetings focused primarily on risk factor assessment and quantification.

Additionally, numerous conference calls and informal meetings were conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment.

4.2 Quantify Risk Factor Impacts

The quantitative impacts of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions) because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in section 6 for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain

within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in quantifying the costs associated with the Lake Worth project.

a. The Sacramento District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) files and a summary Excel spreadsheet detailing all project costs by contract and serves as the basis for the final cost and schedule risk analyses.

b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the feasibility level.

c. Schedules are analyzed for impact to the project cost in terms of both uncaptured escalation (variance from OMB factors and the local market) and unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay. Specific to the Sutter Basin project, the schedule was analyzed only for impacts due to residual fixed costs.

d. The risk analyses accounted for escalation over and above the national average. Based on a detailed calculations for the Isabella Lake Project, Sacramento District has calculated California is 1.92% higher than CWCCIS, meaning that the average inflation for the project area is assumed to be 1.92% higher than the national average for inflation.

e. Per the data in the estimate, the Overhead percentage for the Prime Contractor is 10%, and 10% for the Subcontractors. Thus, the assumed residual fixed cost rate for this project is 10%. For the P80 schedule, this comprises approximately 22% of the total contingency and 7% of the base cost estimate (7.6% for SB7 and 6.6% for SB8). This is due to the accrual of residual fixed costs associated with delay associated with the implementation schedule.

f. The Cost MCX guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria

is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

g. Only high and moderate risk level impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Low level risk impacts should be maintained in project management documentation, and reviewed at each project milestone to determine if they should be placed on the risk "watch list".

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project cost at intervals of confidence (probability).

Table 1 provides the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes only.

Table 1A. Construction Cost Contingency Summary – SB7

Risk Analysis Forecast	Total Construction Cost	Total Contingency[1,2] ($)	Total Contingency (%)
50% Confidence Level			
Construction Cost	$287,039,347	$54,903,347	23.65%
80% Confidence Level			
Construction Cost	$304,596,184	$72,460,184	31.21%
100% Confidence Level			
Construction Cost	$362,901,294	$130,765,294	56.33%

Notes:
1) These figures combine uncertainty in the baseline cost estimates and schedule.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

Table 1B. Construction Cost Contingency Summary – SB8

Risk Analysis Forecast	Total Construction Cost	Total Contingency[1,2] ($)	Total Contingency (%)
50% Confidence Level			
Construction Cost	$511,257,697	$92,972,697	22.23%
80% Confidence Level			
Construction Cost	$541,864,556	$123,579,556	29.54%
100% Confidence Level			
Construction Cost	$641,895,283	$223,610,283	53.46%

Notes:
1) These figures combine uncertainty in the baseline cost estimates and schedule.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register,

sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register. Likewise, Figure 2 presents a sensitivity analysis for schedule growth risk from the high level schedule risks identified in the risk register.

6.3 Schedule and Contingency Risk Analysis

Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes.

Schedule duration contingency was quantified as 29 months for SB7 and 33 months for SB8 based on the P80 level of confidence. These contingencies were used to calculate the projected residual fixed cost impact of project delays that are included in the Table 1 presentation of total cost contingency. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented. Schedule contingency impacts presented in this analysis are based solely on projected residual fixed costs.

Table 2A. Schedule Duration Contingency Summary – SB7

Risk Analysis Forecast	Baseline Schedule Duration (months)	Contingency[1] (months)
50% Confidence Level		
Project Duration	60	20
80% Confidence Level		
Project Duration	60	29
100% Confidence Level		
Project Duration	60	59

Notes:
1) The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented in Table 2.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

Table 2A. Schedule Duration Contingency Summary – SB8

Risk Analysis Forecast	Baseline Schedule Duration (months)	Contingency[1] (months)
50% Confidence Level		
Project Duration	84	23
80% Confidence Level		
Project Duration	84	33
100% Confidence Level		
Project Duration	84	65

Notes:
1) The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented in Table 2.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

Figure 1A. Cost Sensitivity Analysis – SB7

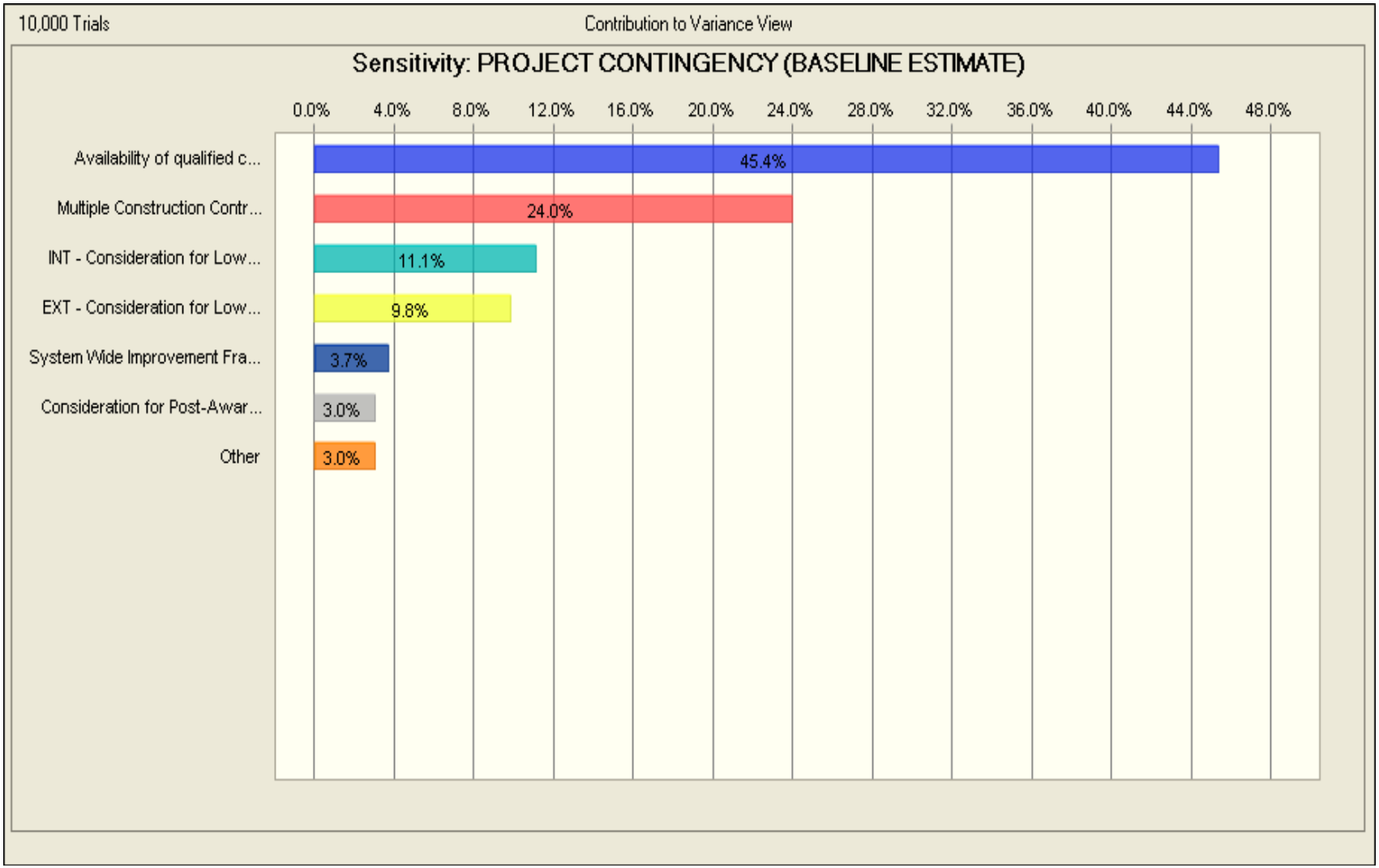


Figure 1B. Cost Sensitivity Analysis – SB8

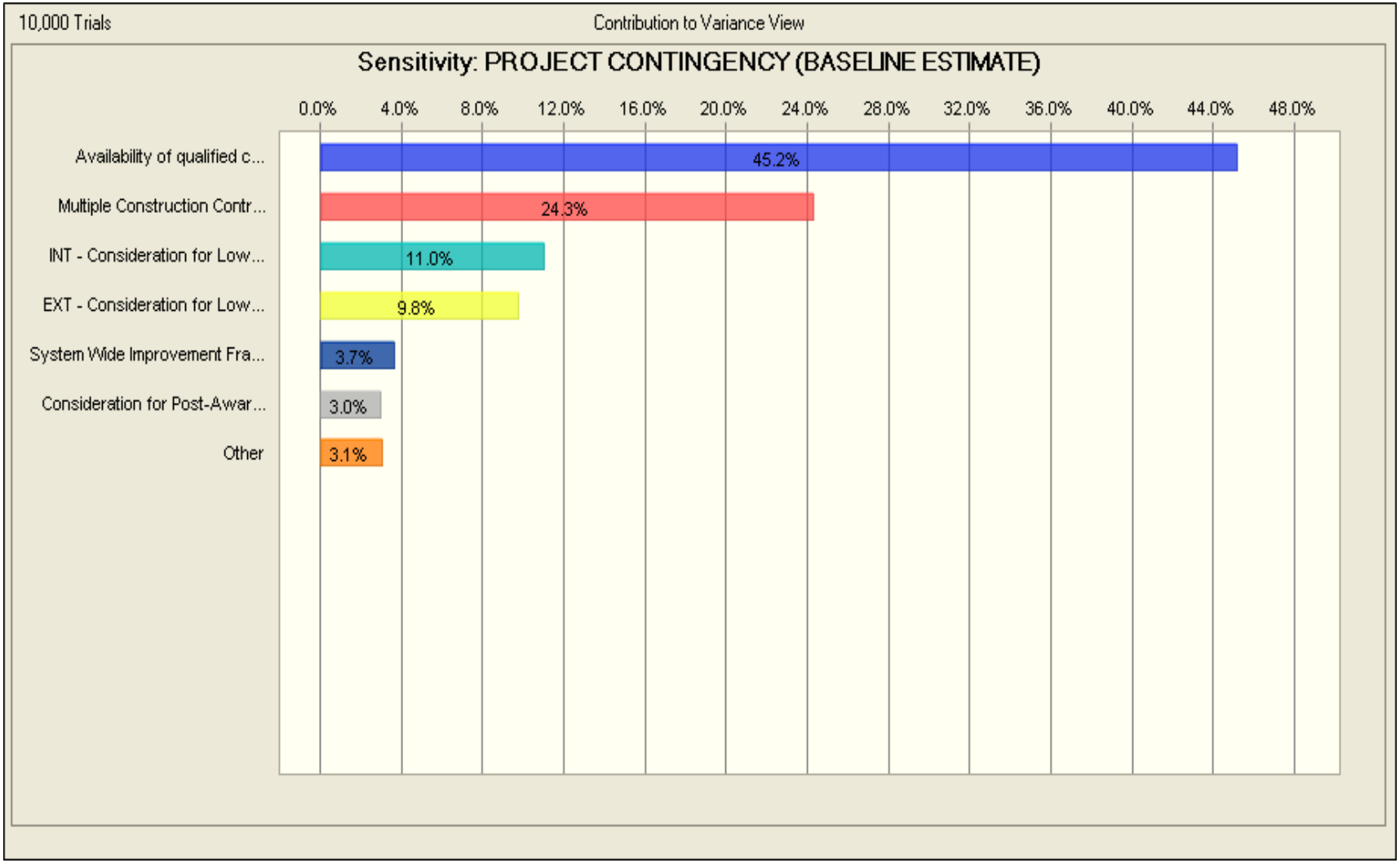


Figure 2A. Schedule Sensitivity Analysis – SB7

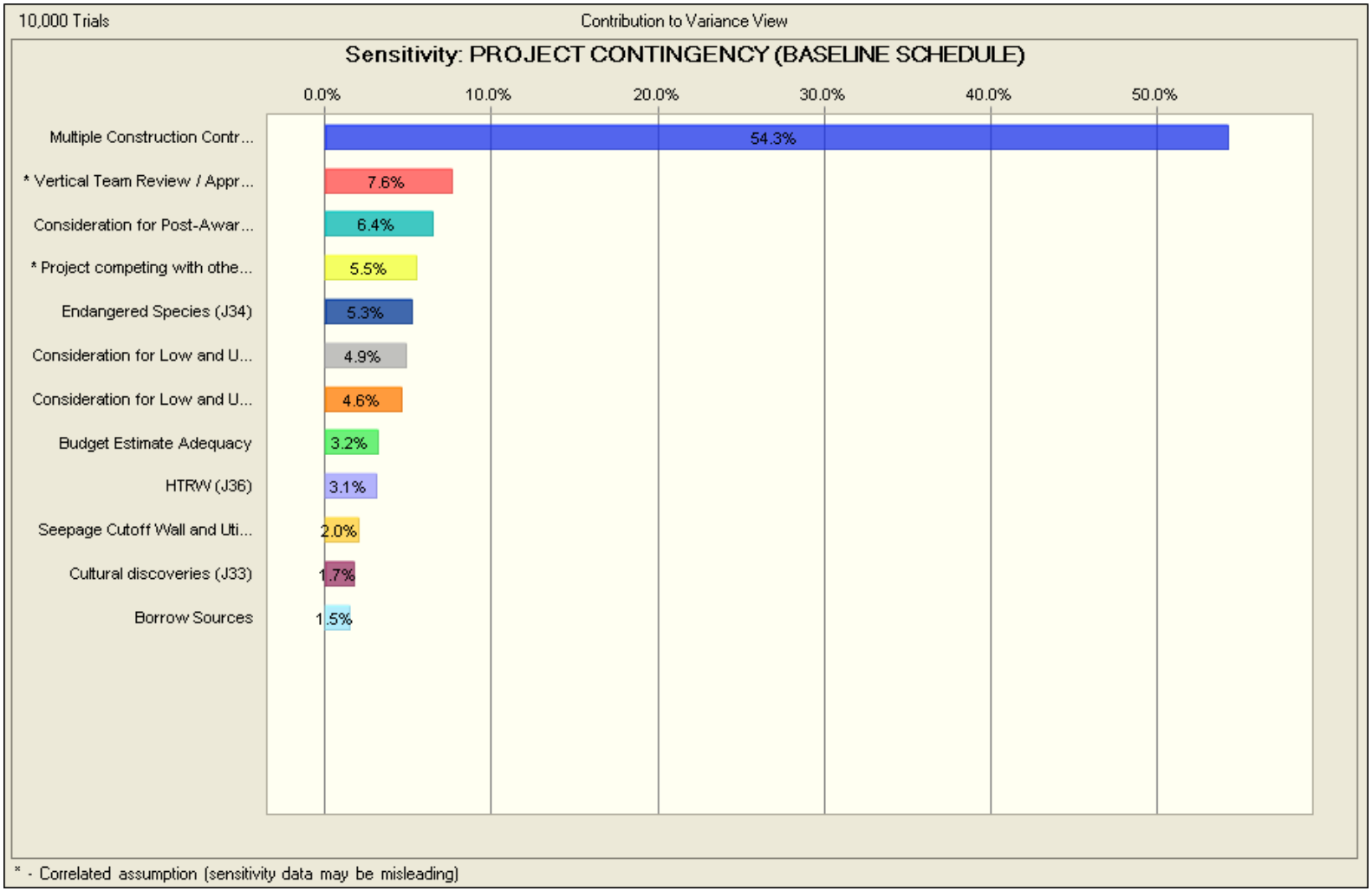
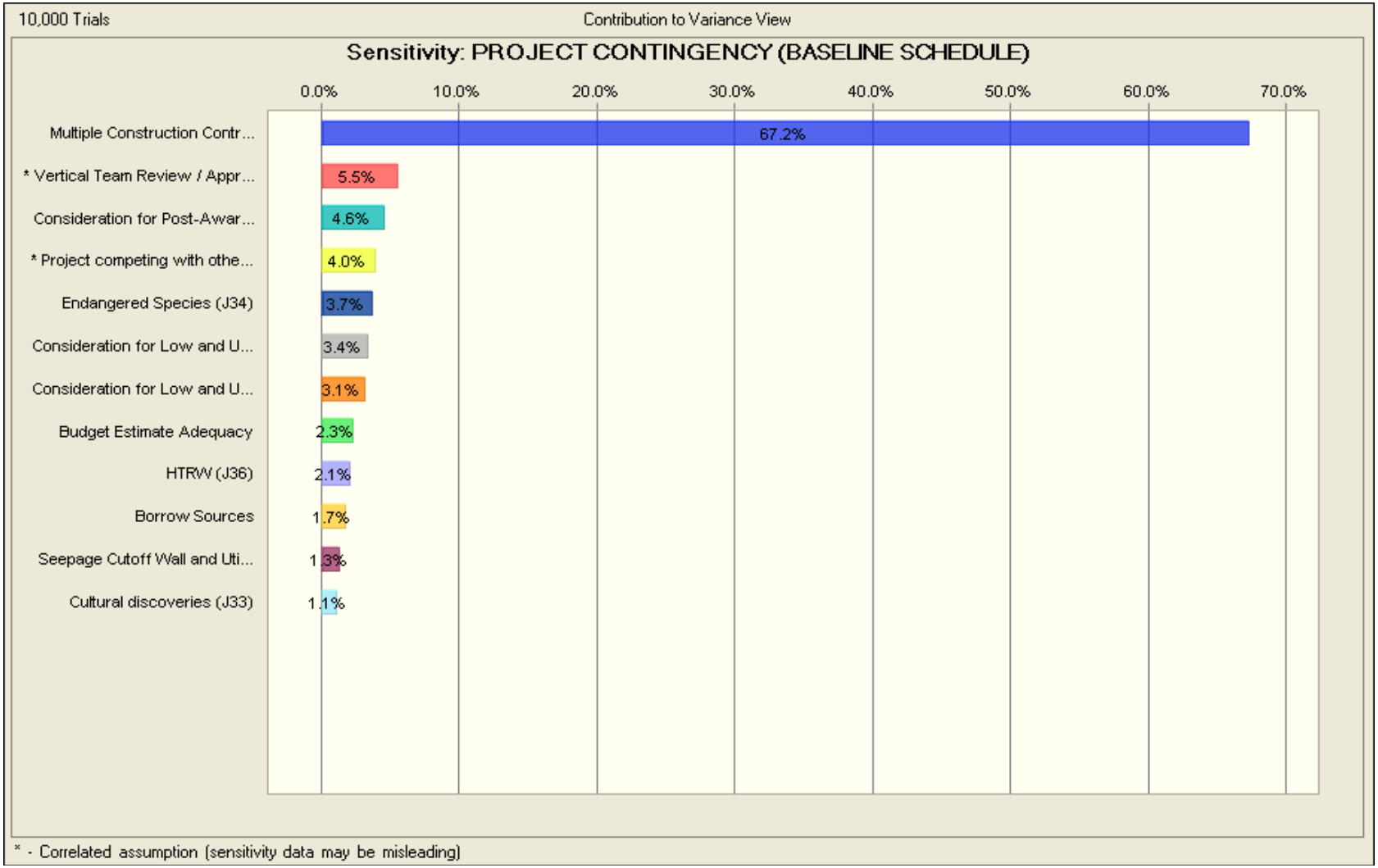


Figure 2B. Schedule Sensitivity Analysis – SB8



7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.1 Major Findings/Observations

Project cost comparison summaries are provided in Table 3 and Figure 3. Additional major findings and observations of the risk analysis are listed below.

1. The key cost risk drivers identified through sensitivity analysis for both Alternatives SB7 and SB8 are CA-3 (Availability of Qualified Contractors) and CA-1 (Multiple Construction Contracts), which together contribute 69 percent of the statistical cost variance.

2. The key schedule risk drivers identified through sensitivity analysis for both Alternatives SB7 and SB8 are CA-1 (Multiple Construction Contracts) and PPM-2 (Vertical Team Review and Approval), which together contribute some 72 percent of the statistical schedule variance.

3. Operation and maintenance activities were not included in the cost estimate or schedules. Therefore, a full life cycle risk analysis could not be performed. Risk analysis results or conclusions could be significantly different if the necessary operation and maintenance activities were included.

Table 3A. SB7 - Construction Cost Comparison Summary (Uncertainty Analysis)

Confidence Level	Project Cost ($)	Contingency ($)	Contingency (%)
P0	**$231,262,557**	**($873,443)**	**-0.38%**
P5	**$257,362,761**	**$25,226,761**	**10.87%**
P10	**$263,204,676**	**$31,068,676**	**13.38%**
P15	**$267,534,510**	**$35,398,510**	**15.25%**
P20	**$270,907,713**	**$38,771,713**	**16.70%**
P25	**$274,089,072**	**$41,953,072**	**18.07%**
P30	**$276,918,764**	**$44,782,764**	**19.29%**
P35	**$279,554,471**	**$47,418,471**	**20.43%**
P40	**$282,117,856**	**$49,981,856**	**21.53%**
P45	**$284,601,805**	**$52,465,805**	**22.60%**
P50	**$287,039,347**	**$54,903,347**	**23.65%**
P55	**$289,705,708**	**$57,569,708**	**24.80%**
P60	**$292,429,102**	**$60,293,102**	**25.97%**
P65	**$295,117,798**	**$62,981,798**	**27.13%**
P70	**$298,003,545**	**$65,867,545**	**28.37%**
P75	**$301,009,741**	**$68,873,741**	**29.67%**
P80	**$304,596,184**	**$72,460,184**	**31.21%**
P85	**$308,624,805**	**$76,488,805**	**32.95%**
P90	**$313,441,223**	**$81,305,223**	**35.02%**
P95	**$321,041,272**	**$88,905,272**	**38.30%**
P100	**$362,901,294**	**$130,765,294**	**56.33%**

Table 3B. SB8 - Construction Cost Comparison Summary (Uncertainty Analysis)

Confidence Level	Project Cost ($)	Contingency ($)	Contingency (%)
P0	**$414,651,794**	**($3,633,206)**	**-0.87%**
P5	**$459,388,162**	**$41,103,162**	**9.83%**
P10	**$469,738,038**	**$51,453,038**	**12.30%**
P15	**$477,101,810**	**$58,816,810**	**14.06%**
P20	**$483,034,512**	**$64,749,512**	**15.48%**
P25	**$488,557,056**	**$70,272,056**	**16.80%**
P30	**$493,575,567**	**$75,290,567**	**18.00%**
P35	**$497,957,376**	**$79,672,376**	**19.05%**
P40	**$502,479,814**	**$84,194,814**	**20.13%**
P45	**$506,930,492**	**$88,645,492**	**21.19%**
P50	**$511,257,697**	**$92,972,697**	**22.23%**
P55	**$515,904,784**	**$97,619,784**	**23.34%**
P60	**$520,615,471**	**$102,330,471**	**24.46%**
P65	**$525,519,906**	**$107,234,906**	**25.64%**
P70	**$530,601,173**	**$112,316,173**	**26.85%**
P75	**$535,912,404**	**$117,627,404**	**28.12%**
P80	**$541,864,556**	**$123,579,556**	**29.54%**
P85	**$548,697,090**	**$130,412,090**	**31.18%**
P90	**$557,358,458**	**$139,073,458**	**33.25%**
P95	**$570,216,222**	**$151,931,222**	**36.32%**
P100	**$641,895,283**	**$223,610,283**	**53.46%**

Figure 3A. SB7 - Project Cost Summary (Uncertainty Analysis)

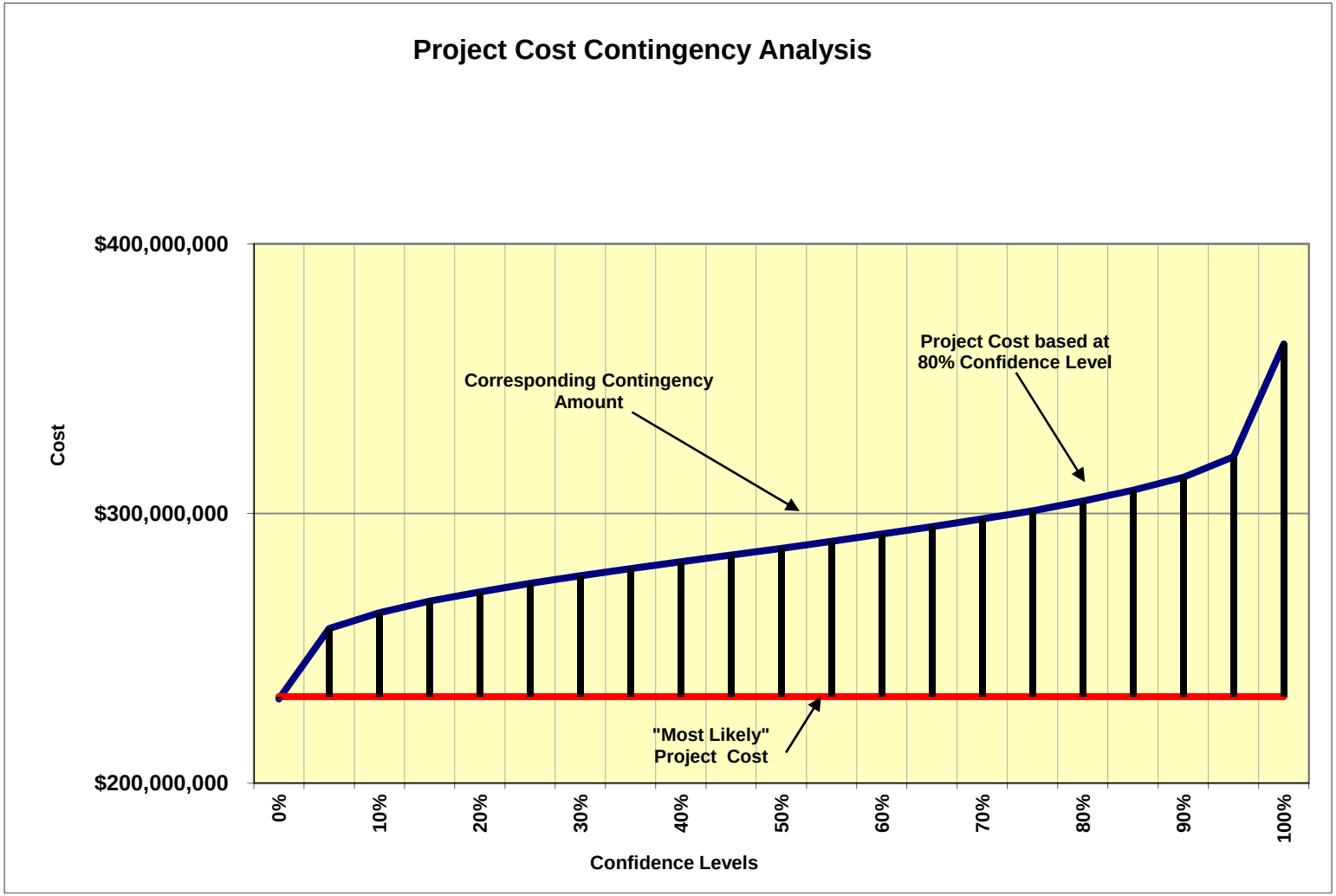


Figure 3B. SB8 - Project Cost Summary (Uncertainty Analysis)

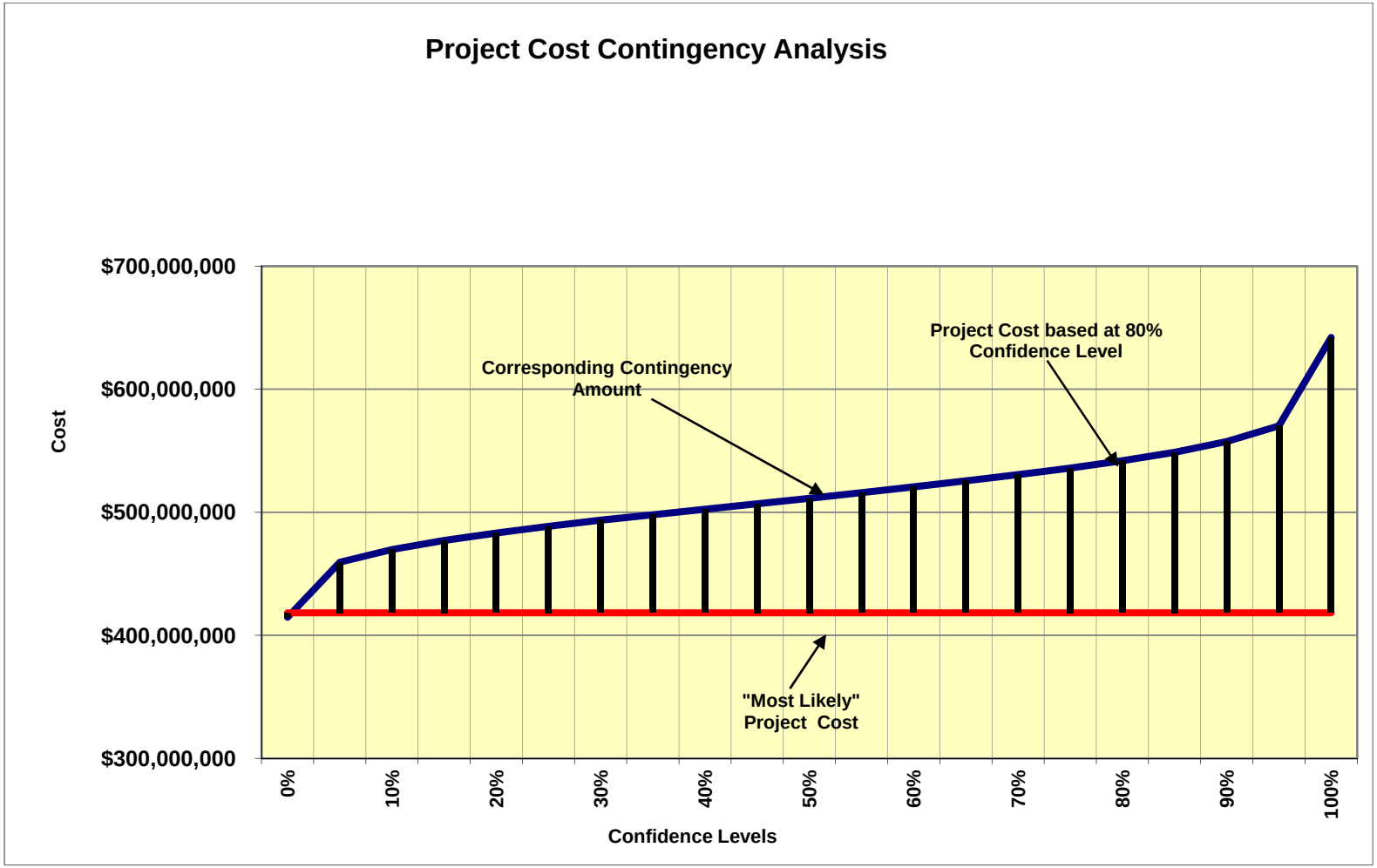


Figure 4A. SB7 - Project Duration Summary (Uncertainty Analysis)

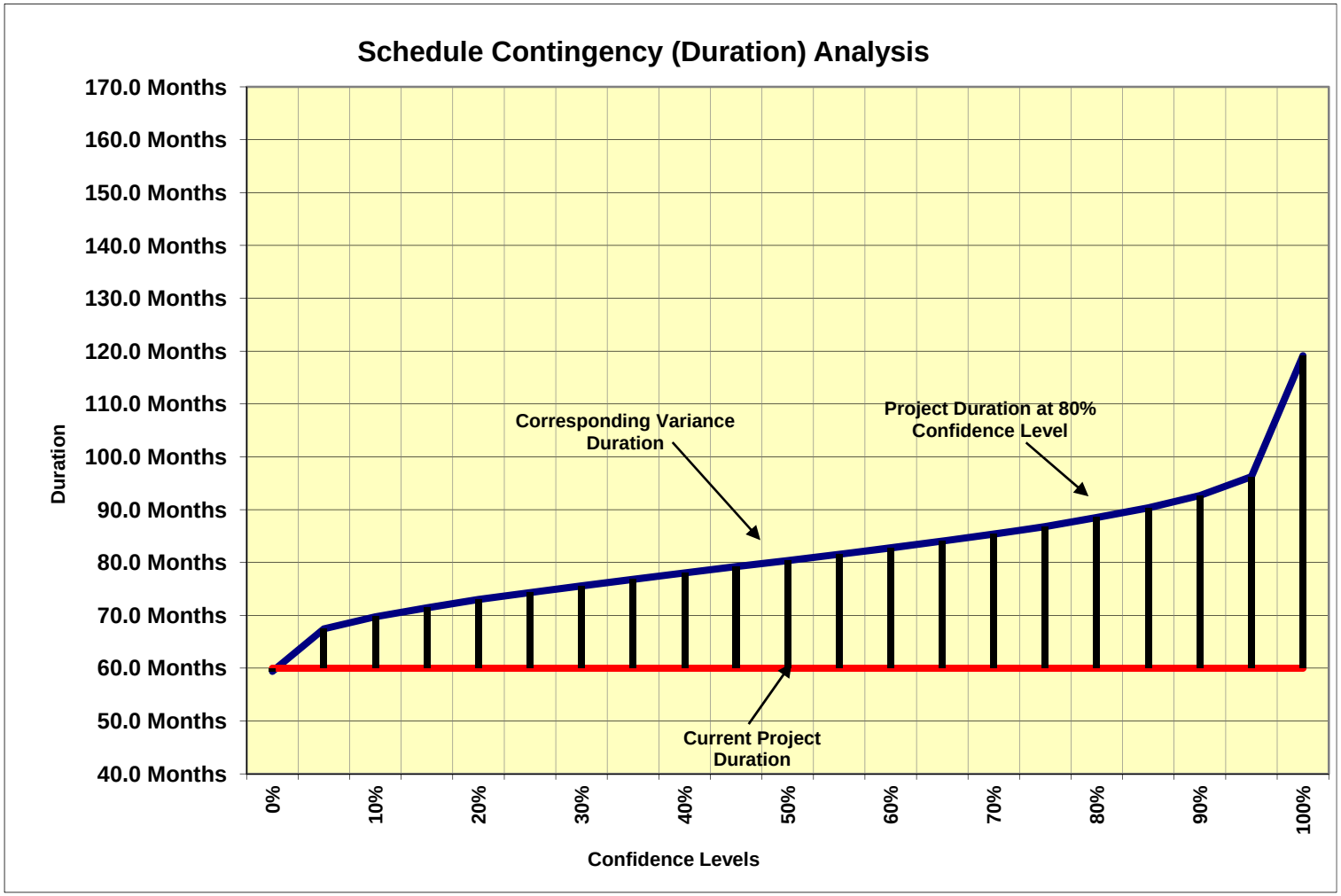
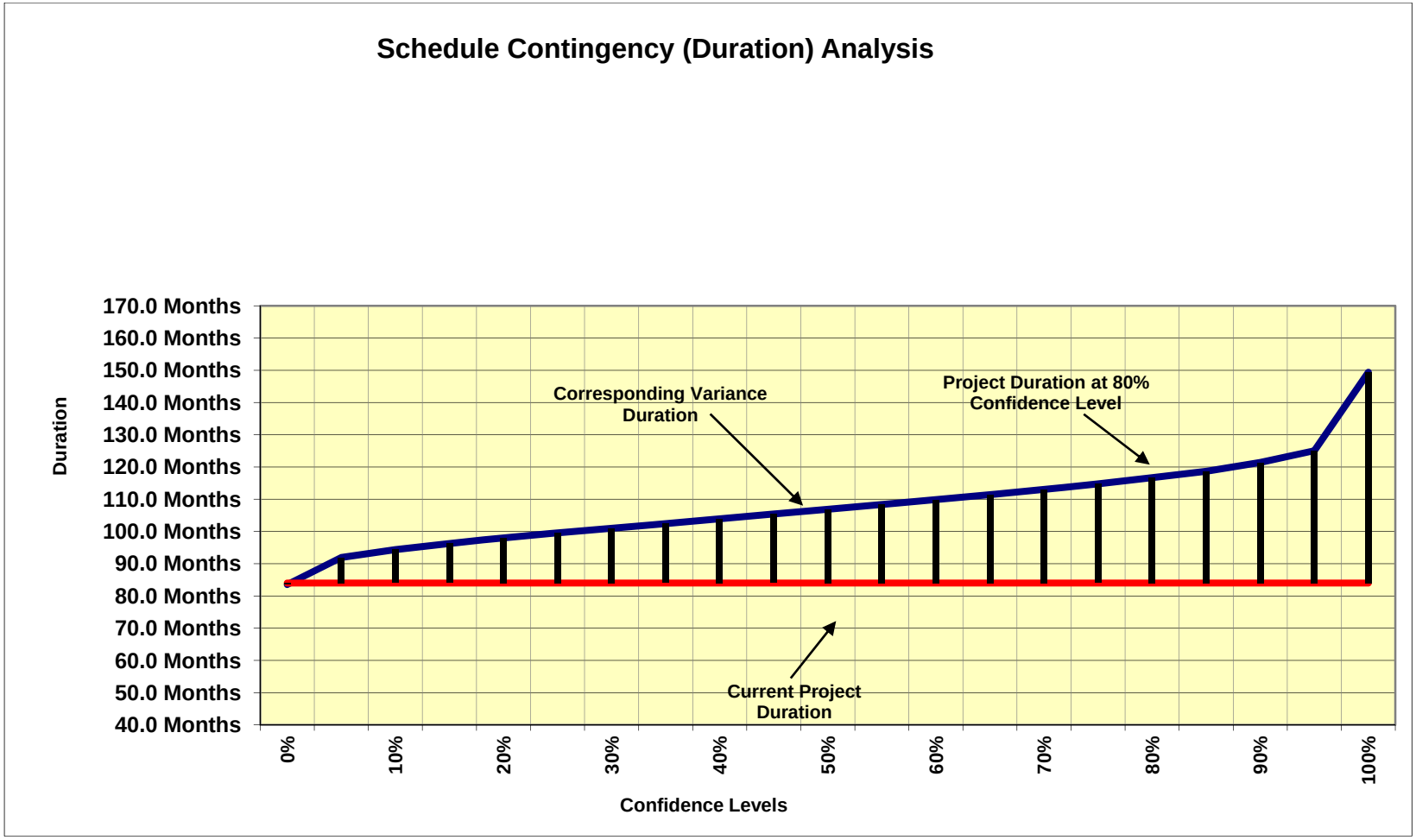


Figure 4B. SB8 - Project Duration Summary (Uncertainty Analysis)



7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*, *4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

1. Key Cost Risk Drivers: The key cost risk drivers identified through sensitivity analysis for both Alternatives SB7 and SB8 are CA-3 (Availability of Qualified Contractors) and CA-1 (Multiple Construction Contracts), which together contribute 69 percent of the statistical cost variance.

a) Availability of Qualified Contractors: There is inherent risk that the ultimate bidding climate at the time of award of future contracts will be unfavorable to the price, as compared to the current working estimates of contract price. The PDT should continue to perform market research and analysis of trends within the construction industry. Ultimately, this uncertainty cannot be mitigated until more information is available. This should be communicated to management, and an adequate amount of contingency should be reserved to capture this risk.

b) Multiple Construction Contracts (Funding Constraints): Project leadership should take proactive measures to obtain decisions regarding funding and acquisition strategy, as well as communication to management regarding the impact of those decisions on cost performance.

2. Key Schedule Risk Drivers: The he key schedule risk drivers identified through sensitivity analysis for both Alternatives SB7 and SB8 are CA-1 (Multiple Construction Contracts) and PPM-2 (Vertical Team Review and Approval), which together contribute some 72 percent of the statistical schedule variance.

a) Multiple Construction Contracts (Funding): Project leadership should take proactive measures to obtain decisions regarding funding and acquisition strategy, as well as communication to management regarding the impact of those decisions on schedule performance.

b) Vertical Team Review and Approval: Project leadership should proactively coordinate and communicate with Management (both at the District, Division and Headquarters). Ultimately, an amount and duration for this issue should be included and protected within the contingency and/or management reserve.

3. Risk Management: Project leadership should use of the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

4. Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

APPENDIX A

Sutter Basin - SB7

Risk Level

Likelihood of Occurrence	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	High	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Low	High

Impact or Consequence of Occurrence

Project Scope Narrative:

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule			Responsibility/POC
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*	
Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)										
	PROJECT & PROGRAM MGMT									
PPM-1	Project competing with other priorities	PDT Design Resources. District has assigned key personnel to various projects. Sutter Pilot study is one of two pilot studies in the nation, so has become a higher priority project. Project Feasibility Study is only funded through FY 13. The schedule currently reflects a Sept 30 Chiefs Report.	With time "priority" status has diminished. Competition for resources will remain an issue through completion of feasibility study. At this point, September 30 competition is likely but review process and unforeseen issues remain possible. A delay into next FY could significantly impact schedule due to unknown availability of future feasibility stud funding after September 30.	Very Unlikely	Negligible	LOW	Unlikely	Critical	MODERATE	Project Manager
PPM-2	Vertical Team Review / Approval Process	Vertical Team review and approval (outside of District control) is required to meet critical milestones.	High demands on vertical teams have created a backlog of projects and pilot projects have lost much of their "priority" status.	Very Unlikely	Negligible	LOW	Likely	Critical	HIGH	Project Manager
PPM-3	PED Phase Staffing / Funding	Majority of design is being performed as in-kind work by the sponsor. Non-Federal Sponsor funding is in place and has not been an issue; minimal risks design will be delayed for funding o staffing issues.		Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Project Manager
	CONTRACT ACQUISITION RISKS									
CA-1	Multiple Construction Contracts	SB-8 Construction Contracts currently divided into 5 contracts with most ~$50-$60 Million. Contracts may need to be divided into smaller increments resulting in increased construction costs, government oversight and construction schedules.	Sponsor will proceed ahead with 221 Crediting agreement, working ahead of Federal Funding.	Likely	Significant	HIGH	Likely	Significant	HIGH	Contracting
CA-2	Incremental Construction Schedule	Fixing the highest risk areas with long delays between projects (5 years or more) could result in last contracts not being completed due to B/C ratios no longer being beneficial.	Projects going beyond 5 years and subject to economic re-evaluation can become problematic.	Very Unlikely	Significant	LOW	Very Unlikely	Negligible	LOW	Contracting
CA-3	Availability of qualified contractors.	Number of seepage cutoff wall contractors could be limited slowing either schedule (insufficient equipment) or increasing cos (limited competition).	It is the opinion of the PDT that equipment will be available, but limited qualified contractors could lead to moderately higher costs.	Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW	Contracting
	TECHNICAL RISKS									
TL-1	Borrow Sources	It has been difficult to find willing landowners to acquire impermeable (clay) borrow material. Cost estimate assumes borrow sources are available and within 25-50miles round trip. Haul could be as much as 100 miles round trip or more. Sponsor may also require additional lengths of time finding "willing" borrow sites.	Real Estate estimate has included a relatively high contingency for procurement of borrow sites.	Likely	Significant	HIGH	Likely	Marginal	MODERATE	Geotechnical/Civil Design
TL-2	Changes in Geomorphology	Riprap protection for scour issues has not been included in the current design. It is assumed that any future scour issues, when they occur, will be covered with O&M funding.		Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Geotechnical/Civil Design

TL-3	Utility Crossings	Pipe penetrations will be removed and replaced but not necessarily to USACE current design guidance. For example, some large pump stations will not be remodeled to up-and-over type pipe penetrations.	Current project design is sufficient. Given the impracticality of meeting all criteria, design waivers will be acquired and USACE criteria will not dictate future design modifications.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Geotechnical/Civil Design
TL-4	Utility Relocations	Time requirement for coordination of relocation of utility poles could be extensive.	Sponsor is confident relocations will not impact construction award schedules.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Geotechnical/Civil Design
TL-5	O&M Access Road	Current design assumes a 10ft to 20ft land acquisition along the entire length of the toe of the levee for an O&M access road and vegetation free zone.	Real Estate estimate assumes a worst case cost (max land acquisition) but enough uncertainties remain that no potentia cost savings will be included.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Geotechnical/Civil Design
TL-6	Utility Corridor	Several areas will require relocation of existing utilities outside th flood critical areas.	Real Estate contingency accounts for additional reaches requiring utility corridor easements.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Geotechnical/Civil Design
TL-7	Soil Bentonite Seepage Cutoff Wall	Design assumes Soil Bentonite Cutoff wall with jet grouting at bridge and railroad crossings. This design is robust enough that any changes in design methodology will not result in cost or schedule increases.	Cost estimate assumes long stick excavation for depths up to 75' design depth and Deep Soil mixing for deeper cutoff walls.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Geotechnical/Civil Design
	LANDS AND DAMAGES RISKS									
LD-1	Real Estate - Utility Corridors	Majority of work is on existing levee already owned by the sponsor. Real Estate has assumed 10 ft to 20 ft permanent real estate acquisition (riverside and landside) for O&M access road and vegetation free zone. Real Estate estimate does not include baseline costs for utility relocation corridors.	Real Estate contingency accounts for additional reaches requiring utility corridor easements. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Real Estate
LD-2	Real Estate - Irrigation Canal and Levee Relocations	Real Estate estimate does not include baseline costs for irrigation canal relocation corridors.	Real Estate contingency accounts for additional relocations. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Real Estate
LD-3	Real Estate - Structural Relocations	Real Estate estimate does not include demolition costs for potential structural relocations.	There is a placeholder cost of $1,920,460 in the appraisal. When buildings are impacted it is not unusual for agencies to acquire the entire property (land/building) and make necessary changes--- altering or raising the buildings and than resale the remainder. This helps to alleviate the time and cost associated with litigation or working with property owners. It is less costly to acquire the entire property when improvements will be impacted versus trying to modify the existing improvements and compensating property owners for damages. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Real Estate
LD-4	Real Estate - Temporary Construction Easements	Temporary construction easements have been assumed along the length of the levee construction.	Staging areas have been identified already in the project area. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Real Estate
	REGULATORY AND ENVIRONMENTAL									
RE-1	Air quality	Contractor will require newer equipment to meet air quality requirement, but air quality credits aren't anticipated. Anticipate qualified California contractor will have worked previous projects with appropriate equipment.		Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Environmental
RE-2	Known cultural Sites	Estimate includes 1% for cultural impacts	Historical structures downtown will require vibration monitoring.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Environmental
RE-3	Cultural discoveries	Cost Estimate includes 1% for cultural investigations.	Majority of work will occur in existing levees, but it is still possible cultural discoveries could be made during construction. Cultural reconnaissance will occur prior to construction and limit possibility of discovery during construction. If cultural discoveries are made, construction must stop in that area. Cultural discovery must be resolved before construction can resume in that reach. IF discovery is made anticipate 3 to 6 month impact. Some 3 miles of Levee and Canal Realignment are required through new previously untouched regions; but greater cultural reconnaissance will be conducted in these areas minimizing potential schedule impacts.	Unlikely	Significant	MODERATE	Likely	Marginal	MODERATE	Environmental

RE-4	Endangered Species	Construction windows are constrained by Federal and State endangered species windows. Work is currently scheduled outside most species windows but Swainson's Hawk will nest in early spring and fledge in early September.	There is the possibility work could be halted around any nesting areas. Bird surveys may be conducted the prior year to determine risk. (Construction schedule for Irrigation canal Jan-March and Levee April - October).	Very Unlikely	Negligible	LOW	Likely	Marginal	MODERATE	Environmental
RE-5	Historic Structures	There are a number of historical structures that may or may not need to be relocated, specifically in Yuba City.	Cultural inventories will identify historic structures and assess possible adverse effects. If a historic structure is identified for relocation mitigation for that resources would be governed by a Memorandum of Agreement coordinated with SHPO.	Likely	Negligible	LOW	Very Unlikely	Negligible	LOW	Environmental
RE-6	HTRW	There may be HTRW sites that are unknown	It is unlikely that HTRW waste be encounter. If HTRW waste is encountered in would not affect cost but the schedule may be affected.	Unlikely	Marginal	LOW	Unlikely	Significant	MODERATE	Environmental
	CONSTRUCTION RISKS									
CON-1	Seepage Cutoff Wall and Utility Penetrations	Replacement construction of Utility Penetration can't begin until after seepage cutoff wall construction has been completed possibly resulting in long periods of temporary service. Costs have been included for temporary up-and-over services for a limited number of sites (4months each site) .	SB7 Levee has fewer gravity flow utilities (more up-and-over type levee crossings) so likely a marginal cost impact.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	Construction
CON-2	Availability of Bentonite	There is risk of escalation on bentonite. There may be come shortages that could impact the costs and schedule.	In the past, contractor for Mayhew Levee raise encountered difficulties procuring sufficient supplies of bentonite. Bentonite has many applications, including in oil drilling. If multiple other projects also requiring bentonite are under construction concurrently, this could be an issue.	Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW	Construction
CON-3	Cobbles	Cobbles in the area can slow or even prevent the construction of seepage cutoff walls. Seepage berms have been included in the design and cost estimate to account for these problematic areas but could anticipate greater numbers required.		Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Construction
CON-4	Slurry Blowout During Construction	In the event of slurry blowout, would require greater levee degradation, suspension of work during cleanup and additional backfill required.	Worst case assume one blowout every 5 miles at a cost of $500,000 per blowout. The levee is far enough from the river that seepage into the river and potential environmental impacts is not anticipated.	Likely	Significant	HIGH	Very Unlikely	Negligible	LOW	Construction
CON-5	Vagrancy and Loitering Issues	There is the issue of vandalism and damage to the contractor, and there may be some risk transference to the contractor. However, the likelihood of claims initiated by the contractor is negligible.		Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Construction
CON-MOD	Consideration for Post-Award Construction Claims and Modifications	There is inherent risk of construction modifications and claims that arise after contract award due to issues such as weather, schedules dictated by O&M cycles, differing site conditions, user directed changes or omissions, inaccurate surveys, and variations in estimated quantities (minor).	Post-award construction contract modifications and claims could impact the ultimate contract costs and delay the overall schedule.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	Construction
	ESTIMATE AND SCHEDULE RISKS									
EST-1	Railroad Crossing	Railroad crossing is currently below crest of levee.	Estimate includes cost of stop log closure structure. May not include costs for establishing temporary railroad services or outages.	Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW	Cost Engineering
EST-2	Budget Estimate Adequacy	All feature codes are currently captured in the estimate. However there may be some uncertainty in the disposition of some feature codes.	While there is inherent uncertainty in the estimate, this risk likely will not amount to significant impact by comparison to the uncertainty regarding the design being captured.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	Cost Engineering
EST-3	Road Repair	Estimate currently includes no cost for repair of roads or bridges.	Assume best case 10 miles of road re-pavement, most likely is 20 miles and worst case is 40 miles.	Likely	Significant	HIGH	Very Unlikely	Negligible	LOW	Cost Engineering
	ECONOMICS RISKS									
FL-1	Escalation / Inflation	With extended funding lags could be multiple years before funding arrives. With multiple years of higher then the national average inflation, as has been experienced in the region in the past, project could be underfunded.	Anticipate negligible impacts	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Cost Engineering
INT-1	Consideration for Low and Unknown Internal Risk	There is inherent risk in all projects that could contribute to cost and schedule variance due to unknowns.	This could impact cost and schedule.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	N/A
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)								
PR-1	System Wide Improvement Framework (SWIF)	Agreement on ETL vegetation requirements will require negotiation and agreement between three parties (USACE, State of California, and Levee Sponsor) in addition to third party entities.	Cost estimate does not include cost for additional vegetation removal. It may be possible it will be decided this removal w be a project cost (as opposed to O&M).	Likely	Critical	HIGH	Very Unlikely	Negligible	LOW	District Management
PR-2	Central Valley Flood Protection Plan	A statewide systemwide program that includes the Sacramento Flood Control Project (study project levees).	Affects all Central Valley studies. Future efforts or alternatives of current studies coordinated as "no regrets actions."	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW	District Management
EXT-1	Consideration for Low and Unknown External Risk	There is inherent risk in all projects that could contribute to cost and schedule variance due to unknowns.	This could impact cost and schedule.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	N/A

*Likelihood, Impact, and Risk Level to be verified through market re Several areas will require relocation of existing utilities outside the flood critical areas.

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.
2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).
3. Likelihood is a measure of the probability of the event occurring -- **Very Unlikely**, **Unlikely**, **Moderately Likely**, **Likely**, **Very Likely.** The likelihood of the event will be the same for both Cost and Schedule, regardless of impact.
4. Impact is a measure of the event's effect on project objectives with relation to scope, cost, and/or schedule -- **Negligible**, **Marginal**, **Significant**, **Critical**, or **Crisis.** Impacts on Project Cost may vary in severity from impacts on Project Schedule.
5. Risk Level is the resultant of Likelihood and Impact **Low**, **Moderate**, or **High**. Refer to the matrix located at top of page.
6. Variance Distribution refers to the behavior of the individual risk item with respect to its potential effects on Project Cost and Schedule. For example, an item with clearly defined parameters and a solid most likely scenario would probably follow a triangular or normal distributior the PDT has little data or probability of modeling with respect to effects on cost or schedule (i.e. "anyone's guess") would probably follow a uniform or discrete uniform distribution.
7. The responsibility or POC is the entity responsible as the Subject Matter Expert (SME) for action, monitoring, or information on the PDT for the identified risk or opportunity.
8. Correlation recognizes those risk events that may be related to one another. Care should be given to ensure the risks are handled correctly without a "double counting."
9. Affected Project Component identifies the specific item of the project to which the risk directly or strongly correlates.
10. Project Implications identifies whether or not the risk item affects project cost, project schedule, or both. The PDT is responsible for conducting studies for both Project Cost and for Project Schedule.
11. Results of the risk identification process are studied and further developed by the Cost Engineer, then analyzed through the Monte Carlo Analysis Method for Cost (Contingency) and Schedule (Escalation) Growth.

Sutter Basin - SB8

Risk Level

Likelihood of Occurrence	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	High	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Low	High

Impact or Consequence of Occurrence

Project Scope Narrative:

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule			Responsibility/POC
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*	
Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)										
	PROJECT & PROGRAM MGMT									
PPM-1	Project competing with other priorities	PDT Design Resources. District has assigned key personnel to various projects. Sutter Pilot study is one of two pilot studies in the nation, so has become a higher priority project. Project Feasibility Study is only funded through FY 13. The schedule currently reflects a Sept 30 Chiefs Report.	With time "priority" status has diminished. Competition for resources will remain an issue through completion of feasibility study. At this point, September 30 competition is likely but review process and unforeseen issues remain possible. A delay into next FY could significantly impact schedule due to unknown availability of future feasibility stud funding after September 30.	Very Unlikely	Negligible	LOW	Unlikely	Critical	MODERATE	Project Manager
PPM-2	Vertical Team Review / Approval Process	Vertical Team review and approval (outside of District control) is required to meet critical milestones.	High demands on vertical teams have created a backlog of projects and pilot projects have lost much of their "priority" status.	Very Unlikely	Negligible	LOW	Likely	Critical	HIGH	Project Manager
PPM-3	PED Phase Staffing / Funding	Majority of design is being performed as in-kind work by the sponsor. Non-Federal Sponsor funding is in place and has not been an issue; minimal risks design will be delayed for funding o staffing issues.		Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Project Manager
	CONTRACT ACQUISITION RISKS									
CA-1	Multiple Construction Contracts	SB-8 Construction Contracts currently divided into 7 contracts with most ~$50-$60 Million. Contracts may need to be divided into smaller increments resulting in increased construction costs, government oversight and construction schedules.	Sponsor will proceed ahead with 221 Crediting agreement, working ahead of Federal Funding.	Likely	Significant	HIGH	Likely	Significant	HIGH	Contracting
CA-2	Incremental Construction Schedule	Fixing the highest risk areas with long delays between projects (5 years or more) could result in last contracts not being completed due to B/C ratios no longer being beneficial.	Projects going beyond 5 years and subject to economic re-evaluation can become problematic.	Very Unlikely	Significant	LOW	Very Unlikely	Negligible	LOW	Contracting
CA-3	Availability of qualified contractors.	Number of seepage cutoff wall contractors could be limited slowing either schedule (insufficient equipment) or increasing cos (limited competition).	It is the opinion of the PDT that equipment will be available, but limited qualified contractors could lead to moderately higher costs.	Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW	Contracting
	TECHNICAL RISKS									
TL-1	Borrow Sources	It has been difficult to find willing landowners to acquire impermeable (clay) borrow material. Cost estimate assumes borrow sources are available and within 25-50miles round trip. Haul could be as much as 100 miles round trip or more. Sponsor may also require additional lengths of time finding "willing" borrow sites.	Real Estate estimate has included a relatively high contingency for procurement of borrow sites.	Likely	Significant	HIGH	Likely	Marginal	MODERATE	Geotechnical/Civil Design
TL-2	Changes in Geomorphology	Riprap protection for scour issues has not been included in the current design. It is assumed that any future scour issues, when they occur, will be covered with O&M funding.		Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Geotechnical/Civil Design

TL-3	Utility Crossings	Pipe penetrations will be removed and replaced but not necessarily to USACE current design guidance. For example, some large pump stations will not be remodeled to up-and-over type pipe penetrations.	Current project design is sufficient. Given the impracticality of meeting all criteria, design waivers will be acquired and USACE criteria will not dictate future design modifications.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Geotechnical/Civil Design
TL-4	Utility Relocations	Time requirement for coordination of relocation of utility poles could be extensive.	Sponsor is confident relocations will not impact construction award schedules.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Geotechnical/Civil Design
TL-5	O&M Access Road	Current design assumes a 10ft to 20ft land acquisition along the entire length of the toe of the levee for an O&M access road and vegetation free zone.	Real Estate estimate assumes a worst case cost (max land acquisition) but enough uncertainties remain that no potentia cost savings will be included.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Geotechnical/Civil Design
TL-6	Utility Corridor	Several areas will require relocation of existing utilities outside th flood critical areas.	Real Estate contingency accounts for additional reaches requiring utility corridor easements.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Geotechnical/Civil Design
TL-7	Soil Bentonite Seepage Cutoff Wall	Design assumes Soil Bentonite Cutoff wall with jet grouting at bridge and railroad crossings. This design is robust enough that any changes in design methodology will not result in cost or schedule increases.	Cost estimate assumes long stick excavation for depths up to 75' design depth and Deep Soil mixing for deeper cutoff walls.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Geotechnical/Civil Design
TL-8	Abandoned Drainage penetrations	Cost included for removal of abandoned penetrations. Additional engineering effort will be required to justify no internal drainage issues will be caused.	Additional effort will have minimal impacts to design cost and schedule.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Geotechnical/Civil Design
	LANDS AND DAMAGES RISKS									
LD-1	Real Estate - Utility Corridors	Majority of work is on existing levee already owned by the sponsor. Real Estate has assumed 10 ft to 20 ft permanent real estate acquisition (riverside and landside) for O&M access road and vegetation free zone. Real Estate estimate does not include baseline costs for utility relocation corridors.	Real Estate contingency accounts for additional reaches requiring utility corridor easements. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Real Estate
LD-2	Real Estate - Irrigation Canal and Levee Relocations	Real Estate estimate does not include baseline costs for irrigation canal relocation corridors.	Real Estate contingency accounts for additional relocations. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Real Estate
LD-3	Real Estate - Structural Relocations	Real Estate estimate does not include demolition costs for potential structural relocations.	There is a placeholder cost of $1,920,460 in the appraisal. When buildings are impacted it is not unusual for agencies to acquire the entire property (land/building) and make necessary changes--- altering or raising the buildings and than resale the remainder. This helps to alleviate the time and cost associated with litigation or working with property owners. It is less costly to acquire the entire property when improvements will be impacted versus trying to modify the existing improvements and compensating property owners for damages. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Real Estate
LD-4	Real Estate - Temporary Construction Easements	Temporary construction easements have been assumed along the length of the levee construction.	Staging areas have been identified already in the project area. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Real Estate
	REGULATORY AND ENVIRONMENTAL									
RE-1	Air quality	Contractor will require newer equipment to meet air quality requirement, but air quality credits aren't anticipated. Anticipate qualified California contractor will have worked previous projects with appropriate equipment.		Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Environmental
RE-2	Known cultural Sites	Estimate includes 1% for cultural impacts	Historical structures downtown will require vibration monitoring.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Environmental

RE-3	Cultural discoveries	Cost Estimate includes 1% for cultural investigations.	Majority of work will occur in existing levees, but it is still possible cultural discoveries could be made during construction. Cultural reconnaissance will occur prior to construction and limit possibility of discovery during construction. If cultural discoveries are made, construction must stop in that area. Cultural discovery must be resolved before construction can resume in that reach. IF discovery is made anticipate 3 to 6 month impact. Some 3 miles of Levee and Canal Realignment are required through new previously untouched regions; but greater cultural reconnaissance will be conducted in these areas minimizing potential schedule impacts.	Unlikely	Significant	MODERATE	Likely	Marginal	MODERATE	Environmental
RE-4	Endangered Species	Construction windows are constrained by Federal and State endangered species windows. Work is currently scheduled outside most species windows but Swainson's Hawk will nest in early spring and fledge in early September.	There is the possibility work could be halted around any nesting areas. Bird surveys may be conducted the prior year to determine risk. (Construction schedule for Irrigation canal Jan-March and Levee April - October).	Very Unlikely	Negligible	LOW	Likely	Marginal	MODERATE	Environmental
RE-5	Historic Structures	There are a number of historical structures that may or may not need to be relocated, specifically in Yuba City.	Cultural inventories will identify historic structures and assess possible adverse effects. If a historic structure is identified for relocation mitigation for that resources would be governed by a Memorandum of Agreement coordinated with SHPO.	Likely	Negligible	LOW	Very Unlikely	Negligible	LOW	Environmental
RE-6	HTRW	There may be HTRW sites that are unknown	It is unlikely that HTRW waste be encounter. If HTRW waste is encountered in would not affect cost but the schedule may be affected.	Unlikely	Marginal	LOW	Unlikely	Significant	MODERATE	Environmental
	CONSTRUCTION RISKS									
CON-1	Seepage Cutoff Wall and Utility Penetrations	Replacement construction of Utility Penetration can't begin until after seepage cutoff wall construction has been completed possibly resulting in long periods of temporary service. Costs have been included for temporary up-and-over services for a limited number of sites (4months each site) .	SB8 Levee reach has multiple gravity flow lines that could be impacted.	Likely	Significant	HIGH	Likely	Marginal	MODERATE	Construction
CON-2	Availability of Bentonite	There is risk of escalation on bentonite. There may be come shortages that could impact the costs and schedule.	In the past, contractor for Mayhew Levee raise encountered difficulties procuring sufficient supplies of bentonite. Bentonite has many applications, including in oil drilling. If multiple other projects also requiring bentonite are under construction concurrently, this could be an issue.	Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW	Construction
CON-3	Cobbles	Cobbles in the area can slow or even prevent the construction of seepage cutoff walls. Seepage berms have been included in the design and cost estimate to account for these problematic areas but could anticipate greater numbers required	Greater likelihood of encountering cobbles in SB8 regions, but larger numbers of seepage berms have also been included so assume minimal impacts	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Construction
CON-4	Slurry Blowout During Construction	In the event of slurry blowout, would require greater levee degradation, suspension of work during cleanup and additional backfill required.	Worst case assume one blowout every 5 miles at a cost of $500,000 per blowout. The levee is far enough from the river that seepage into the river and potential environmental impacts is not anticipated.	Likely	Significant	HIGH	Very Unlikely	Negligible	LOW	Construction
CON-5	Vagrancy and Loitering Issues	There is the issue of vandalism and damage to the contractor, and there may be some risk transference to the contractor. However, the likelihood of claims initiated by the contractor is negligible.		Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Construction
CON-MOD	Consideration for Post-Award Construction Claims and Modifications	There is inherent risk of construction modifications and claims that arise after contract award due to issues such as weather, schedules dictated by O&M cycles, differing site conditions, user directed changes or omissions, inaccurate surveys, and variations in estimated quantities (minor).	Post-award construction contract modifications and claims could impact the ultimate contract costs and delay the overall schedule.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	Construction
	ESTIMATE AND SCHEDULE RISKS									
EST-1	Railroad Crossing	Railroad crossing is currently below crest of levee.	Estimate includes cost of stop log closure structure. May not include costs for establishing temporary railroad services or outages.	Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW	Cost Engineering
EST-2	Budget Estimate Adequacy	All feature codes are currently captured in the estimate. However there may be some uncertainty in the disposition of some feature codes.	While there is inherent uncertainty in the estimate, this risk likely will not amount to significant impact by comparison to the uncertainty regarding the design being captured.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	Cost Engineering
EST-3	Road Repair	Estimate currently includes no cost for repair of roads or bridges.	Assume best case 10 miles of road re-pavement, most likely is 20 miles and worst case is 40 miles. SB-8 Low water bridges that may require repair.	Likely	Significant	HIGH	Very Unlikely	Negligible	LOW	Cost Engineering
	ECONOMICS RISKS									

FL-1	Escalation / Inflation	With extended funding lags could be multiple years before funding arrives. With multiple years of higher then the national average inflation, as has been experienced in the region in the past, project could be underfunded.	Anticipate negligible impacts	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Cost Engineering
INT-1	Consideration for Low and Unknown Internal Risk	There is inherent risk in all projects that could contribute to cost and schedule variance due to unknowns.	This could impact cost and schedule.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	N/A
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)								
PR-1	System Wide Improvement Framework (SWIF)	Agreement on ETL vegetation requirements will require negotiation and agreement between three parties (USACE, State of California, and Levee Sponsor) in addition to third party entities	Cost estimate does not include cost for additional vegetation removal. It may be possible it will be decided this removal w be a project cost (as opposed to O&M).	Likely	Critical	HIGH	Very Unlikely	Negligible	LOW	District Management
PR-2	Central Valley Flood Protection Plan	A statewide systemwide program that includes the Sacramento Flood Control Project (study project levees).	Affects all Central Valley studies. Future efforts or alternatives of current studies coordinated as "no regrets actions."	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW	District Management
EXT-1	Consideration for Low and Unknown External Risk	There is inherent risk in all projects that could contribute to cost and schedule variance due to unknowns.	This could impact cost and schedule.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	N/A

*Likelihood, Impact, and Risk Level to be verified through market re Several areas will require relocation of existing utilities outside the flood critical areas.

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.
2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).
3. Likelihood is a measure of the probability of the event occurring -- **Very Unlikely**, **Unlikely**, **Moderately Likely**, **Likely**, **Very Likely.** The likelihood of the event will be the same for both Cost and Schedule, regardless of impact.
4. Impact is a measure of the event's effect on project objectives with relation to scope, cost, and/or schedule -- **Negligible**, **Marginal**, **Significant**, **Critical**, or **Crisis.** Impacts on Project Cost may vary in severity from impacts on Project Schedule.
5. Risk Level is the resultant of Likelihood and Impact **Low**, **Moderate**, or **High**. Refer to the matrix located at top of page.
6. Variance Distribution refers to the behavior of the individual risk item with respect to its potential effects on Project Cost and Schedule. For example, an item with clearly defined parameters and a solid most likely scenario would probably follow a triangular or normal distributior the PDT has little data or probability of modeling with respect to effects on cost or schedule (i.e. "anyone's guess") would probably follow a uniform or discrete uniform distribution.
7. The responsibility or POC is the entity responsible as the Subject Matter Expert (SME) for action, monitoring, or information on the PDT for the identified risk or opportunity.
8. Correlation recognizes those risk events that may be related to one another. Care should be given to ensure the risks are handled correctly without a "double counting."
9. Affected Project Component identifies the specific item of the project to which the risk directly or strongly correlates.
10. Project Implications identifies whether or not the risk item affects project cost, project schedule, or both. The PDT is responsible for conducting studies for both Project Cost and for Project Schedule.
11. Results of the risk identification process are studied and further developed by the Cost Engineer, then analyzed through the Monte Carlo Analysis Method for Cost (Contingency) and Schedule (Escalation) Growth.

Total Project Cost Summary NED and LPP

****TOTAL PROJECT COST SUMMARY****

3/20/2013

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE DRAFT FEASIBILITY REPORT, NED PLAN
PROJECT: Sutter Basin SB7 TPCS
LOCATION: CALIFORNIA

U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT
P.O.C.: JEREMIAH A. FROST, CHIEF, COST ENGINEERING SECTION

Current MCACES Estimate Prepared: 25-Feb-2013
Effective Price Level (EPL): 1-Oct-2012

PROGRAM YEAR(BUDGET EC) 2014
EFF. PRICE LEVEL DATE:1-Oct-2013

TOTAL PROJECT COST (FULLY FUNDED)
SPENT THRU: 1-Oct-2011

WB NO.	Civil Works FEATURE DESCRIPTION	ESTIMATED COST COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	PROJECT FIRST COST ESC. (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	ESC. MIDPT(%)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
	Index Codes: 0 - no esc. applied; A - Administration; C - Combined indexes; All other codes used coincides with the Code of Accounts.													
		Contingency Applied To Remaining Cost Only												
	FEDERAL COSTS													
6	FISH & WILDLIFE FACILITIES	4,552	910	20	5,462	1.58	4,624	924	5,548	0	10	5,098	1,020	6,118
11	LEVEES & FLOODWALLS	176,268	54,598	31	230,866	1.58	179,053	55,536	234,589	0	11	198,027	61,338	259,365
18	CULT. RESRC. PRESERV. (1	2,164	654	30	2,818		2,173	659	2,832	0		2,388	721	3,109
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	182,984	56,162		239,146		185,850	57,119	242,969	0		205,513	63,079	268,592
1	LANDS & DAMAGES, Admin (2	5,846	293	5	6,139	2.93	6,017	302	6,319	0	17	7,065	354	7,419
30	PLAN/ENGINEERING/DESIGN	32,547	10,090	31	42,637	2.93	33,501	10,385	43,886	0	18	39,595	12,275	51,870
31	CONSTRUCTION MANAGE'MT	15,370	4,765	31	20,135	2.93	15,820	4,905	20,725	0	24	19,644	6,090	25,734
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	236,747	71,310		308,057		241,188	72,711	313,899	0		271,817	81,798	353,615
	NON-FEDERAL CONTRIBUTION (-)	20,331	5,926		26,257		20,907	6,132	27,039	0		25,533	7,482	33,015
	TOTAL FEDERAL COSTS	**$216,416**	**$65,384**		**$281,800**		**$220,281**	**$66,579**	**$286,860**	**$0**		**$246,284**	**$74,316**	**$320,600**
	NON-FEDERAL COSTS													
1	LANDS AND DAMAGES	32,051	9,382	29	41,433	1.58	32,557	9,531	42,088	0	8	35,155	10,291	45,446
2	RELOCATIONS	49,206	15,254	31	64,460	1.58	49,983	15,495	65,478	0	11	55,370	17,165	72,535
30	PLAN/ENGINEERING/DESIGN	8,857	2,746	31	11,603	1.58	8,997	2,789	11,786	0	8.3	9,743	3,020	12,763
31	CONSTRUCTION MANAGE'MT	4,921	1,526	31	6,447	1.58	4,999	1,550	6,549	0	11	5,527	1,714	7,241
	SUBTOTAL NON-FEDERAL (INCLUDES FED IRRIGATION SHARE)	95,035	28,908		123,943		96,536	29,365	125,901	0		105,795	32,190	137,985
	NON-FEDERAL CONTRIBUTION (+)	20,331	5,926		26,257		20,907	6,132	27,039	0		25,533	7,482	33,015
	TOTAL NON-FEDERAL COSTS	**$115,366**	**$34,834**		**$150,200**		**$117,443**	**$35,497**	**$152,940**	**$0**		**$131,328**	**$39,672**	**$171,000**
	TOTAL FEDERAL AND NON-FEDERAL COSTS	**$331,782**	**$100,218**		**$432,000**		**$337,724**	**$102,076**	**$439,800**	**$0**		**$377,612**	**$113,988**	**$491,600**

GENERAL NOTES

(1 Cultural Resources Preservation costs associated with mitigation and/or data recovery up to one percent of the total Federal cost are not subject to cost sharing.
(2 Federal administrative costs for non-Federal land acquisition.
(3 The Fully Funded cost estimate was prepared in compliance with Indexes used from CWCCIS reflecting OMB future rates Mar. 31 ,2012..
(4 01 Account for Land and Damages cost are from Real Estates.

CONTINGENCY RATIONALE

(A CONTINGENCIES USED WAS DERIVED BY THE COST RISK ANALYSIS PROCESS AND IS BASED ON A 80% CONFIDENCE LEVEL.

_____ **CHIEF, COST ENGINEERING**

_____ **PROJECT MANAGER**

TOTAL FEDERAL COSTS	**$320,600**
TOTAL NON-FEDERAL COSTS	**$171,000**
THE MAXIMUM PROJECT COSTS	**$491,600**

****TOTAL PROJECT COST SUMMARY****

3/20/2013

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE DRAFT FEASIBILITY REPORT, LPP PLAN
PROJECT: Sutter Basin SB7 TPCS
LOCATION: CALIFORNIA

U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT
P.O.C.: JEREMIAH A. FROST, CHIEF, COST ENGINEERING SECTION

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PROGRAM YEAR(BUDGET EC) 2014
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TOTAL PROJECT COST (FULLY FUNDED)
SPENT THRU: 1-Oct-2011

WB NO.	Civil Works FEATURE DESCRIPTION	ESTIMATED COST COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	PROJECT FIRST COST ESC. (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	ESC. MIDPT(%)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
	Index Codes: 0 - no esc. applied; A - Administration; C - Combined indexes; All other codes used coincides with the Code of Accounts.													
		Contingency Applied To Remaining Cost Only												
	FEDERAL COSTS													
6	FISH & WILDLIFE FACILITIES	9,286	1,857	20	11,143	1.58	9,433	1,886	11,319	0	12	10,592	2,118	12,710
11	LEVEES & FLOODWALLS	263,858	79,201	30	343,059	1.58	268,027	80,474	348,501	0	13	302,254	90,676	392,930
18	CULT. RESRC. PRESERV. (1	2,164	654		2,818		2,173	659	2,832			2,388	721	3,109
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	275,308	81,712		357,020		279,633	83,019	362,652	0		315,234	93,515	408,749
1	LANDS & DAMAGES, Admin (2	8,401	420	5	8,821	2.93	8,647	432	9,079	0	22	10,590	529	11,119
30	PLAN/ENGINEERING/DESIGN	49,166	14,749	30	63,915	2.93	50,607	15,181	65,788	0	23	62,385	18,715	81,100
31	CONSTRUCTION MANAGE'MT	23,218	6,965	30	30,183	2.93	23,898	7,169	31,067	0	30	30,971	9,291	40,262
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	356,093	103,846		459,939		362,785	105,801	468,586	0		419,180	122,050	541,230
	NON-FEDERAL CONTRIBUTION(-)	139,677	38,462		178,139		142,504	39,222	181,726	0		172,896	47,734	220,630
	TOTAL FEDERAL NED COSTS	**$216,416**	**$65,384**		**$281,800**		**$220,281**	**$66,579**	**$286,860**	**$0**		**$246,284**	**$74,316**	**$320,600**
	NON-FEDERAL COSTS													
1	LANDS AND DAMAGES	41,859	10,979	26	52,838	1.58	42,520	11,153	53,673	0	9.9	46,740	12,260	59,000
2	RELOCATIONS	141,426	42,428	30	183,854	1.58	143,661	43,098	186,759	0	13	161,916	48,575	210,491
30	PLAN/ENGINEERING/DESIGN	25,457	7,637	30	33,094	1.58	25,859	7,758	33,617	0	10	28,505	8,552	37,057
31	CONSTRUCTION MANAGE'MT	14,143	4,242	30	18,385	1.58	14,366	4,309	18,675	0	13	16,172	4,850	21,022
	SUBTOTAL NON-FEDERAL (INCLUDES FED IRRIGATION SHARE)	222,885	65,286		288,171		226,406	66,318	292,724	0		253,333	74,237	327,570
	NON-FEDERAL CONTRIBUTION (+)	139,677	38,462		178,139		142,504	39,222	181,726	0		172,896	47,734	220,630
	Non-Federal Contribution - NED	20,331	5,926		26,257		20,907	6,132	27,039	0		25,533	7,482	33,015
	Additional Cost Above NED	119,346	32,536		151,882		121,597	33,090	154,687	0		147,363	40,252	187,615
	TOTAL NON-FEDERAL COSTS	**$362,562**	**$103,748**		**$466,310**		**$368,910**	**$105,540**	**$474,450**	**$0**		**$426,229**	**$121,971**	**$548,200**
	TOTAL FEDERAL AND NON-FEDERAL COSTS	**$578,978**	**$169,132**		**$748,110**		**$589,191**	**$172,119**	**$761,310**	**$0**		**$672,513**	**$196,287**	**$868,800**

SutterBasin_Alt SB7 (NED Plan)

Estimated by	CESPK-ED-SC
Designed by	USACE (Sacramento District)
Prepared by	Tri Duong
Preparation Date	2/25/2013
Effective Date of Pricing	2/25/2013
Estimated Construction Time	Days

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Description	Quantity	UOM	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	ContractCost
Contract Cost			**177,868,590.77**	**17,042,972.37**	**18,747,269.61**	**14,934,264.56**	**1,432,830.46**	**230,025,927.77**
Fix-in-Place	**1.00**	**EA**	**177,868,590.77**	**17,042,972.37**	**18,747,269.61**	**14,934,264.56**	**1,432,830.46**	**230,025,927.77**
CONTRACT A (Reach 2 to 5)	**1.00**	**LS**	**50,233,446.45**	**4,911,619.52**	**5,402,781.47**	**4,093,429.48**	**347,696.18**	**64,988,973.11**
02 Relocations	**1.00**	**LS**	**12,109,103.41**	**1,198,930.22**	**1,318,823.24**	**770,230.58**	**13,908.41**	**15,410,995.86**
06 Mitigation	**1.00**	**LS**	**951,650.00**	**0.00**	**0.00**	**0.00**	**0.00**	**951,650.00**
11 Levees & Floodwalls	**1.00**	**LS**	**37,172,693.04**	**3,712,689.30**	**4,083,958.23**	**3,323,198.91**	**333,787.77**	**48,626,327.25**
STAR BEND FIX-IN-PLACE (Reach 6)	**1.00**	**LS**	**5,940,084.96**	**591,508.50**	**650,659.35**	**549,214.69**	**59,303.32**	**7,790,770.82**
02 Relocations	**1.00**	**LS**	**876,285.72**	**87,628.57**	**96,391.43**	**60,742.05**	**2,394.66**	**1,123,442.43**
06 Mitigation	**1.00**	**LS**	**20,000.00**	**0.00**	**0.00**	**0.00**	**0.00**	**20,000.00**
11 Levees & Floodwalls	**1.00**	**LS**	**5,043,799.25**	**503,879.92**	**554,267.92**	**488,472.64**	**56,908.66**	**6,647,328.40**
CONTRACT B (Reach 7 to12)	**1.00**	**LS**	**48,290,653.84**	**4,444,505.96**	**4,888,956.56**	**3,888,869.59**	**371,883.31**	**61,884,869.27**
02 Relocations	**1.00**	**LS**	**10,572,537.13**	**1,053,613.29**	**1,158,974.62**	**666,993.63**	**9,160.41**	**13,461,279.09**
06 Mitigation	**1.00**	**LS**	**1,427,950.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1,427,950.00**
11 Levee & Floodwalls	**1.00**	**LS**	**36,290,166.71**	**3,390,892.67**	**3,729,981.94**	**3,221,875.96**	**362,722.90**	**46,995,640.18**
CONTRACT C1 (Reach 13-18)	**1.00**	**LS**	**46,978,972.29**	**4,549,747.23**	**5,004,721.95**	**3,985,253.52**	**382,021.63**	**60,900,716.61**
02 Relocations	**1.00**	**LS**	**8,817,754.51**	**881,775.45**	**969,953.00**	**547,235.81**	**4,264.98**	**11,220,983.74**
06 Mitigation	**1.00**	**LS**	**1,413,700.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1,413,700.00**
11 Levees & Floodwalls	**1.00**	**LS**	**36,747,517.78**	**3,667,971.78**	**4,034,768.96**	**3,438,017.71**	**377,756.65**	**48,266,032.87**
CONTRACT C2 (Reach 19-21)	**1.00**	**LS**	**26,425,433.23**	**2,545,591.16**	**2,800,150.28**	**2,417,497.27**	**271,926.02**	**34,460,597.96**
02 Relocations	**1.00**	**LS**	**6,239,914.92**	**608,971.13**	**669,868.25**	**446,613.29**	**24,231.12**	**7,989,598.72**
06 Mitigation	**1.00**	**LS**	**738,118.00**	**0.00**	**0.00**	**0.00**	**0.00**	**738,118.00**
11 Levees & Floodwalls	**1.00**	**LS**	**19,447,400.31**	**1,936,620.03**	**2,130,282.03**	**1,970,883.97**	**247,694.89**	**25,732,881.24**

SutterBasin_Alt_SB8

Estimated by	CESPK-ED-SC
Designed by	HDR,Wood Rogers,MHM & USACE (Sacramento District)
Prepared by	Tri Duong
Preparation Date	2/25/2013
Effective Date of Pricing	2/25/2013
Estimated Construction Time	Days

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Description	Quantity	UOM	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	ContractCost
Contract Cost			**319,112,906.08**	**30,404,816.59**	**33,445,298.25**	**25,422,770.50**	**2,178,054.69**	**414,569,465.84**
Fix-in-Place	**1.00**	**EA**	**319,112,906.08**	**30,404,816.59**	**33,445,298.25**	**25,422,770.50**	**2,178,054.69**	**414,569,465.84**
CONTRACT A (Reach 2 to 5)	**1.00**	**LS**	**50,233,446.45**	**4,911,619.52**	**5,402,781.47**	**4,093,429.48**	**347,696.18**	**64,988,973.11**
02 Relocations	**1.00**	**LS**	**12,109,103.41**	**1,198,930.22**	**1,318,823.24**	**770,230.58**	**13,908.41**	**15,410,995.86**
06 Mitigation	**1.00**	**LS**	**951,650.00**	**0.00**	**0.00**	**0.00**	**0.00**	**951,650.00**
11 Levees & Floodwalls	**1.00**	**LS**	**37,172,693.04**	**3,712,689.30**	**4,083,958.23**	**3,323,198.91**	**333,787.77**	**48,626,327.25**
STAR BEND FIX-IN-PLACE (Reach 6)	**1.00**	**LS**	**5,940,084.96**	**591,508.50**	**650,659.35**	**549,214.69**	**59,303.32**	**7,790,770.82**
02 Relocations	**1.00**	**LS**	**876,285.72**	**87,628.57**	**96,391.43**	**60,742.05**	**2,394.66**	**1,123,442.43**
06 Mitigation	**1.00**	**LS**	**20,000.00**	**0.00**	**0.00**	**0.00**	**0.00**	**20,000.00**
11 Levees & Floodwalls	**1.00**	**LS**	**5,043,799.25**	**503,879.92**	**554,267.92**	**488,472.64**	**56,908.66**	**6,647,328.40**
CONTRACT B (Reach 7 to12)	**1.00**	**LS**	**48,290,653.84**	**4,444,505.96**	**4,888,956.56**	**3,888,869.59**	**371,883.31**	**61,884,869.27**
02 Relocations	**1.00**	**LS**	**10,572,537.13**	**1,053,613.29**	**1,158,974.62**	**666,993.63**	**9,160.41**	**13,461,279.09**
06 Mitigation	**1.00**	**LS**	**1,427,950.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1,427,950.00**
11 Levee & Floodwalls	**1.00**	**LS**	**36,290,166.71**	**3,390,892.67**	**3,729,981.94**	**3,221,875.96**	**362,722.90**	**46,995,640.18**
CONTRACT C1 (Reach 13-18)	**1.00**	**LS**	**46,978,972.29**	**4,549,747.23**	**5,004,721.95**	**3,985,253.52**	**382,021.63**	**60,900,716.61**
02 Relocations	**1.00**	**LS**	**8,817,754.51**	**881,775.45**	**969,953.00**	**547,235.81**	**4,264.98**	**11,220,983.74**
06 Mitigation	**1.00**	**LS**	**1,413,700.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1,413,700.00**
11 Levees & Floodwalls	**1.00**	**LS**	**36,747,517.78**	**3,667,971.78**	**4,034,768.96**	**3,438,017.71**	**377,756.65**	**48,266,032.87**
CONTRACT C2 (Reach 19-25)	**1.00**	**LS**	**43,916,685.24**	**3,984,994.52**	**4,383,493.98**	**3,501,544.82**	**338,003.04**	**56,124,721.59**
02 Relocations	**1.00**	**LS**	**13,742,621.34**	**1,374,262.13**	**1,511,688.35**	**860,416.37**	**8,983.82**	**17,497,972.01**
06 Mitigation	**1.00**	**LS**	**1,667,600.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1,667,600.00**
11 Levees & Floodwalls	**1.00**	**LS**	**28,506,463.90**	**2,610,732.39**	**2,871,805.63**	**2,641,128.44**	**329,019.22**	**36,959,149.59**
CONTRACT D1 (Reach 26-33)	**1.00**	**LS**	**67,593,541.19**	**6,521,640.28**	**7,173,804.30**	**5,272,081.42**	**411,101.98**	**87,339,955.47**
02 Relocations	**1.00**	**LS**	**29,859,471.41**	**2,946,663.30**	**3,241,329.63**	**1,947,351.21**	**51,018.57**	**38,413,620.42**
06 Mitigation	**1.00**	**LS**	**1,892,700.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1,892,700.00**
11 Levees & Floodwalls	**1.00**	**LS**	**35,841,369.78**	**3,574,976.98**	**3,932,474.68**	**3,324,730.22**	**360,083.41**	**47,033,635.06**
CONTRACT D2 (Reach 34-41)	**1.00**	**LS**	**56,159,522.11**	**5,400,800.58**	**5,940,880.64**	**4,132,376.96**	**268,045.23**	**75,539,458.96**
02 Relocations	**1.00**	**LS**	**32,008,850.36**	**3,186,093.40**	**3,504,702.74**	**1,952,807.96**	**7,816.57**	**44,298,104.47**
06 Mitigation	**1.00**	**LS**	**1,911,200.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1,911,200.00**
11 Levees & Floodwalls	**1.00**	**LS**	**22,239,471.75**	**2,214,707.18**	**2,436,177.89**	**2,179,569.01**	**260,228.67**	**29,330,154.49**

Appendix D
Environmental

D1. Scoping Report

Memorandum

Date:	July 29, 2011
To:	Matt Davis, U.S. Army Corps of Engineers
Cc:	Chris Elliott, ICF International, Jennifer Rogers, ICF International
From:	Ingrid Norgaard, ICF International
Subject:	**Public Scoping Meeting Summary for the Sutter Basin Project and Feather River West Levee Project Environmental Scoping Meetings—June 27 and 28, 2011**

Introduction

Two efforts are presently underway to study flood risk reduction improvements in Sutter and Butte Counties, one known as the Sutter Basin Feasibility Study, sponsored by the U.S. Army Corps of Engineers (USACE) to determine federal interest in flood risk reduction project(s), and one known as the Feather River West Levee Project (FRWLP), sponsored by the Sutter Butte Flood Control Agency (SBFCA) as a locally driven flood risk reduction project.

The two projects are being studied in close coordination because they at least partially overlap in their study areas, purpose, potential improvements, potential effects, and involved parties. Therefore, a joint scoping process is being conducted for the two projects to explain the relationship between the two efforts and obtain public input in a manner that is convenient, efficient, and integrated. It is anticipated that the two planning efforts will result in a separate Environmental Impact Study/Environmental Impact Report (EIS/EIR) for each project, in accordance with the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA).

Sutter Basin Feasibility Study

USACE initiated the Sutter Basin project in 2001 and is conducting a feasibility study to evaluate flood damage reduction, ecosystem restoration, and recreation opportunities within the study area. The Central Valley Flood Protection Board (CVFPB) and SBFCA, in their roles as non-federal local sponsors, are coordinating with USACE on the feasibility study. USACE, acting as the federal lead agency under NEPA, and SBFCA, acting as the state lead agency under CEQA, have determined that an EIS/EIR will be prepared to describe alternatives, potential environmental effects, and mitigation measures.

FRWLP

SBFCA is planning the FRWLP to address levee deficiencies in the west levee of the Feather River from Thermalito Afterbay to the Sutter Bypass confluence to meet federal, state, and local flood protection criteria and goals. In 2010, an assessment district was enacted to provide local funding toward flood management improvements. These funds will be matched with those from the Disaster Preparedness and Flood Prevention Bond Act of 2006 (Proposition 1E) administered by the California Department of Water Resources (DWR). The purpose of the FRWLP would be to construct improvements as quickly as possible in advance of and compatible with the Sutter Basin Feasibility Study. USACE, acting as the federal lead agency under NEPA, and SBFCA, acting as the state lead agency under the CEQA, have determined that an EIS/EIR will be prepared to describe alternatives, potential environmental effects, and mitigation measures.

Development of the draft EIS/EIR to evaluate the FRWLP is underway and scheduled for public release in early 2012. A public release date for the Sutter Basin Project draft EIS/EIR has yet to be determined.

SBFCA and USACE have been carrying out scoping activities to assist them in determining the scope, and content of the environmental information for these two projects. SBFCA and USACE have had ongoing inter-agency consultation with responsible and interested agencies such as the Central Valley Flood Protection Board, Department of Fish and Game, Department of Water Resources (DWR), and California Regional Water Quality Control Board to name a few. In addition, SBFCA and USACE conducted a total of four public scoping meetings for the public and for federal and state agency staff on June 27th and June 28th, 2011. The following summarizes the outreach conducted to inform responsible and interested agencies and the public of the proposed projects, the scoping meetings, and the public comment received.

Noticing

Notice of Intent/Preparation

In compliance with the requirements set forth in CEQA, SBFCA and USACE prepared a Notice of Preparation (NOP). The NOP contained a brief description of the proposed project, project date, probable environmental effects, the date, time and place of the public scoping meetings, and contact information. The NOP solicited participation in determining the scopes and content of the environmental information of the EIS/EIRs. On May 20, 2011 the NOP was sent to Responsible and Trustee Agencies and involved federal agencies, to the State Clearinghouse, and parties previously requesting notice in writing. The comment period on the NOP was May 20, 2011 to July 08, 2011.

In compliance with the requirements set forth in NEPA, USACE prepared a Notice of Intent (NOI) describing its intent to prepare an EIS/EIR, the proposed action, the possible alternatives, and relevant scoping meeting and contact information. The NOI was posted in the Federal Register, the United States Government's official noticing and reporting publication, on May 20, 2011. The official comment period for the NOI was May 20, 2011 to July 08, 2011.

Mailings

SBFCA utilized a previously developed mailing list of interested stakeholders to send an email notification encouraging attendance at the scoping meetings.

Notifications

Advertisements briefly introducing the lead agencies, the proposed projects and associated environmental review processes, and publicizing the scoping meetings were placed in the Appeal Democrat and the Gridley Herald newspapers. Both newspapers are intended to reach a local and regional public audience that residents routinely rely upon to keep them abreast of Sutter and Butte county issues. The advertisements were published in the Appeal Democrat on June 20 and June 27, 2011. The advertisements were published in the Gridley Herald on June 22 and June 24, 2011. A media release was also emailed out to a number media contacts within the region on June 22, 2011.

Attachment A contains copies of the following:

- Notice of Preparation
- Notice of Intent
- Email Notification
- Appeal Democrat and Gridley Herald Ledger Advertisements
- Media Release

Public Meetings

Four public scoping meetings were held to inform the public of the proposed projects and seek feedback on the range of alternatives, environmental effects, and issues of concern related to the Sutter Basin Project and the FRWLP. The four meetings were held at two different times for two days. On June 27, 2011 the meeting times were from 3:30 to 5:30 p.m. and 6:30 to 8:30 p.m., at the Yuba City Veterans Memorial Community Center. On June 28, 2011 the meeting times were from 3:30 to 5:30 p.m. and 6:30 to 8:30 p.m., at the Gridley Veterans Memorial Hall. The meeting locations were chosen as they are central to the region. The meeting times were chosen to accommodate both the work day schedules of public agency representatives and the general public, including residents and business owners.

The meetings were open-house style workshops in which attendees could read and view the information about the two projects and interact with project staff including SBFCA, USACE, DWR, HDR Engineering consultant staff, and ICF International (ICF) environmental consulting staff.

Twenty-six graphic display boards were on display for attendees to review. The boards described and illustrated the Sutter Basin Project and FRWLP history, purpose, need and objectives, study area, levee deficiencies and potential improvements, environmental considerations, the CEQA/NEPA process and project timeline and were on display for attendees to review. SBFCA, USACE, HDR and

ICF staff were stationed at display boards to interact with public attendees and provide additional detail or answer any questions.

A Power Point presentation was given to provide a brief introduction to the Sutter Basin Project and the FRWLP including objectives, schedule, environmental compliance, and related flood control work in the region.

A fact sheet, providing an overview of the Sutter Basin Project and the FRWLP including purpose and goals, maps of the corresponding study areas, an overview of the environmental compliance process and timeline, was also made available.

Comment cards were prepared so that meeting attendees could provide feedback on the projects. These cards could be filled out during the meeting and given to a project team member.

Attachment B contains copies of the following:

- Display boards
- Power Point presentation
- Fact sheet
- Comment card templates

Public Feedback

There were 36 people in total who attended the two meetings. Twelve people attended the meeting from 3:30 to 5:00 p.m. and four people attended the meeting from 6:30 to 8:00 p.m. on June 27, 2011. Fifteen people attended the meeting from 3:30 to 5:00 p.m. and five people attended the meeting from 6:30 to 8:00 p.m. on June 28, 2011.

Five comments were received from the public regarding the EIS/EIRs during the scoping period. Below is a list summarizing the comments received.

- A request was made to keep the process for the Sutter Basin Feasibility Study on schedule so the state will be able to release EIP funding for the FRWLP.
- A comment was received regarding the importance of coordinating with the Lower Feather River Corridor Management Project so not to have to duplicate efforts on environmental studies.
- A comment was received in favor of the option of putting in a levee setback in the Nelson Slough area.
- A comment was received in opposition of the project.
- A comment addressed two issues. The first comment pertains to the lack of attention to the east levee of the Sutter Bypass. The second comment suggested using a perimeter levee around Yuba City, or a J levee on the south and west side.

Attachment C contains copies of the following:

- Comments received from all interested parties (including those transcribed by court reporter)
- Attendee sign-in sheet templates

Next Steps

The comments received during the scoping period will assist in determining which issues are evaluated in detail in both the Sutter Basin Project and FRWLP EIS/EIRs. Once alternatives have been developed based on the scoping process and preexisting information, they will be analyzed, and draft EIS/EIRs will be developed. Upon the release of the draft EIR/EIS, the public will have 45 days to comment on the document. Additionally, at least one public hearing will be held so the public and agencies can learn more about both of the draft EIR/EISs, ask questions regarding the analysis, and provide comments. At these meetings, the alternatives will be presented and explained.

Development of the draft EIS/EIR to evaluate the FRWLP is underway and scheduled for public release in early 2012. A public release date for the Sutter Basin Project draft EIS/EIR has yet to be determined.

Attachment A

- Notice of Preparation
- Notice of Intent
- Email Notification
- Appeal Democrat and Gridley Herald Ledger Advertisements
- Media Release

STATE OF CALIFORNIA

GOVERNOR'S OFFICE *of* PLANNING AND RESEARCH

STATE CLEARINGHOUSE AND PLANNING UNIT

JERRY BROWN
GOVERNOR

Notice of Preparation

May 20, 2011

To: Reviewing Agencies

Re: Sutter Basin Feasibility Study and Feather River West Levee Project
SCH# 2011052062

Attached for your review and comment is the Notice of Preparation (NOP) for the Sutter Basin Feasibility Study and Feather River West Levee Project draft Environmental Impact Report (EIR).

Responsible agencies must transmit their comments on the scope and content of the NOP, focusing on specific information related to their own statutory responsibility, within 30 days of receipt of the NOP from the Lead Agency. This is a courtesy notice provided by the State Clearinghouse with a reminder for you to comment in a timely manner. We encourage other agencies to also respond to this notice and express their concerns early in the environmental review process.

Please direct your comments to:

Ingrid Norgaard
Sutter Butte Flood Control Agency
c/o ICF International
630 K Street, Suite 400
Sacramento, CA 95814

with a copy to the State Clearinghouse in the Office of Planning and Research. Please refer to the SCH number noted above in all correspondence concerning this project.

If you have any questions about the environmental document review process, please call the State Clearinghouse at (916) 445-0613.

Sincerely,

Scott Morgan
Director, State Clearinghouse

Attachments
cc: Lead Agency

Document Details Report
State Clearinghouse Data Base

SCH# 2011052062
Project Title Sutter Basin Feasibility Study and Feather River West Levee Project
Lead Agency Sutter Butte Flood Control Agency

Type NOP Notice of Preparation

Description Two efforts are presently underway to study flood risk reduction improvements in Sutter and Butte Counties, one known as the Sutter Basin Feasibility Study, sponsored by the U.S. Army Corps of Engineers (USACE) to determine federal interest in flood risk reduction project(s), and one known as the Feather River West Levee Project (FRWLP), sponsored by the Sutter Butte Flood Control Agency (SBFCA) as a locally driven flood risk reduction project.

Lead Agency Contact

Name Ingrid Norgaard
Agency Sutter Butte Flood Control Agency
Phone 916 737-3000 **Fax**
email inorgaard@icfi.com
Address c/o ICF International
630 K Street, Suite 400
City Sacramento **State** CA **Zip** 95814

Project Location

County Sutter, Butte
City
Region
Cross Streets
Lat / Long
Parcel No.
Township **Range** **Section** **Base**

Proximity to:

Highways
Airports
Railways
Waterways
Schools
Land Use

Project Issues Aesthetic/Visual; Agricultural Land; Air Quality; Biological Resources; Archaeologic-Historic; Geologic/Seismic; Toxic/Hazardous; Water Quality; Landuse; Other Issues; Minerals; Noise; Population/Housing Balance; Public Services; Recreation/Parks; Economics/Jobs; Traffic/Circulation

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Reviewing Agencies Resources Agency; Department of Conservation; Central Valley Flood Protection Board; Office of Historic Preservation; Department of Parks and Recreation; Department of Water Resources; Department of Fish and Game, Region 2; Office of Emergency Management Agency, California; Native American Heritage Commission; State Lands Commission; Caltrans, District 3; State Water Resources Control Board, Division of Water Quality; Regional Water Quality Control Bd., Region 5 (Sacramento); Regional Water Quality Control Bd., Region 5 (Redding)

Date Received 05/20/2011 **Start of Review** 05/20/2011 **End of Review** 06/20/2011

ources Agency

Resources Agency
Nadell Gayou

Dept. of Boating & Waterways
Mike Sotelo

California Coastal Commission
Elizabeth A. Fuchs

Colorado River Board
Gerald R. Zimmerman

Dept. of Conservation
Rebecca Salazar

California Energy Commission
Eric Knight

Cal Fire
Allen Robertson

Central Valley Flood Protection Board
James Herota

Office of Historic Preservation
Ron Parsons

Dept of Parks & Recreation
Environmental Stewardship Section

California Department of Resources, Recycling & Recovery
Sue O'Leary

S.F. Bay Conservation & Dev't. Comm.
Steve McAdam

Dept. of Water Resources
Resources Agency
Nadell Gayou

Conservancy

and Game

Depart. of Fish & Game
Scott Flint
Environmental Services Division

Fish & Game Region 1
Donald Koch

- ☐ **Fish & Game Region 1E**
  Laurie Harnsberger
- ☐ **Fish & Game Region 2**
  Jeff Drongesen
- ☐ **Fish & Game Region 3**
  Charles Armor
- ☐ **Fish & Game Region 4**
  Julie Vance
- ☐ **Fish & Game Region 5**
  Don Chadwick
  Habitat Conservation Program
- ☐ **Fish & Game Region 6**
  Gabrina Gatchel
  Habitat Conservation Program
- ☐ **Fish & Game Region 6 I/M**
  Brad Henderson
  Inyo/Mono, Habitat Conservation Program
- ☐ **Dept. of Fish & Game M**
  George Isaac
  Marine Region

Other Departments

- ☐ **Food & Agriculture**
  Steve Shaffer
  Dept. of Food and Agriculture
- ☐ **Depart. of General Services**
  Public School Construction
- ☐ **Dept. of General Services**
  Anna Garbeff
  Environmental Services Section
- ☐ **Dept. of Public Health**
  Bridgette Binning
  Dept. of Health/Drinking Water

Independent Commissions,Boards

- ☐ **Delta Protection Commission**
  Linda Flack
- ☐ **Cal EMA (Emergency Management Agency)**
  Dennis Castrillo
- ☐ **Governor's Office of Planning & Research**
  State Clearinghouse

- ☐ **Native American Heritage Comm.**
  Debbie Treadway
- ☐ **Public Utilities Commission**
  Leo Wong
- ☐ **Santa Monica Bay Restoration**
  Guangyu Wang
- ☐ **State Lands Commission**
  Marina Brand
- ☐ **Tahoe Regional Planning Agency (TRPA)**
  Cherry Jacques

Business, Trans & Housing

- ☐ **Caltrans - Division of Aeronautics**
  Philip Crimmins
- ☐ **Caltrans - Planning**
  Terri Pencovic
- ☐ **California Highway Patrol**
  Scott Loetscher
  Office of Special Projects
- ☐ **Housing & Community Development**
  CEQA Coordinator
  Housing Policy Division

Dept. of Transportation

- ☐ **Caltrans, District 1**
  Rex Jackman
- ☐ **Caltrans, District 2**
  Marcelino Gonzalez
- ☐ **Caltrans, District 3**
  Bruce de Terra
- ☐ **Caltrans, District 4**
  Lisa Carboni
- ☐ **Caltrans, District 5**
  David Murray
- ☐ **Caltrans, District 6**
  Michael Navarro
- ☐ **Caltrans, District 7**
  Elmer Alvarez
- ☐ **Caltrans, District 8**
  Dan Kopulsky
- ☐ **Caltrans, District 9**
  Gayle Rosander
- ☐ **Caltrans, District 10**
  Tom Dumas
- ☐ **Caltrans, District 11**
  Jacob Armstrong
- ☐ **Caltrans, District 12**
  Chris Herre

Cal EPA

Air Resources Board

- ☐ Airport Projects
  Jim Lerner
  - ☐ Transportation Projects
    Douglas Ito
  - ☐ Industrial Projects
    Mike Tollstrup
- ☐ **State Water Resources Control Board**
  Regional Programs Unit
  Division of Financial Assistance
- ☐ **State Water Resources Control Board**
  Student Intern, 401 Water Quality Certification Unit
  Division of Water Quality
- ☐ **State Water Resouces Control Board**
  Steven Herrera
  Division of Water Rights
- ☐ **Dept. of Toxic Substances Control**
  CEQA Tracking Center
- ☐ **Department of Pesticide Regulation**
  CEQA Coordinator

Regional Water Quality Control Board (RWQCB)

- ☐ **RWQCB 1**
  Cathleen Hudson
  North Coast Region (1)
- ☐ **RWQCB 2**
  Environmental Document Coordinator
  San Francisco Bay Region (2)
- ☐ **RWQCB 3**
  Central Coast Region (3)
- ☐ **RWQCB 4**
  Teresa Rodgers
  Los Angeles Region (4)
- ☐ **RWQCB 5S**
  Central Valley Region (5)
  - ☐ **RWQCB 5F**
    Central Valley Region (5)
    Fresno Branch Office
  - ☐ **RWQCB 5R**
    Central Valley Region (5)
    Redding Branch Office
- ☐ **RWQCB 6**
  Lahontan Region (6)
  - ☐ **RWQCB 6V**
    Lahontan Region (6)
    Victorville Branch Office
- ☐ **RWQCB 7**
  Colorado River Basin Region (7)
- ☐ **RWQCB 8**
  Santa Ana Region (8)
- ☐ **RWQCB 9**
  San Diego Region (9)

☐ **Other** _____

Last Updated on 01/10/11

POLICY JUSTIFICATION

Kingdom of Saudi Arabia – Night Vision Equipment

The Government of the Kingdom of Saudi Arabia has requested a possible sale of 200 High-performance In-Line Sniper Sight (HISS) Thermal Weapon Sights - 1500 meter, 200 MilCAM Recon III LocatIR Long Range, Light Weight Thermal Binoculars with Geo Location, 7,000 Dual Beam Aiming Lasers (DBAL A2), 6000 AN/PVS-21 Low Profile Night Vision Goggles (LPNVG), spare and repair parts, support equipment, technical documentation and publications, translation services, training, U. S. government and contractor technical and logistics support services, and other related elements of logistical and program support. The estimated cost is $330 million.

This proposed sale will contribute to the foreign policy and national security of the United States by helping to improve the security of a friendly country which has been, and continues to be, an important force for political stability and economic progress in the Middle East.

The proposed sale will augment Saudi Arabia's capability to meet current and future threats from potential adversaries during operations conducted at night and during low visibility conditions. The Royal Saudi Land Forces (RSLF) are responsible for regional, perimeter, and border security operations. This proposed sale meets their defense and counter-terrorism requirements to deter current insurgent activity along their southern border and contributes to their overall military posture. The RSLF already has night vision devices in its inventory and will have no difficulty absorbing this night vision equipment into its inventory.

The proposed sale of this equipment will not alter the basic military balance in the region.

The prime contractors will be FLIR Inc. in Boston, Massachusetts and Laser Devices, Inc. in Monterey, California. There are no known offset agreements proposed in connection with this potential sale.

Implementation of this sale will not require the assignment of any U.S. Government or contractor representatives to recipient.

There will be no adverse impact on U.S. defense readiness as a result of this proposed sale.

[FR Doc. 2011–12405 Filed 5–19–11; 8:45 am]
BILLING CODE 5001–06–C

DEPARTMENT OF DEFENSE

Department of the Army; Corps of Engineers

Notice of Intent To Prepare Draft Environmental Impact Statements/ Environmental Impact Reports for the Sutter Basin Feasibility Study and the Section 408 Permission for the Feather River West Levee Project, Sutter and Butte Counties, CA

AGENCY: Department of the Army, U.S. Army Corps of Engineers; DoD.

ACTION: Notice of intent.

SUMMARY: Pursuant to the National Environmental Policy Act of 1969, as amended, and the California Environmental Quality Act (CEQA), the U.S. Army Corps of Engineers (USACE) intends to prepare a separate Environmental Impact Statement/ Environmental Impact Report (EIS/EIR) for each of the following related flood risk management study efforts in north-central California: a Feasibility Study of flood risk management and related water resources problems in the Sutter Basin conducted by USACE under the authority of the Flood Control Act of 1962 (Pub. L. 87–874); and under Section 14 of the Rivers and Harbors Act

of 1899 (as amended) (33 U.S.C. 408), and Section 404 of the Clean Water Act (33 U.S.C. 1344), the proposed Feather River West Levee Project (FRWLP), sponsored by the Sutter Butte Flood Control Agency (SBFCA) as a locally driven flood management improvement project. The two projects are being studied in close coordination because they partially overlap in their study areas, purpose, potential improvements, potential effects, and involved parties. Therefore, a joint scoping process is being conducted for the two projects to explain the relationship between the two efforts and obtain public input in a manner that is convenient, efficient, and integrated. Figures of the two project areas can be viewed at the SBFCA *Web site at: http://www.sutterbutteflood.org/index.php/notices_documents.*

Sutter Basin Feasibility Study. On March 20, 2000, the State of California entered into a feasibility cost-sharing agreement (FCSA) with USACE to initiate a feasibility study. An amendment to the FCSA was signed in 2010, which included SBFCA as a non-Federal sponsor. The purpose of the study is to address flood risk, ecosystem restoration and recreation-related issues in the study area. If a Federal interest is determined, the study would result in a decision document, a General Investigation Feasibility Study report and EIS/EIR, which would be the basis for a recommendation to Congress for authorization. The Central Valley Flood Protection Board (CVFPB) and SBFCA are coordinating with USACE on the feasibility study. USACE, as the Federal lead agency under NEPA, and SBFCA, as the state lead agency under CEQA in coordination with CVFPB, have determined that an EIS/EIR will be prepared to describe alternatives, potential environmental effects, and mitigation measures.

FRWLP. SBFCA is planning the FRWLP to construct improvements to the west levee of the Feather River from Thermalito Afterbay to the Sutter Bypass confluence to meet Federal, state, and local flood protection criteria and goals. In 2010, an assessment district was enacted to provide local funding toward flood management improvements. These funds may be matched with those from the Early Implementation Program (funded through previous state bonds) administered by the California Department of Water Resources (DWR). In order to implement the project, the sponsor must acquire permission from USACE to alter the Federal project under Section 14 of the Rivers and Harbors Act of 1899 (as amended) (33 U.S.C. 408 or, Section 408). USACE also has authority under Section 404 of the Clean Water Act (33 U.S.C. 1344) over activities involving the discharge of dredged or fill material to waters of the United States, which are known to be in the project area. The purpose of the FRWLP would be to construct improvements as quickly as possible in advance of and compatible with the Sutter Basin Project. USACE, acting as the Federal lead agency under NEPA, and SBFCA, acting as the state lead agency under the CEQA in coordination with CVFPB, have determined that an EIS/EIR will be prepared to describe alternatives, potential environmental effects, and mitigation measures.

DATES: Public scoping meetings will be held on Monday, June 27 at 3:30 p.m. and 6:30 p.m. at the Veterans Memorial Community Building, 1425 Veterans Memorial Circle, Yuba City, CA and on Tuesday, June 28 at 3:30 p.m. and 6:30 p.m. at the Veterans Memorial Hall, 245 Sycamore Street, Gridley, CA. Send written comments by July 8, 2011 (see **ADDRESSES**).

ADDRESSES: Written comments and suggestions concerning the scope and content of the environmental information may be submitted to Mr. Matt Davis, U.S. Army Corps of Engineers, Sacramento District, Attn: Planning Division (CESPK–PD–R), 1325 J Street, Sacramento, CA 95814. Requests to be placed on the mailing list also should be sent to this address.

FOR FURTHER INFORMATION CONTACT: Questions about the proposed actions and environmental review process should be addressed to Matt Davis at (916) 557–6708, *e-mail: Matthew.G.Davis@usace.army.mil* (see **ADDRESSES**).

SUPPLEMENTARY INFORMATION:

1. *Proposed Action. Sutter Basin Feasibility Study.* USACE is conducting a feasibility study to evaluate structural and non-structural flood-risk-management measures, including re-operation of existing reservoirs; improvements to existing levees; construction of new levees; and other storage, conveyance, and non-structural options. The Sutter Basin study area covers approximately 285 square miles and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. Flood waters potentially threatening the study area originate from the Feather River watershed and/or the upper Sacramento River watershed, above Colusa Weir. The study area is essentially encircled by project levees and the high ground of Sutter Buttes. Geotechnical analysis and historical performance during past floods indicates the project levees are at risk of failure due to underseepage. The risk of levee failure coupled with the consequence of deep flooding presents a threat to public safety and property. Considering the collective changes to riparian and aquatic ecosystems brought about by agriculture, urbanization, mining, and flood risk management and water supply infrastructure, and the national concern for environmental quality and protection, every opportunity to restore and protect natural resources should be taken whenever changes in the water management system are being contemplated. Ecosystem restoration measures likely would include restoration of floodplain function and habitat. Recreation measures include those outdoor recreation opportunities associated with sustainable water resource development. The feasibility phase of this project is cost-shared 50% Federal, 50% non-Federal with the project sponsors, the State of California CVFPB and the SBFCA. The study will focus on alternatives in the study area that comprise flood risk management, ecosystem restoration, and recreation management measures. As part of the study, an EIS/EIR will be prepared with USACE as the lead agency under NEPA and SBFCA in cooperation with CVFPB as the lead agency under CEQA.

FRWLP. SBFCA is proposing a levee improvement project along the Feather River west levee under the California DWR's Early Implementation Program to expeditiously complete flood-risk reduction measures in advance of the Sutter Basin Feasibility Study. Known as the FRWLP, the project proposes to construct levee improvements between the Thermalito Afterbay and the Feather River/Sutter Bypass confluence. Primary deficiencies of the levee include through-seepage, under-seepage, and embankment instability (*e.g.,* overly steepened slopes). Alternatives considered may include measures such as slurry cutoff walls, seepage berms, stability berms, internal drains, relief wells, sheet-pile walls, slope flattening, and potential new levee alignments. As part of the project, an EIS/EIR is being prepared. USACE has authority under Section 14 of the Rivers and Harbors Act of 1899 (as amended) (33 U.S.C. 408), over alterations to Federal flood control project levees and any such alterations as proposed by SBFCA are subject to approval by USACE. USACE also has authority under Section 404 of the Clean Water Act (33 U.S.C. 1344) over activities involving the discharge of dredged or fill material to waters of the United States, which are known to be in

the project area. Due to these authorities, USACE is acting as the lead agency for the EIS pursuant to NEPA. SBFCA will be acting as the lead agency for the EIR according to CEQA as an agency of the State of California with delegated authority to approve the project.

2. *Alternatives.* The EIS/EIRs will consider several alternatives for reducing flood damage. Alternatives analyzed during the investigation will consist of a combination of one or more measures to reduce the risk of flooding. These measures include installing cutoff walls, and constructing seepage berms.

3. *Scoping Process.*

a. A series of public scoping meetings will be held on June 27 and 28, 2011, to present information to the public and to receive comments from the public on both the feasibility study and the FRWLP. These meetings are intended to initiate the process to involve concerned individuals, and local, state, and Federal agencies.

b. Significant issues to be analyzed in depth in the environmental documents include effects on hydraulics, wetlands and other waters of the U.S., vegetation and wildlife resources, special-status species, aesthetics, cultural resources, recreation, land use, fisheries, water quality, air quality, transportation, and socioeconomics; and cumulative effects of related projects in the study area.

c. USACE is consulting with the State Historic Preservation Officer to comply with the National Historic Preservation Act and with the U.S. Fish and Wildlife Service and National Marine Fisheries Service to comply with the Endangered Species Act. USACE also is coordinating with the U.S. Fish and Wildlife Service to comply with the Fish and Wildlife Coordination Act.

d. A 45-day public review period will be provided for individuals and agencies to review and comment on the draft environmental documents. All interested parties are encouraged to respond to this notice and provide a current address if they wish to be notified of the draft EIS/EIR circulation.

4. *Availability.* The draft EIS/EIR for the FRWLP is scheduled to be available for public review and comment in late 2011. The draft EIS/EIR for the Sutter Basin Feasibility Study is scheduled to be available for public review and comment in mid 2012.

Dated: May 12, 2011.

Andrew B. Kiger,

LTC, EN, Commanding.

[FR Doc. 2011–12510 Filed 5–19–11; 8:45 am]

BILLING CODE 3720–58–P

DEPARTMENT OF DEFENSE

Department of the Army; Corps of Engineers

Notice of Availability of the Final Programmatic Environmental Impact Statement for the Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River, Missouri River Basin, United States

AGENCY: Department of the Army, U.S. Army Corps of Engineers, DoD.

ACTION: Notice of Availability.

SUMMARY: In accordance with the National Environmental Policy Act of 1969, as amended, the U.S. Army Corps of Engineers intends to file a Final Programmatic Environmental Impact Statement (FPEIS) for the Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat on the Riverine Segments of the Upper Missouri River with the U.S. Environmental Protection Agency. The FEIS is available for final public review. Details on the proposed action, location and areas of environmental concern addressed in the FPEIS are provided below under **SUPPLEMENTARY INFORMATION**.

DATES: The review period will be open 30 days from the date of this notice. The Record of Decision is anticipated to be issued in August, 2011.

ADDRESSES: Written comments should be sent to: Department of the Army; Corps of Engineers, Omaha District; CENWO–PM–AC; ATTN: Emergent Sandbar Habitat Programmatic EIS; 1616 Capitol Avenue; Omaha, NE 68102–4901, or e-mailed to: *Cynthia.s.upah@usace.army.mil.* Comments must be postmarked, e-mailed, or otherwise submitted no later than June 13, 2011. Copies of the FPEIS have been sent to all agencies and individuals who participated in the scoping process or public hearings and to those requesting copies. The FEIS is available online at: *http://www.moriverrecovery.org/mrrp/MRRP_PUB_DEV.download_documentation_peis.* To obtain a copy, please contact Ms. Cynthia Upah.

FOR FURTHER INFORMATION CONTACT: Ms. Cynthia Upah, Project Manager, by telephone: (402) 995–2672, by mail: 1616 Capitol Avenue, Omaha, NE 68102–4901, or by e-mail: *Cynthia.s.upah@usace.army.mil.* For inquires from the media, please contact the USACE Omaha District Public Affairs Officer (PAO), Ms. Monique Farmer by telephone: (402) 995–2416, by mail: 1616 Capitol Avenue, Omaha, NE 68102, or by e-mail: *Monique.l.farmer@usace.army.mil.*

SUPPLEMENTARY INFORMATION: 1. *Background.* The Emergent Sandbar Habitat (ESH) program is being implemented by the U.S. Army Corps of Engineers (Corps) for the benefit of the interior population of the Interior least tern (least tern) and the northern Great Plains piping plover (piping plover). This implementation program resulted from a Biological Opinion (BiOp) issued by the U.S. Fish and Wildlife Service (USFWS) in which the Reasonable and Prudent Alternative (RPA) called for the Corps to provide sufficient ESH acreage in order to meet biological metrics (fledge ratios) to avoid jeopardizing continued existence of the species, as defined by the Endangered Species Act (ESA).

The FPEIS is needed to provide National Environmental Policy Act (NEPA) coverage for the mechanical and artificial construction of ESH in the riverine segments of the Upper Missouri River, pursuant to the 2003 BiOp Amendment RPA IV(b) 3, and to compare impacts among a range of alternatives. The goal is to inform the selection of a preferred alternative that allows for the creation and replacement of sufficient habitat to support tern and plover populations on the Missouri River in a safe, efficient and cost-effective manner that minimizes negative environmental consequences.

Alternatives to the proposed project that are considered in the FPEIS include (1) no action, including existing program activities and no action; (2) and 6 action alternatives of various acreage creation. Environmental issues addressed in the FPEIS include hydrology, water quality, aggradation and degradation, biological resources, air quality, noise and recreation.

After detailed consideration of the environmental and social impacts, and cumulative effects, of the Alternatives, the Corps has identified an Adaptive Management Implementation Process (AMIP) as the preferred alternative, and not one of the specific acreage alternatives. The key aspect of the AMIP is that, rather than selecting a specific acreage alternative and pursuing such construction, actions would be progressively implemented with the focus on monitoring a combination of biological and physical metrics (measurements). Implementation of progressively larger acreage amounts of habitat would continue until the desired biological response is attained and sustained.

Join Us To Learn More About Local Flood Risk Reduction Efforts

Join the U.S. Army Corps of Engineers (USACE) and the Sutter Butte Flood Control Agency (SBFCA) for a public scoping meeting to learn about two proposed flood risk reduction efforts in Sutter and Butte counties. USACE's Sutter Basin Feasibility Study will look at potential improvements throughout the Sutter Basin, while SBFCA's Feather River West Levee Project is proposing to repair 44 miles of the river's west levee.

The public is encouraged to attend these meetings to comment on the scope of the proposed projects and the preparation of related environmental documents.

Meeting Dates & Times

June 27 at 3:30 p.m. and 6:30 p.m.
Veterans Memorial Community Building
1425 Veterans Memorial Circle, Yuba City

June 28 at 3:30 p.m. and 6:30 p.m.
Gridley Veterans Memorial Hall
249 Sycamore Street, Gridley

A presentation will begin 30 minutes after the start of each meeting. The same information will be presented at each meeting.

If you have questions or need special assistance or accommodations at a meeting, call 916-231-9618 at least 72 hours in advance of the meeting you plan to attend.

US Army Corps of Engineers®
Sacramento District

www.sutterbutteflood.org • www.spk.usace.army.mil

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FOR IMMEDIATE RELEASE
CONTACT: INGRID NORGAARD
EMAIL: inorgaard@icfi.com
PHONE: 916-737-3000

Agencies Hosting Public Meetings Related to Proposed Flood Improvements in Sutter and Butte Counties

The public is invited to attend to provide input on environmental process

Yuba City, June 22, 2011—The U.S. Army Corps of Engineers' (USACE) Sacramento District and the Sutter Butte Flood Control Agency (SBFCA) will hold four public scoping meetings on June 27 and 28 to provide the public an opportunity to comment on proposed regional flood risk management projects.

The purpose of the USACE's Sutter Basin Project is to address flood risk management, ecosystem restoration, and recreation issues in the Sutter Basin study area. The project is currently in the feasibility study phase. The study area covers approximately 285 square miles and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes and Cherokee Canal.

SBFCA is planning the Feather River West Levee Project (FRWLP) to address levee deficiencies found along 44 miles of the west levee of the Feather River from the Thermalito Afterbay south to the Sutter Bypass. The west levee provides flood risk management benefits to the cities of Yuba City, Gridley, Live Oak, and Biggs and portions of unincorporated areas of Butte and Sutter counties. Measures are being evaluated to meet Federal, state, and local flood protection criteria and goals.

The Sutter Basin Project and FRWLP are being studied in close coordination because of related study areas, purpose, potential measures and potential effects. It is anticipated that two separate environmental impact statements/environmental impact reports (EIS/EIR) will be developed—one for the Sutter Basin Project and one for FRWLP. The public release of the draft EIS/EIR to evaluate FRWLP is scheduled for early 2012. The release of the Sutter Basin Project's draft EIS/EIR has yet to be determined. The California Department of Water Resources and Central Valley Flood Protection Board are also involved in these two efforts.

Combined and coordinated scoping for the two efforts is being conducted to ensure an efficient process for interested stakeholders. Public input will be solicited about the content of the environmental documents. Please join us at one of four scoping meetings to provide input.

City of Yuba City
June 27 at 3:30 p.m. *and* 6:30 p.m.
Veteran's Memorial Community Bldg.
1425 Veterans Memorial Circle,
Yuba City

City of Gridley
June 28 at 3:30 p.m. *and* 6:30 p.m.
Gridley Veteran's Memorial Hall
249 Sycamore Street, Gridley

-MORE-

A presentation will be given 30 minutes after each meeting begins. The content of all four meetings will be the same. For questions about the meetings or to make special accommodations for attendees, contact Ms. Norgaard at 916-737-3000 or via email at inorgaard@icfi.com.

Learn more about the Sutter Basin Project at www.spk.usace.army.mil and about the FRWLP at www.sutterbutteflood.org.

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Attachment B

- Display boards
- Power Point presentation
- Fact sheet
- Comment card templates

Station 2 - Overview, Purpose, and Objectives 110x13

2A
About the SBP
36x18

2B
SBP Study Area MAP
36x24

2C
SBP Timeline
36x18

2D
Inside Look at a Levee
30x24

2E
Typical Levee Deficiencies
30x24

2F
About the FRWLP
36x18

2G
FRWLP Study Area MAP
36x24

2H
FRWLP Timeline & Funding
36x18

Station 3 - Potential Measures 110x13

3A Slurry Wall 25x20	3B Stability Berm 25x20	3C Seepage Berm 25x20	3D Relief Well 25x20
3E Sheet-Pile Wall 25x20	3F Slope Flattening 25x20	3G Internal Drain 25x20	3H New/Relocated Levee 25x20
3I Re-Operation 25x20	3J Non-Structural 25x20	3K Ecosystem Restoration 25x20	3L Recreation 25x20

Station 4 - Environmental Process 110x13

4A
About NEPA/CEQA
24x32

4B
Scoping
24x32

4C
Enviro Issues
24x32

4D
Regulatory Compliance
24x32

4E
SBP Photo
52x32

4F
FRWLP Photo
52x32

Welcome to the Sutter Basin Project & Feather River West Levee Project Environmental Scoping Meeting

US Army Corps of Engineers®
Sacramento District

Overview, Purpose, and Objectives

About the Sutter Basin Project

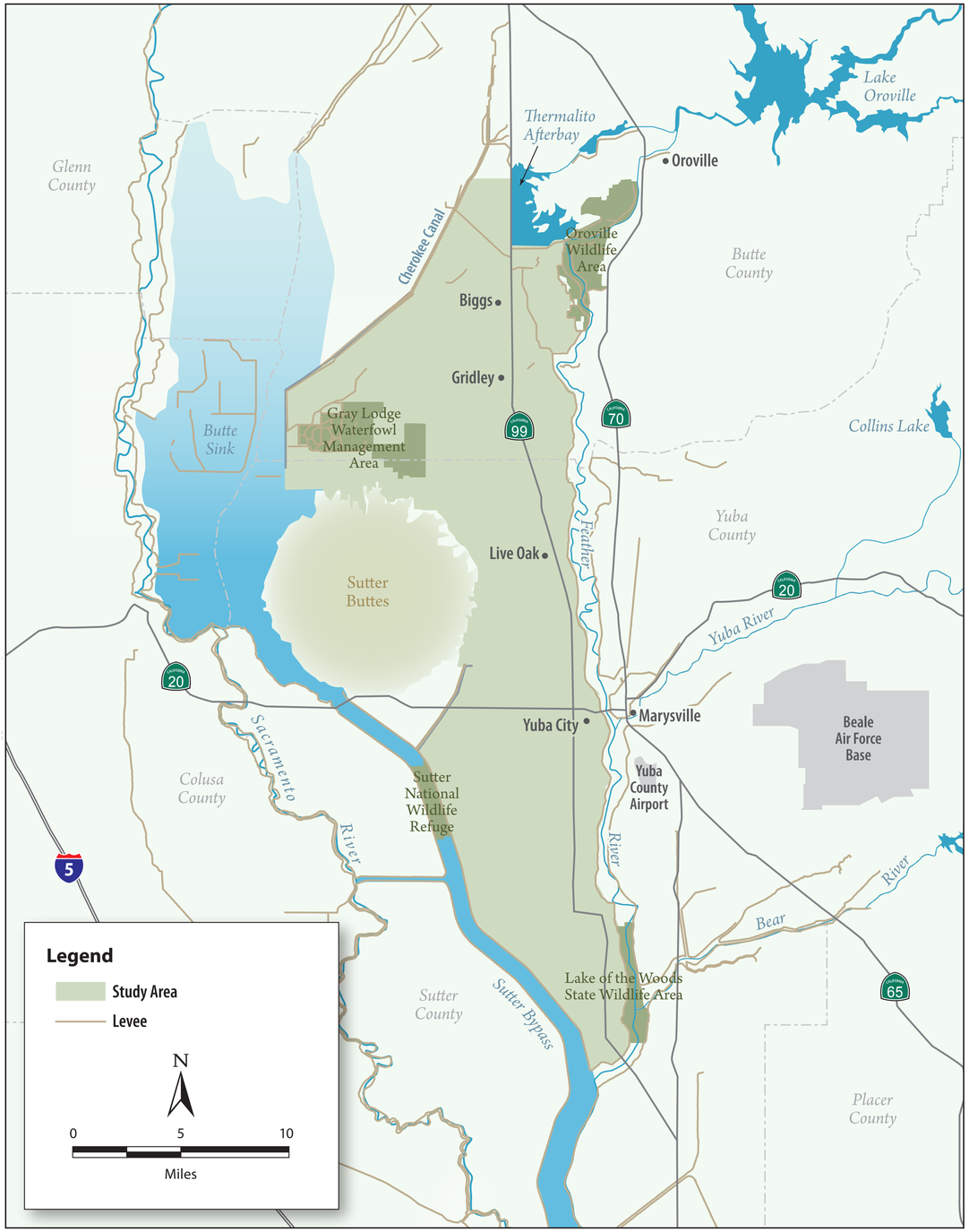
In 2000, the State of California and USACE entered into a cost-sharing agreement to initiate a feasibility study within the Sutter Basin. An amendment of the cost-sharing agreement was signed in July 2010 to include SBFCA as a non-Federal sponsor. The purpose of the feasibility study is to address flood risk management, ecosystem restoration, and recreation issues in the study area.

The Sutter Basin Project feasibility study evaluates approximately 285 square miles that are roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The study area is essentially encircled by project levees and the high ground of the Sutter Buttes. Past flood events and geotechnical analysis show these levees have a higher probability of failure related to through-and under-seepage than levees designed to meet current standards. Additionally, the levees are at risk of overtopping from floods greater than they are designed to withstand.

As part of the Sutter Basin Project feasibility study, USACE is evaluating a variety of flood risk management measures that could include re-operation of reservoirs; improvements to existing levees; construction of new levees; other storage, conveyance, and non-structural options; and measures that could potentially restore the ecosystem within the study area and develop or expand recreation facilities.

This study will be the basis for a recommendation to Congress to address water resources and related issues within the study area.

Sutter Basin Project Area



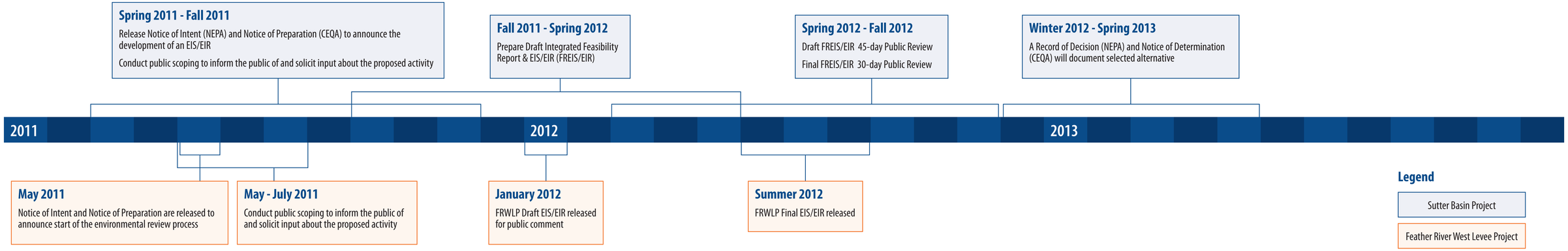
2B - SBP Study Area.indd 1 6/21/11 2:10 PM

Sutter Basin Project Funding and Timeline

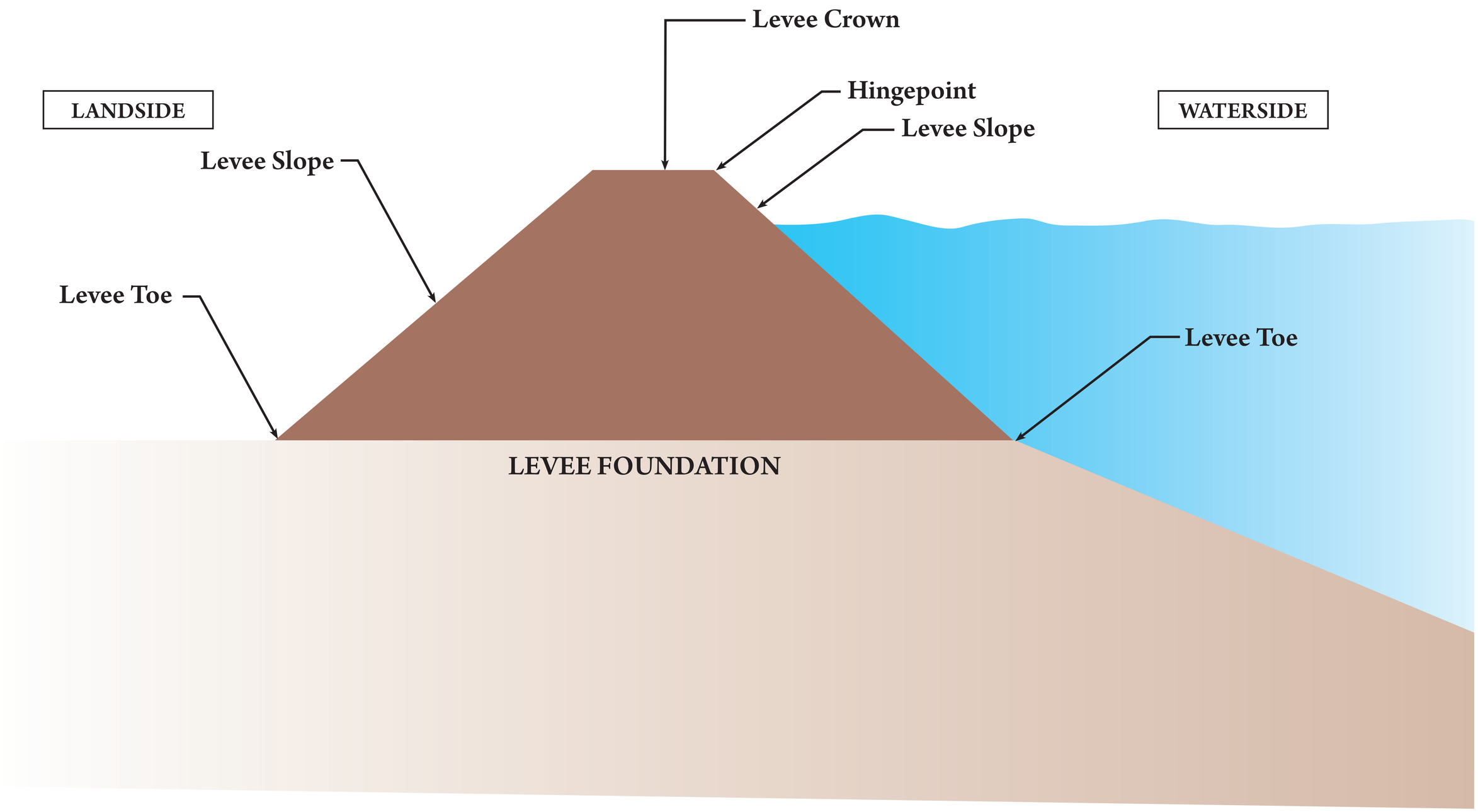
Funding

The feasibility study phase of this project is cost-shared; USACE will fund 50% and SBFCA and the State of California will fund the remaining 50% of the project.

Timeline



An "Inside" Look at a Levee



2D - Inside Look at Levee.indd 1
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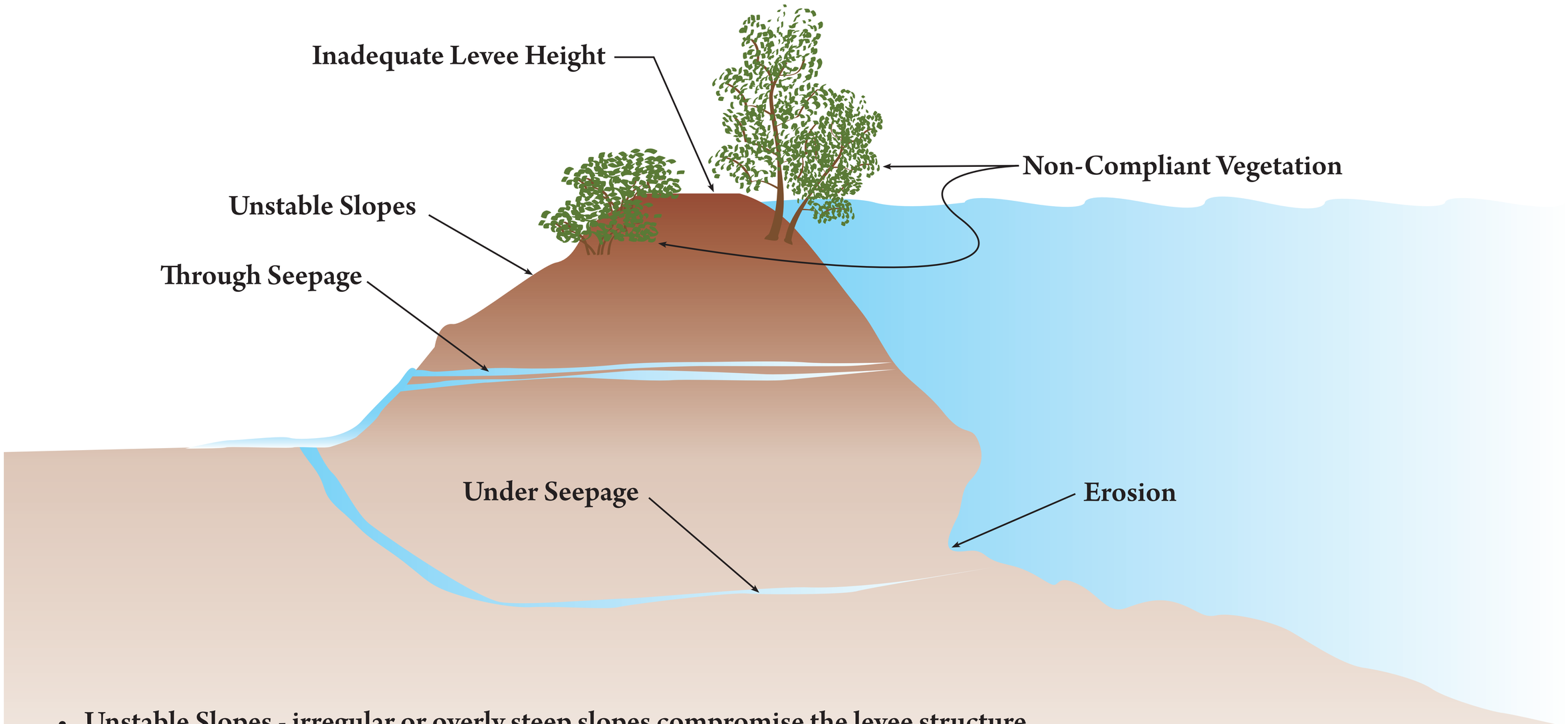
Typical Levee Deficiencies



- Unstable Slopes - irregular or overly steep slopes compromise the levee structure
- Inadequate levee height - levee height may be too low relative to predicted water levels
- Non-Compliant Vegetation - can lead to levee instability and hinder levee monitoring and maintenance
- Erosion - water flow, wakes and waves, remove soil material, damaging the levee
- Seepage

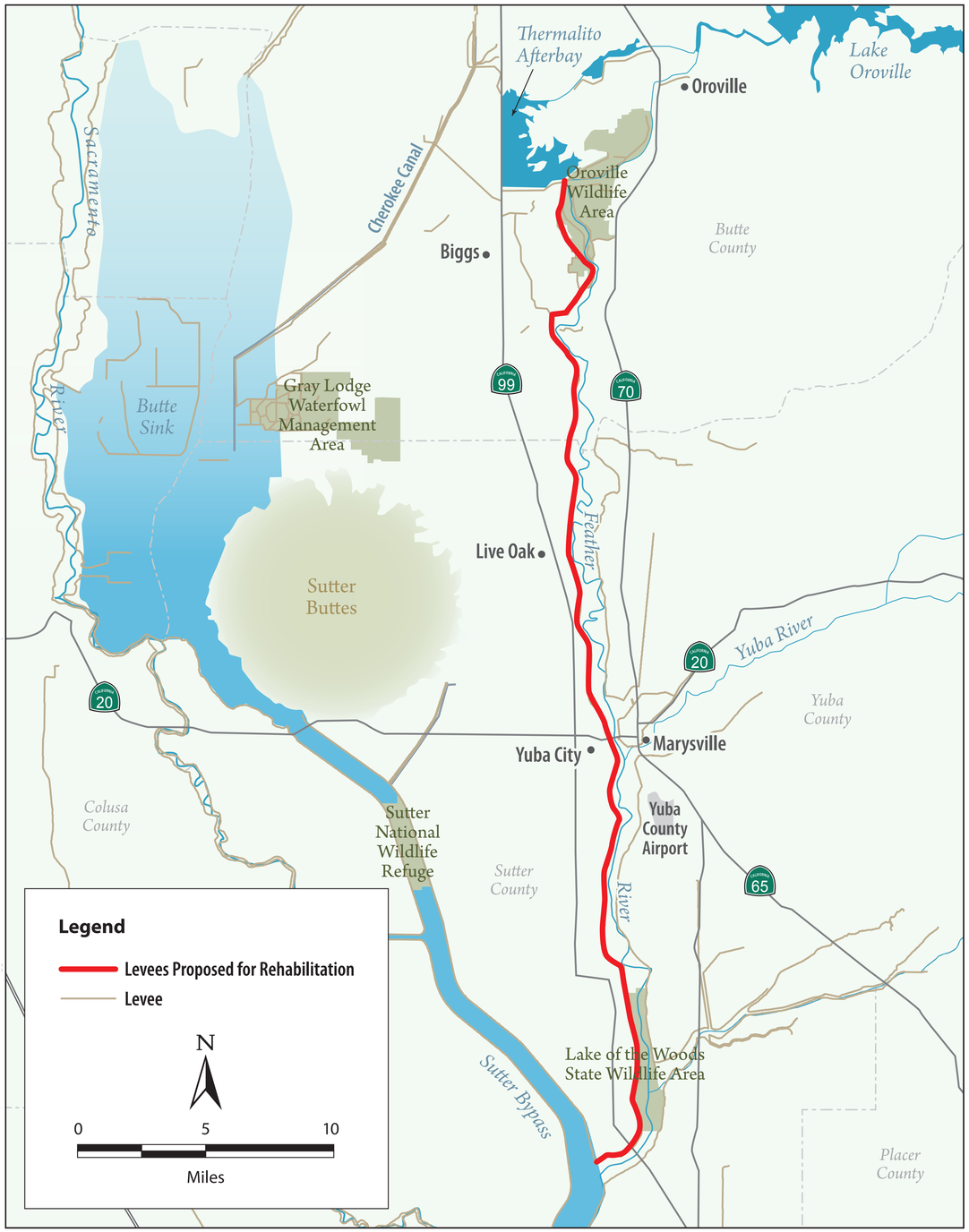
2E - Levee Deficiencies.indd 1 6/21/11 2:13 PM

About the Feather River West Levee Project

Communities in both Butte and Sutter Counties have an unfortunate historical knowledge of devastating flood events within the region. Sutter Butte Flood Control Agency (SBFCA) is planning the Feather River West Levee Project (FRWLP) to address levee deficiencies found along 44 miles of the west levee of the Feather River from the Thermalito Afterbay south to the Sutter Bypass. Measures are being evaluated to meet Federal, state, and local flood protection criteria and goals. The FRWLP is expected to:

- Increase public safety by providing 200-year flood protection from Yuba City north to the Thermalito Afterbay, and the appropriate level of flood protection south of Yuba City (in conjunction with repairs to the Sutter Bypass, which are the responsibility of the state).
- Save property owners millions of dollars annually in flood insurance costs by delaying, preventing, or cutting short FEMA floodplain mapping.
- Allow cities and counties to implement general plans, which will soon be restricted for any urban or urbanizing community without 200-year flood protection. This would not apply to areas with fewer than 10,000 residents.
- Sustain and grow the local economy by creating construction jobs, protecting property values, and allowing for responsible development.

Feather River West Levee Project Area



2G - FRWLP Study Area.indd 1
6/21/11 2:16 PM

Feather River West Levee Project Funding and Timeline

Funding

The FRWLP is estimated at $250 million for construction. A local assessment district enacted in 2010 will pay 29% of the project cost and the State of California is expected to pay the remaining share.

Timeline

Environmental specialists are currently analyzing the effects the FRWLP could have if implemented, to comply with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). This analysis will help engineers finalize the project design, and request Federal and state permits. The goal is to construct the FRWLP as quickly as possible in advance of and compatible with the Sutter Basin Project, potentially beginning construction in 2013.

May 2011
Notice of Intent and Notice of Preparation are released to announce start of the environmental review process

May-July 2011
Sutter Basin Project and FRWLP scoping period

January 2012
FRWLP Draft EIS/EIR released for public comment

Summer 2012
FRWLP Final EIS/EIR released

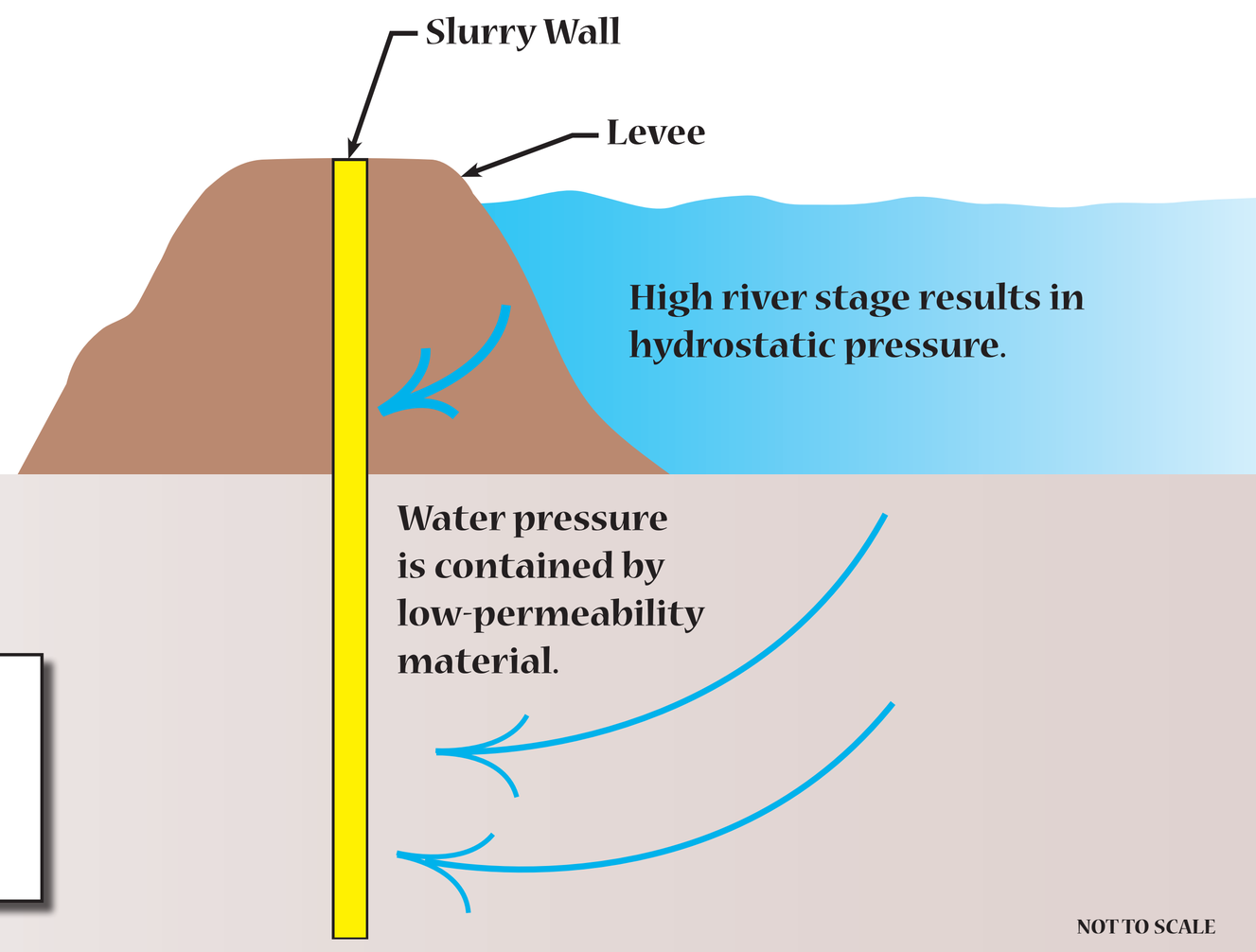
2011 2012

2H - Funding and Timeline.indd 1 6/22/11 1:24 PM

Potential Measures

Slurry Cut-off Wall

Concept:
Water-seepage and through-seepage are controlled by a low-permeability wall constructed within the levee cross section.

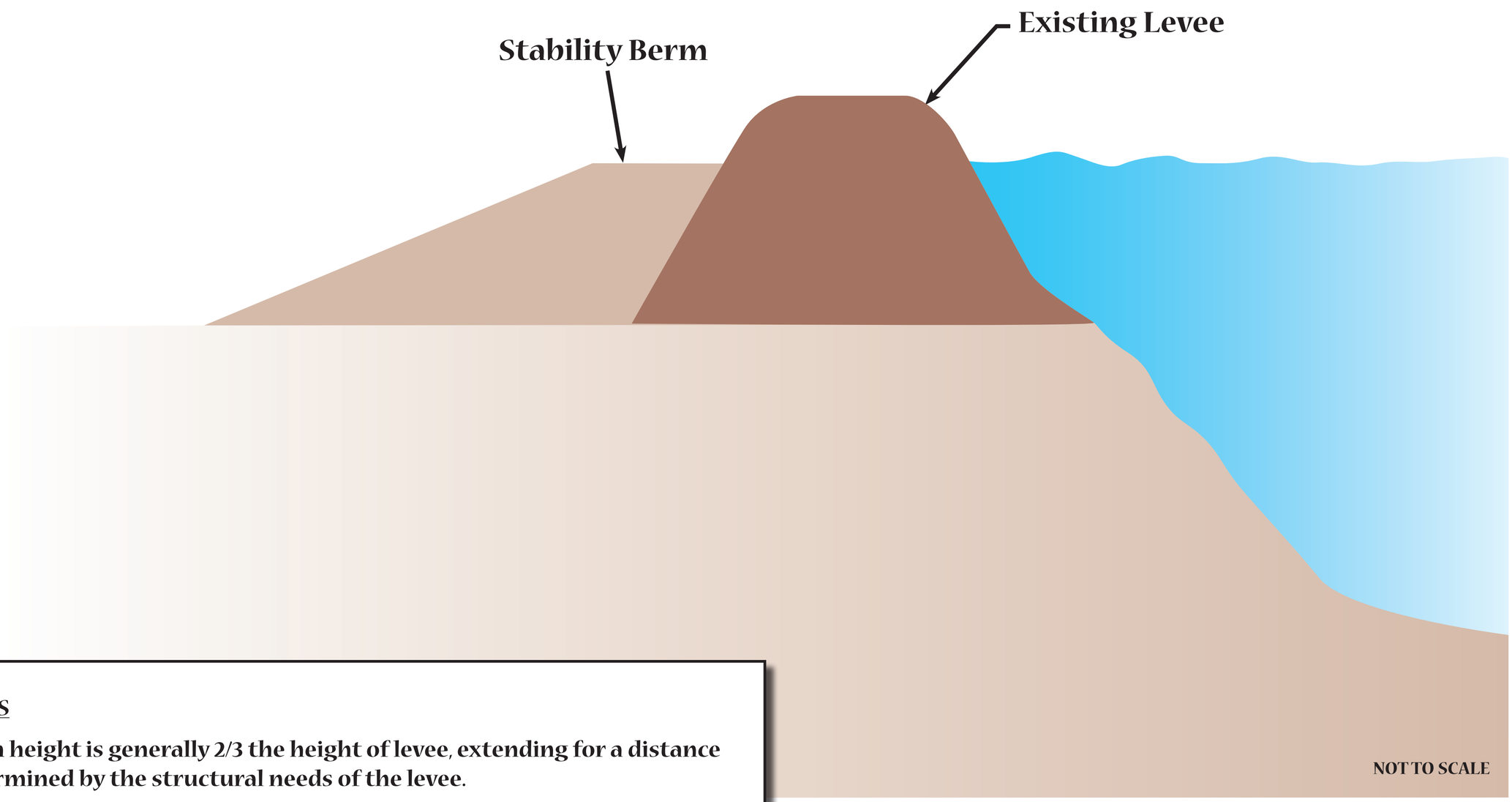


DETAILS

- Constructed via traditional slot trench, deep soil mix method, or jet grouting.
- Wall is approximately 3 ft wide and up to 140 ft deep.

Stability Berm

Concept:
Provides additional support to levee
to increase strength.

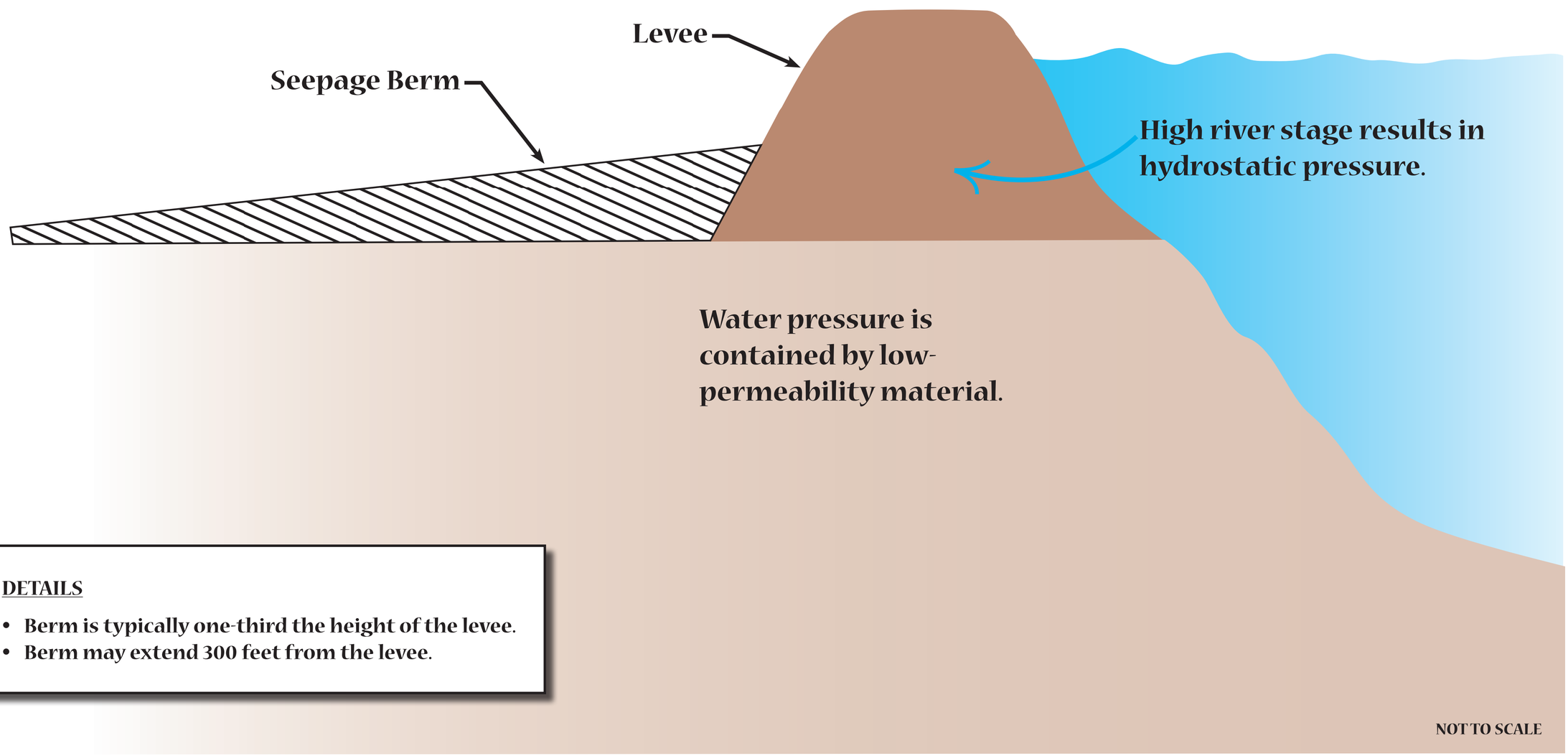


DETAILS

- **Berm height is generally 2/3 the height of levee, extending for a distance determined by the structural needs of the levee.**

Seepage Berm

Concept:
Water pressure is contained and dispersed by a thickened soil layer.

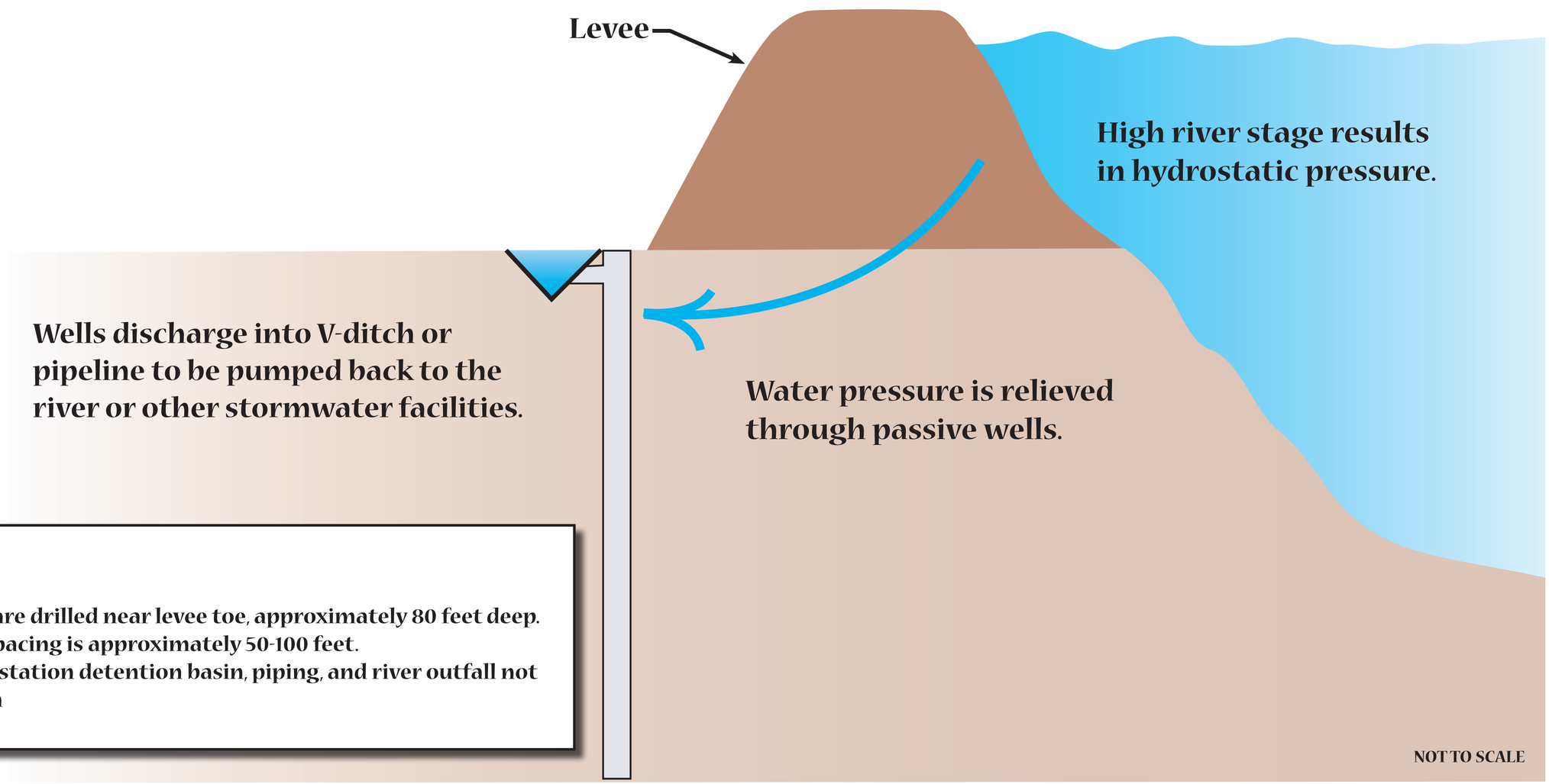


DETAILS

- Berm is typically one-third the height of the levee.
- Berm may extend 300 feet from the levee.

Relief Well

Concept:
Water pressure is relieved via passive wells, which direct water discharge into a collection system.

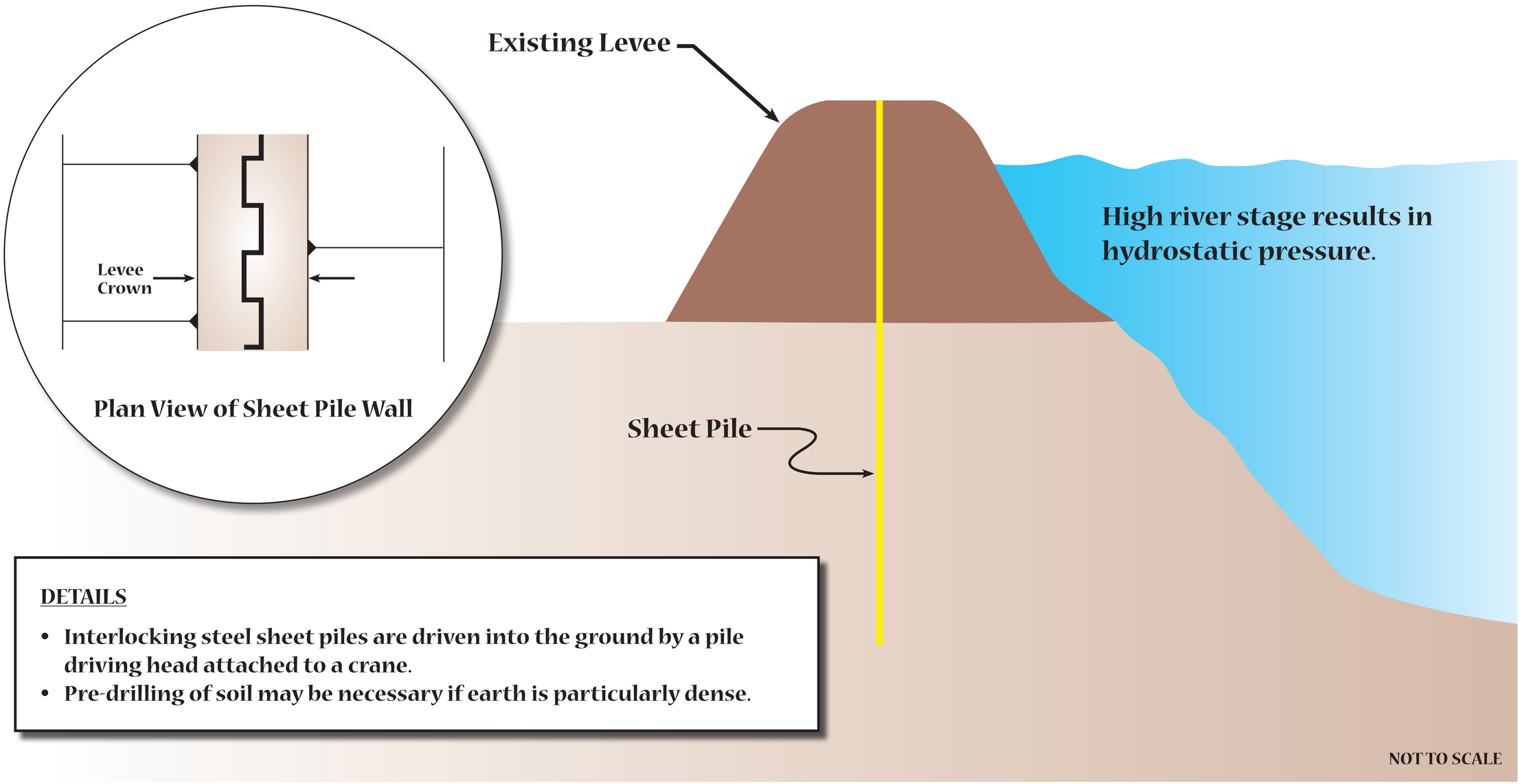


DETAILS

- Wells are drilled near levee toe, approximately 80 feet deep.
- Well spacing is approximately 50-100 feet.
- Pump station detention basin, piping, and river outfall not shown

Sheet Pile Wall

Concept:
Steel panels are driven into the levee core to provide a seepage barrier.

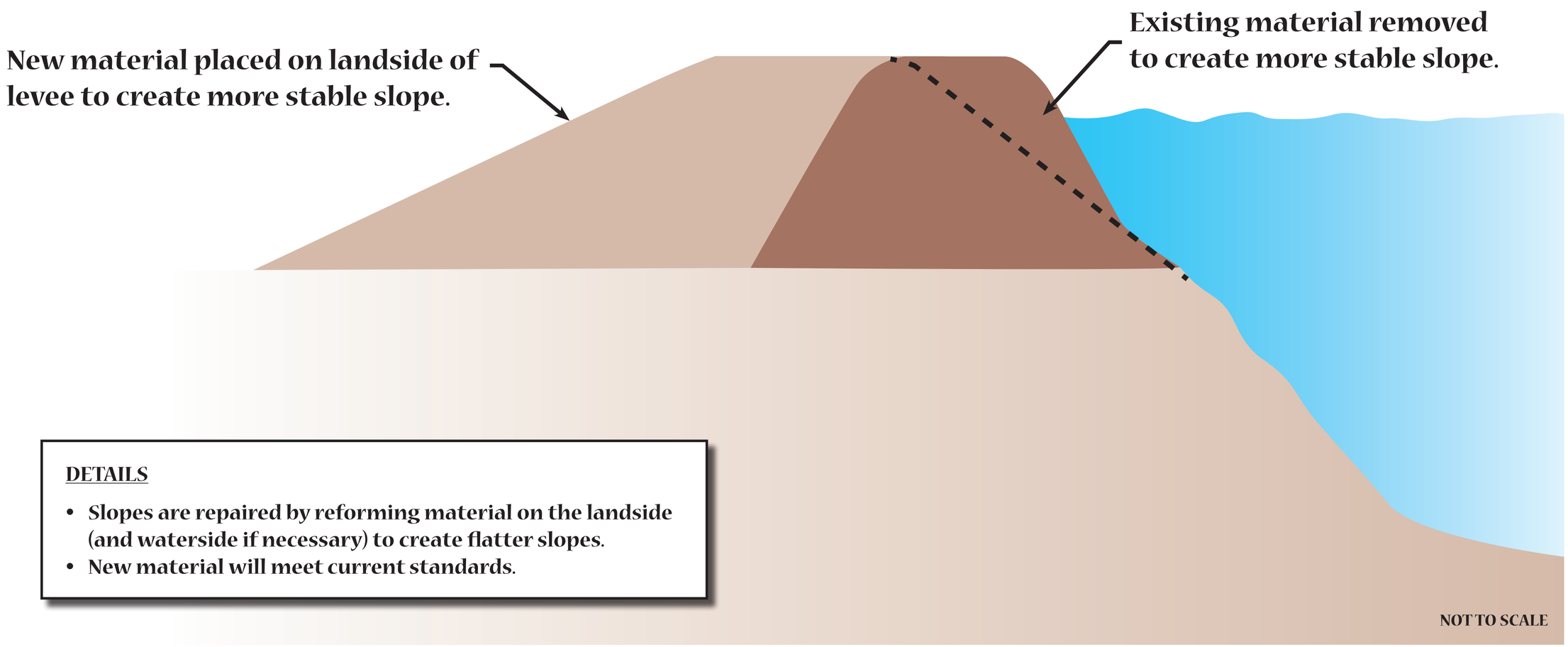


DETAILS

- Interlocking steel sheet piles are driven into the ground by a pile driving head attached to a crane.
- Pre-drilling of soil may be necessary if earth is particularly dense.

Slope Flattening

Concept:
Flatter slopes are more stable and less susceptible to erosion.

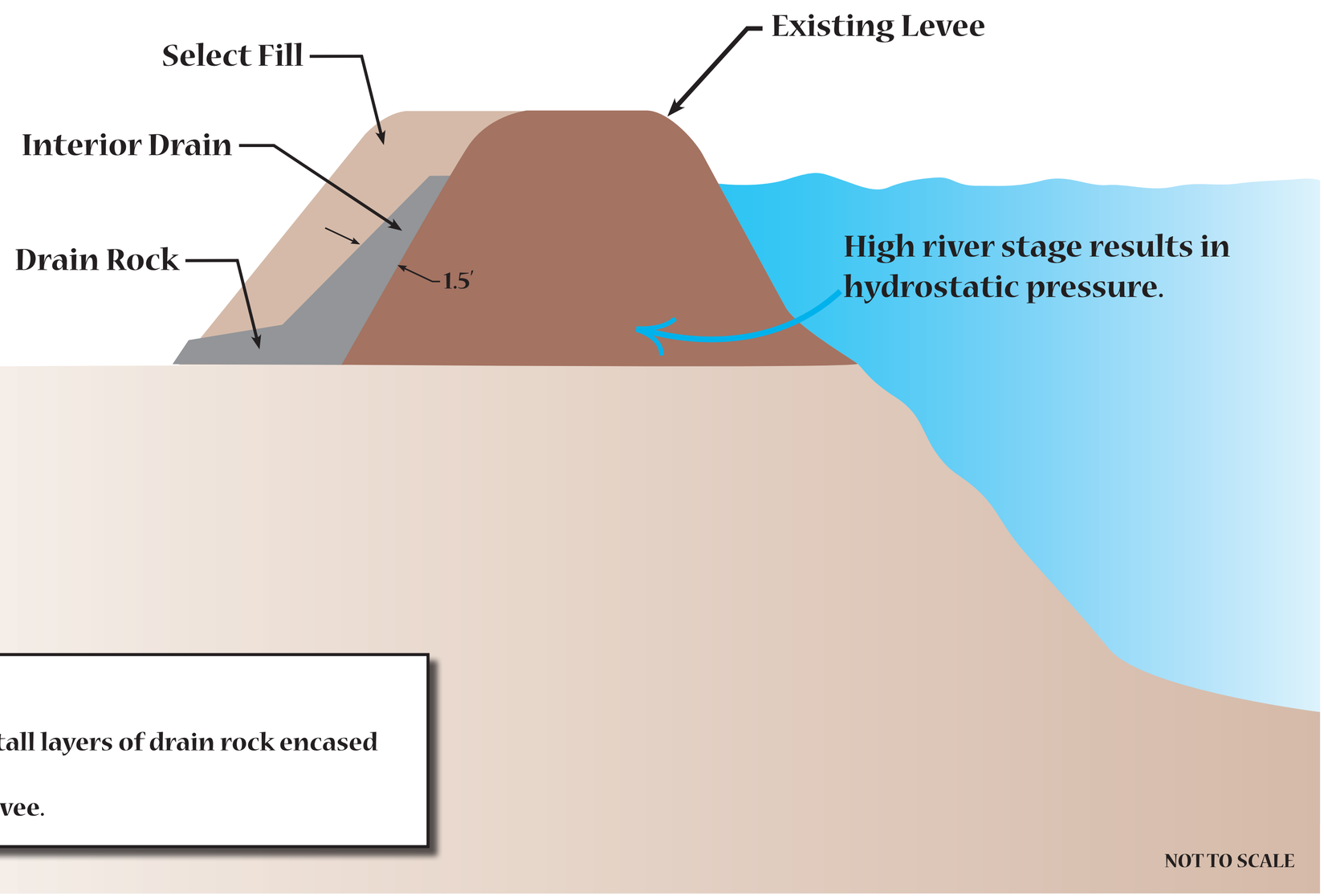


DETAILS

- Slopes are repaired by reforming material on the landside (and waterside if necessary) to create flatter slopes.
- New material will meet current standards.

Internal Drain

Concept:
Capture any through-seepage and
direct it away from the face of the levee.

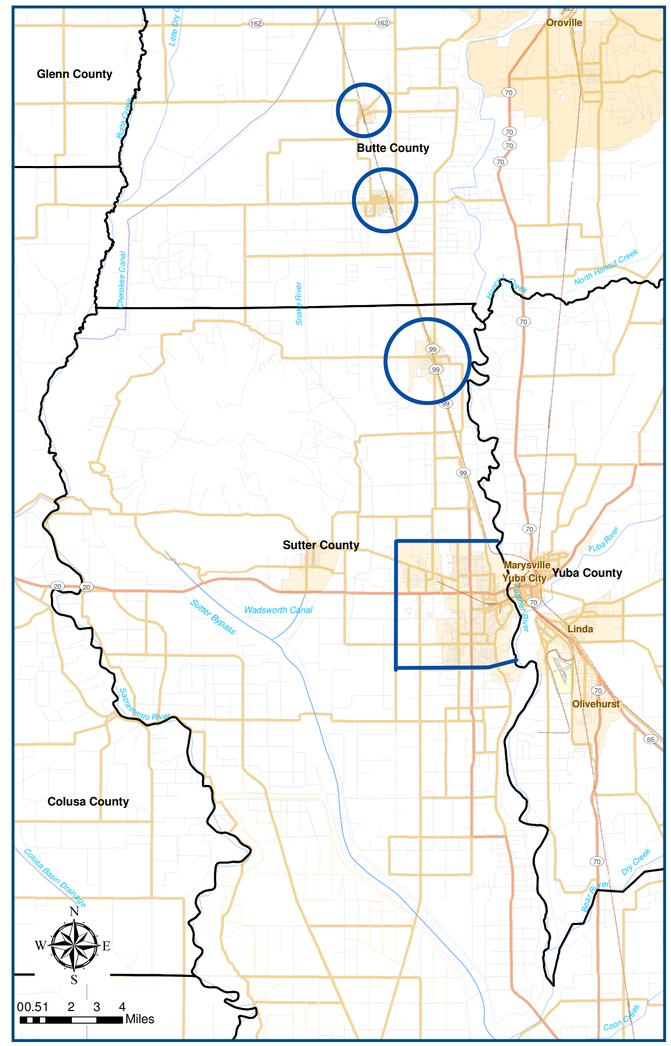


DETAILS

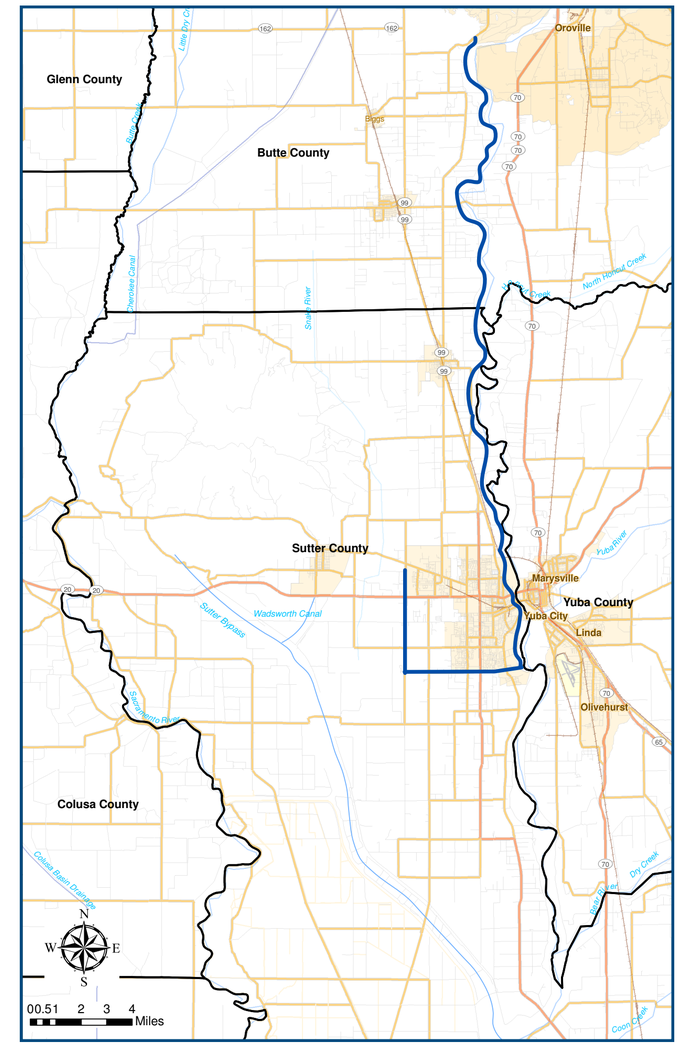
- Levee is partially excavated to install layers of drain rock encased in filter sand.
- Placed on the landside 1/3 of the levee.

New Levee Location

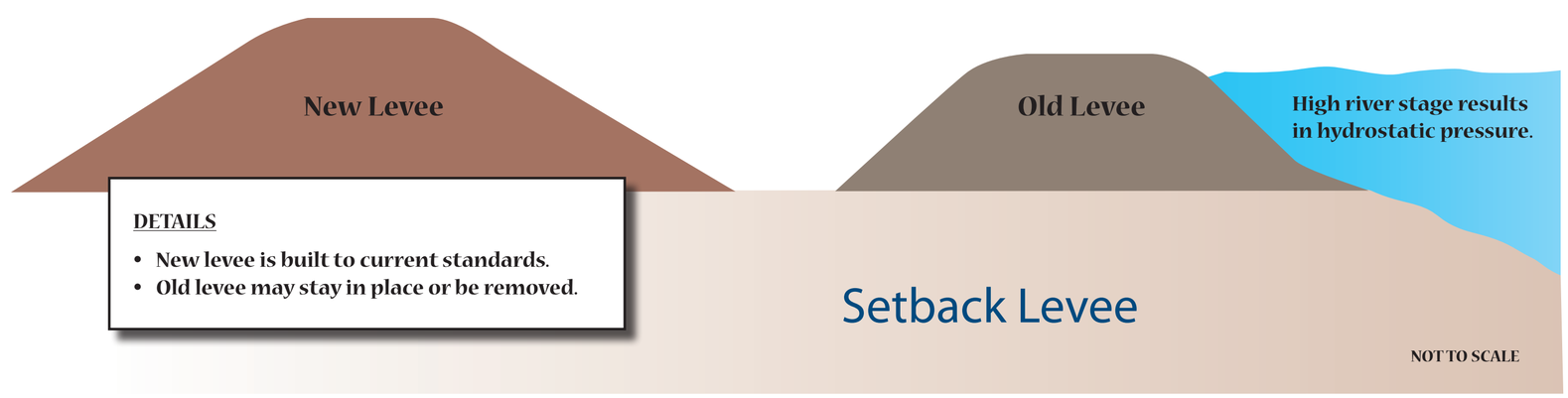
Concept:
A new levee is built where the existing levee is not readily repairable or where a change in the floodplain is an option (such as setback levees, ring levees, J-levees or similar concepts).



Ring Levees



J-Levees



Reservoir Reoperation Flood Risk Management

Reduce flood risk by improving a reservoir's ability to store peak flood flows through a variety of operational or physical modifications.

Examples:

- Reallocate storage for flood risk management purposes.
- Utilize flood forecast based operations to release storage in anticipation of a flood event.

Non-Structural Flood Risk Management

Non-structural measures reduce flood risk without significantly altering the nature or extent of the flooding. They do this by changing the use made of the floodplains, or by accommodating existing uses to the flood hazard.

Examples:

- Flood proofing
- Relocation of structures
- Flood warning/preparedness systems
- Regulation of floodplain uses

Ecosystem Restoration

Existing levees have isolated the floodplains from waterways, thereby eliminating significant floodplain habitats for native species, including Federally-listed species and other special-status species. There is potential to restore these areas in conjunction with flood risk management measures.

Examples:

- Realign levees to restore floodplains and river function
- Establish riparian/wetland habitat in conjunction with detention basins and other storage facilities
- Modify water inflow to select ponds to restore fish production and riparian/wetland habitats
- Convert nonnative habitats to native riparian/wetland habitats
- Eradicate exotic invasive plant species and establish native habitat

Recreation

An opportunity exists to create or enhance recreation features consistent with flood damage reduction and ecosystem restoration project features.

Examples:

- Multi-purpose paved trail on levee crown with access points, highway under crossings, public safety facilities, and appropriate signage
- Provide wildlife viewing platforms
- Picnic areas with associated parking and facilities
- Provide increased river access points

Environmental Process

About NEPA & CEQA

It is anticipated the Sutter Basin Project and FRWLP will result in two separate environmental impact statements/ environmental impact reports (EIS/EIR)—one for each project. Both documents will disclose an activity's potential alternatives, potential effects, and proposed mitigation measures in compliance with the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA), respectively.

A joint EIS/EIR is prepared when there is both a Federal and state agency interest in an activity, and/or when a state agency needs permission to perform an action under Federal jurisdiction. The development of the draft joint EIS/EIR to evaluate the FRWLP is underway and scheduled for release in early 2012. The release date of USACE's draft joint EIS/EIR for the Sutter Basin Project has yet to be determined.

Scoping and Other Public Engagement

Scoping is a process used to inform the public of a proposed activity and provide an opportunity to give comment, insight, and local information related to the range of alternatives, environmental effects, and/or issues of concern related to the proposed activity.

Because the agencies are working to create two joint, albeit separate, environmental documents for these two projects, a joint scoping period is also being held. During the scoping process public input will be solicited about the scope of the environmental documents and the agencies will communicate with the public about the two efforts.

Scoping is particularly informative in a flood risk management project because the citizens of the effected community could have insight into the performance of a levee that the agencies are unaware of (think locations of under-seepage or boils or areas of general poor levee performance).

The comments received from public scoping will be used to inform development of the alternatives; defining the environment and resources potentially affected by the alternatives; and analysis of effects resulting from the alternatives. The affected environment broadly includes physical, biological, and social topic areas. Effects are identified and analyzed both for project construction and long-term operations and maintenance.

Potential Environmental Issues

The effect of a proposed activity on natural and built resources will be evaluated in the environmental documents for the Sutter Basin Project and the FRWLP. Resources analyzed in the EIS/EIRs will include, but are not limited to:

- Transportation and Navigation
- Vegetation and Wetlands
- Socioeconomics and Environmental Justice
- Wildlife
- Fisheries and Aquatics
- Cultural Resources
- Air Quality, GHG and Climate Change
- Public Health and Environmental Hazards
- Land Use and Agriculture

Other Regulatory Compliance

USACE and SBFCA will need to comply with several regulations to complete the environmental process. Those could include:

Section 404: Establishes regulation of discharges of pollutants

- USACE grants 404 permits. The compliance mechanism is an Individual Permit, including 404(b)(1) alternatives analysis to identify least environmentally damaging practicable alternative (LEDPA)

Section 401: Requires certification that the project will not adversely affect water quality

- Administered by State of California through the Regional Water Quality Control Board

Rivers and Harbors Act

- Section 14 of the Rivers and Harbors Act requires permission from USACE for alterations to Federal flood control projects
    - More commonly referred to as Section 408

Endangered Species Act

- Purpose is to protect species and the ecosystems upon which they depend
- Administered by two Federal agencies: NMFS and USFWS
- Section 7 requires Federal agencies to ensure any action authorized, funded, or carried out is not likely to jeopardize the continued existence of a listed species or modify their habitat
- If a listed species may be present, the agency must conduct a biological assessment (BA)
    - Analyzes the potential effects of the project on listed species and critical habitat
- NMFS/USFWS then determines a need for a biological opinion (BO) or letter of concurrence

National Historic Preservation Act

- Section 106: Requires consideration of resources eligible or potentially eligible for the National Register of Historic Places
    - Administered by California State Historic Preservation Officer (SHPO)

Fish and Game Code

- Section 1600 et seq.: Work on the waterside of the levee will require Streambed Alteration Agreement
- Section 2050 et seq.: Potential effects on listed species will require demonstration that effects have been fully mitigated or incidental take permit

Thank you for your interest in these two public safety projects. Please provide us with your input on the scope of the projects and the environmental analysis here.

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5A - Comments.indd 1 6/22/11 5:44 AM

Welcome to the

SUTTER BASIN PROJECT FEASIBILITY STUDY
&
FEATHER RIVER WEST LEVEE PROJECT

PUBLIC SCOPING MEETING

JUNE 27 & 28, 2011

US Army Corps of Engineers®
Sacramento District

Presentation Outline

1. Coordinated Flood Management Efforts
2. How Did We Get Here?
3. A Closer Look at Each Project
4. The Environmental Process

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Coordinated Flood Management Efforts

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Sutter Basin Project Feasibility Study

- Led by U.S. Army Corps of Engineers (USACE)
- Initiated in 2001
- Purpose is to evaluate a Federal interest in flood risk management, ecosystem restoration, and recreation projects in study area
- Coordinating with Sutter Butte Flood Control Agency (SBFCA), Central Valley Flood Protection Board (CVFPB), and California Department of Water Resources (DWR)

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Feather River West Levee Project (FRWLP)

- Led by local agency SBFCA
- Initiated upon approval of annual property assessment in 2010
- Purpose is to address levee deficiencies in the Feather River's west levee from Thermalito Afterbay to Sutter Bypass
- Construction start targeted for 2013
- SBFCA is coordinating with USACE, CVFPB, and DWR

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A Joint Approach

- Studied in coordination due to similar study areas, purpose, potential improvements, effects, and parties involved
- Separate but coordinated EIS/EIRs will be developed for each project
- USACE is NEPA lead and SBFCA is CEQA lead agency for environmental process, jointly coordinating with CVFPB and DWR

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How Did We Get Here?

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A Brief Local History

- Before 1850, the Feather and Sacramento Rivers overflowed their banks in high-water periods every few years
- Sediment from hydraulic mining in the mid-1800s caused river beds to rise
- Levees were consequently privately constructed in late 1800s and early 1900s to combat primarily overtopping
- Levees were improved and incorporated under the Sacramento River Flood Control Project by USACE in early 1900s

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A Brief Local History (cont.)

- Oroville Dam and Reservoir were completed in 1967, adding substantial flood storage
- New Bullards Bar Dam and Reservoir completed in 1970, adding substantial flood storage
- Flood risk is still present, with major events
- In 1955, breach on Feather River near Shanghai Bend (38 people killed)
- In 1986, break on Yuba River and slump on Sutter Bypass
- In 1997, breaches on Feather River and Sutter Bypass

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Recent Flood Management Efforts

- Levee evaluation studies by USACE, DWR, and SBFCA have documented deficiencies in the system
- In 2010, property owners of Sutter and Butte Counties approved the formation of an assessment district to provide local funds for flood risk management

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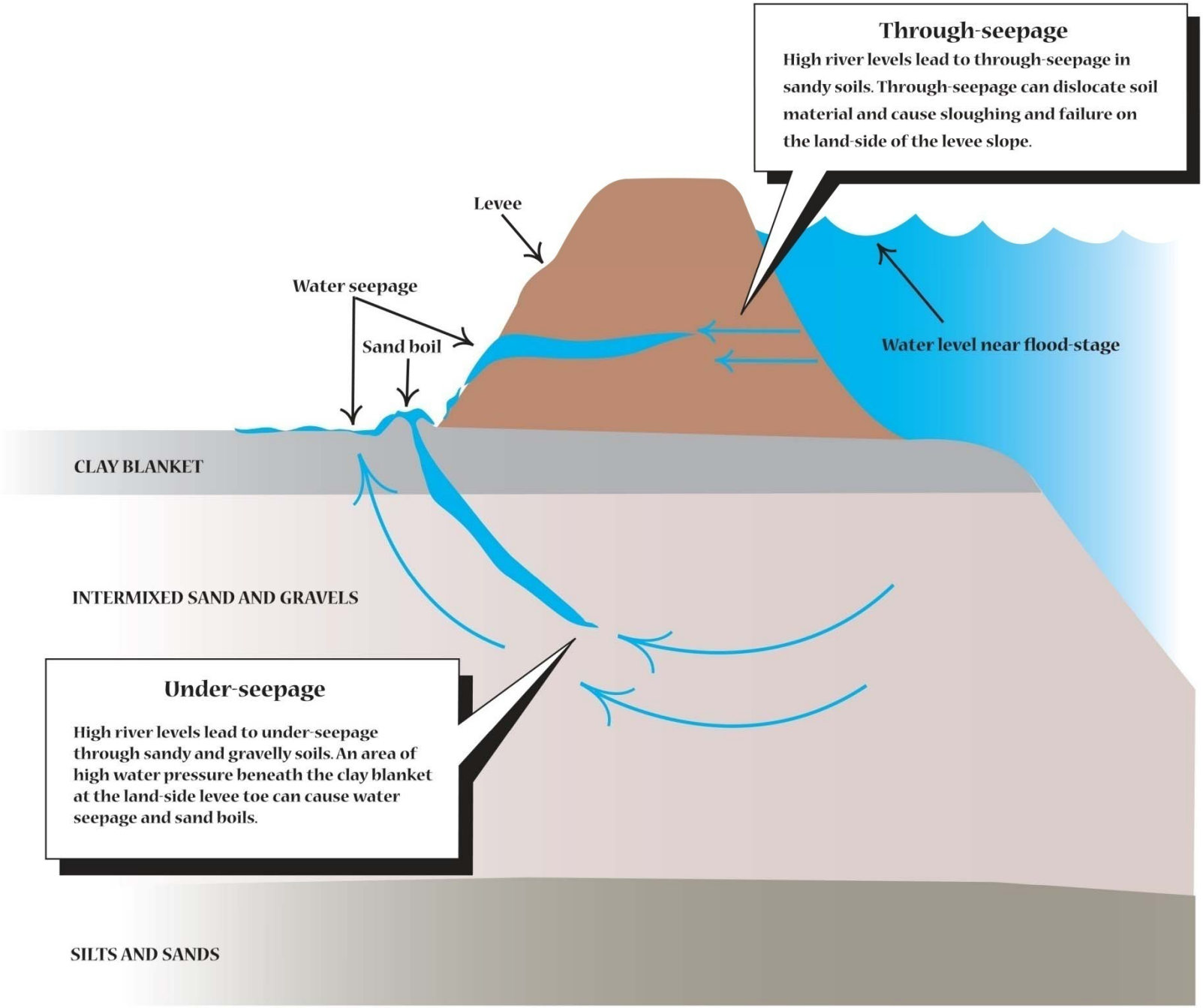
Through-seepage
High river levels lead to through-seepage in sandy soils. Through-seepage can dislocate soil material and cause sloughing and failure on the land-side of the levee slope.
Levee
Water seepage
Sand boil
Water level near flood-stage
CLAY BLANKET
INTERMIXED SAND AND GRAVELS
Under-seepage
High river levels lead to under-seepage through sandy and gravelly soils. An area of high water pressure beneath the clay blanket at the land-side levee toe can cause water seepage and sand boils.
SILTS AND SANDS

A Closer Look at Each Project

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Sutter Basin Project Feasibility Study: Study Area

- Study area encompasses ~284 sq. miles and is nearly encircled by Federal Project levees
- Includes portions of Sutter and Butte Counties
- About 44 miles long and 9 miles wide
- Feather River to the east and the Cherokee Canal, Wadsworth Canal, Sutter Buttes, and Sutter Bypass to the west

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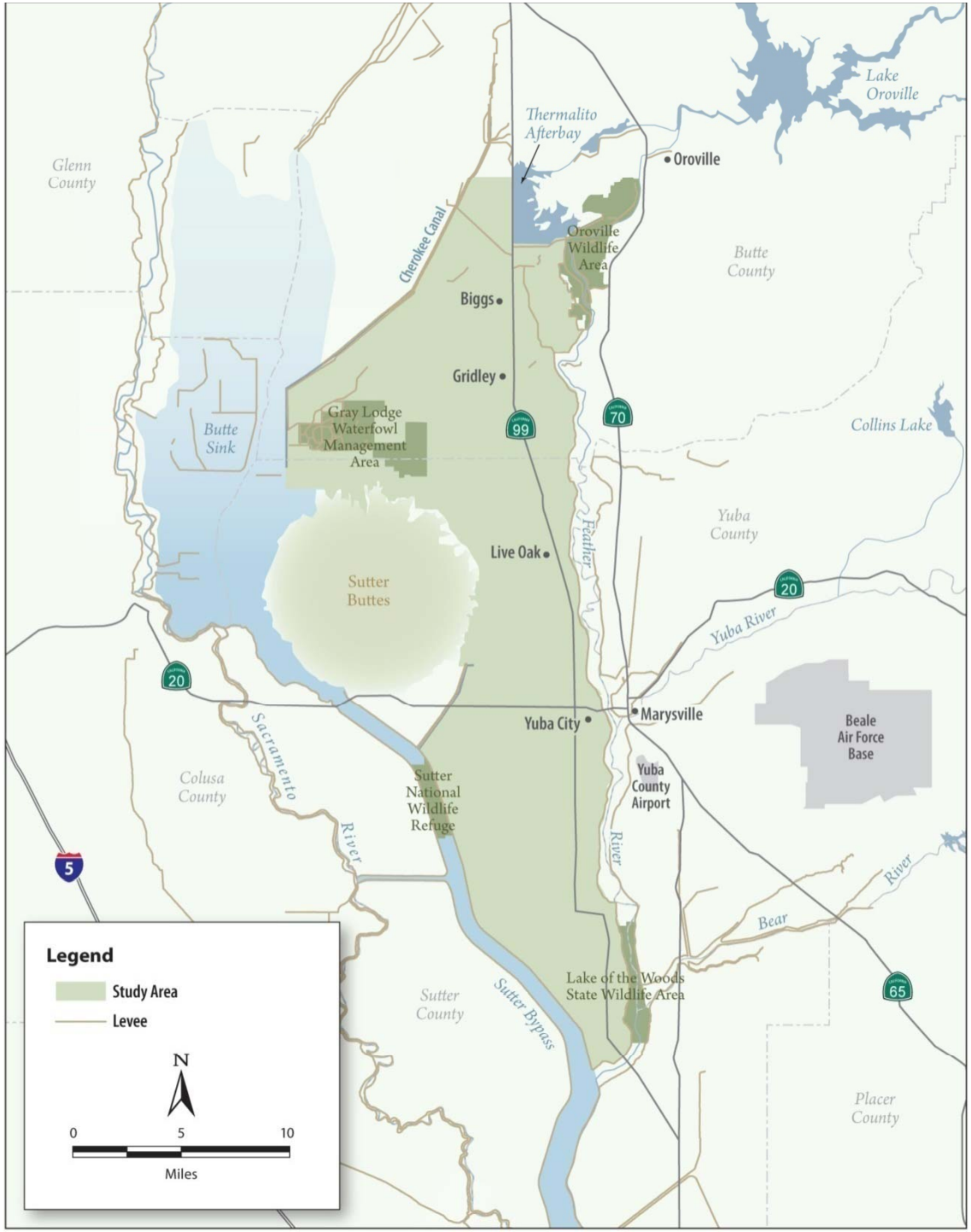
Sutter Basin Project Study Area



Sutter Basin Project Feasibility Study: Problems and Potential Measures

- Levees are at risk due to under- and through-seepage and overtopping
- Study will evaluate measures including: re-operation of reservoirs, improvements to existing levees, building new levees, and other storage & conveyance options
- Ecosystem restoration would include restoration of floodplain function and habitat

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Sutter Basin Project Feasibility Study: Potential Alternatives & Funding

- Potential alternatives include those that comprise flood risk management, ecosystem restoration, and recreation measures
- Funding for the feasibility study phase only is cost-shared, 50% Federal (USACE) and 50% non-Federal (SBFCA and CVFPB)

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Feather River West Levee Project: Study Area

- Will improve 44-miles of levees from the Thermalito Afterbay to the Sutter Bypass
- Provides flood risk management benefits to Live Oak, Biggs, Gridley, and Yuba City and unincorporated areas

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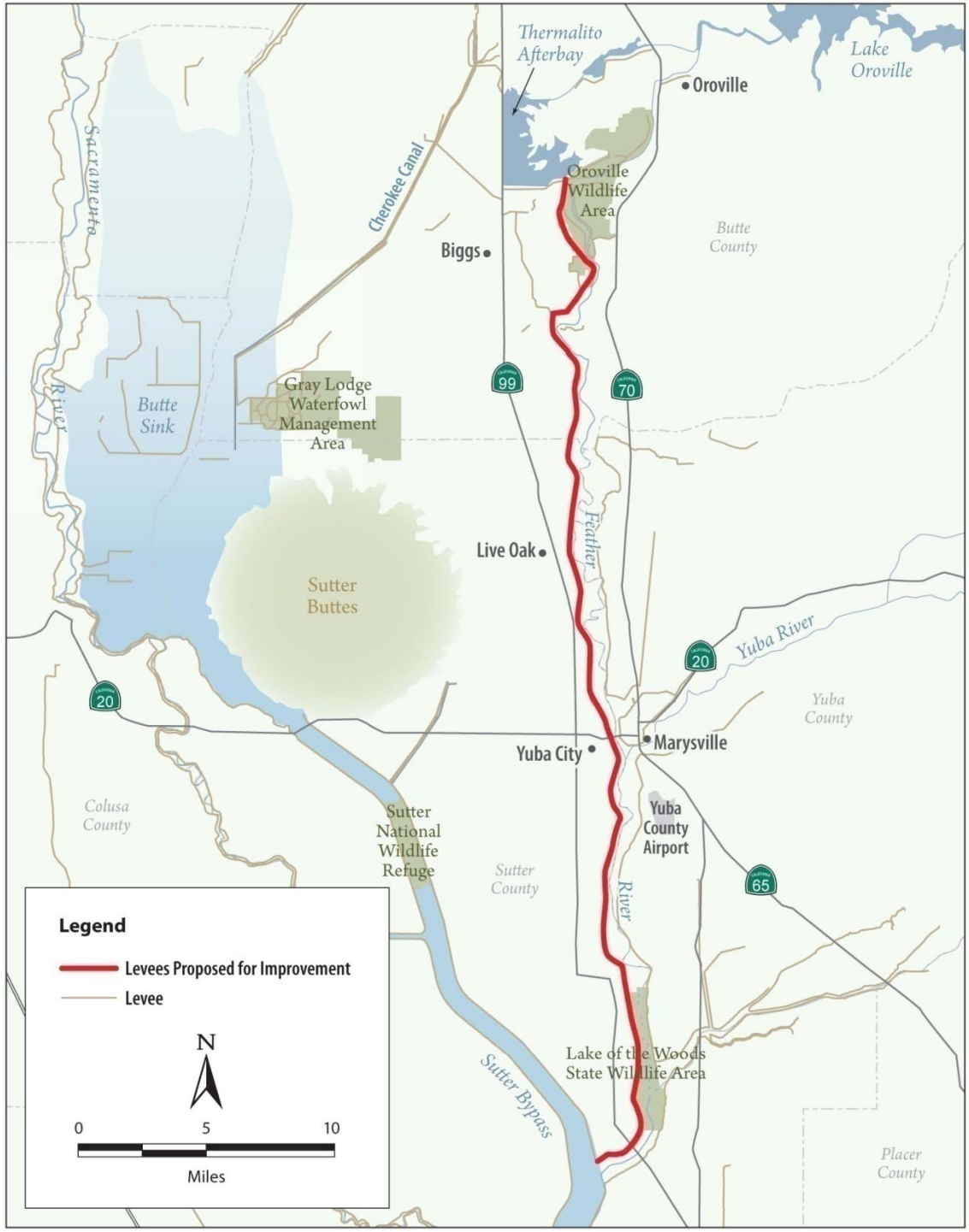
Feather River West Levee Project Study Area



Feather River West Levee Project: Problems and Potential Measures

- Primary deficiencies include through-seepage and under-seepage
- Measures may include slurry walls, seepage berms, stability berms, internal drains, relief wells, sheet-pile walls, slope flattening, and new levee alignments

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Feather River West Levee Project: Funding

- The project cost is estimated at $300 million
- The state is expected to pay as much as 76% of project costs
- Locals (within assessment district) will pay the remaining share through annual assessment (anticipated to be in effect for 33 years)

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THE ENVIRONMENTAL PROCESS

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NEPA & CEQA

- NEPA (Federal) and CEQA (state) are both processes that require:
  - Analysis and disclosure of an activity's potential effect on the natural and built environments
  - Identification of alternatives and mitigation measures to reduce effects
- Processes may necessitate an EIS and EIR depending on potential effects (type and degree)

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JOINT EIS/EIR

- Prepared when there is both a Federal and state agency interest in an activity, and/or
- When a state lead agency needs permission to perform an action under Federal jurisdiction (Section 408 permission & Section 404 permit)
- Agencies partner to analyze effects in a joint EIS/EIR and disclose an activity's potential effects

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WHAT IS *SCOPING*?

- Scoping is a process used to inform the public of the proposed activity and provide an opportunity to give input on the range of alternatives, potential environmental effects, and any issues of concern related to the proposed activity

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Scoping Period

- May 20, 2011 to July 8, 2011
- Comments will be accepted via e-mail, fax, and USPS
- Comments must be postmarked, faxed, or time-stamped (email) before or on July 8, 2011

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Ways to Comment

- Via E-mail
- Facsimile
- Via U.S. Postal Service
- Today via written comment (see comment cards)
- Provide oral comments to court reporter

US Army Corps of Engineers®
Sacramento District

Contact Information

Mail or E-mail comments to:

Matt Davis
U.S Army Corps of Engineers
1325 J Street
Sacramento, CA 95814

Phone: 916-557-6708
Fax: 916-557-7856

Matthew.G.Davis@usace. army.mil

Ingrid Norgaard
Sutter Butte Flood Control Agency
c/o ICF International
630 K Street, Suite 400
Sacramento, CA 95814

Phone: 916-737-3000
Fax: 916-737-3030

inorgaard@icfi.com

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THANK YOU FOR ATTENDING

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Coordinated Environmental Analysis

It is anticipated the Sutter Basin Project and FRWLP will result in two separate environmental impact statements/environmental impact reports (EIS/EIR)—one for each project. Both documents will disclose alternatives, potential effects, and proposed mitigation measures in compliance with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA), respectively. A joint EIS/EIR is prepared when there is both a Federal and state agency interest in an activity, and/or when a state agency needs permission to perform an action under Federal jurisdiction.

Development of the draft EIS/EIR to evaluate the FRWLP is underway and scheduled for public release in early 2012. A public release date for the Sutter Basin Project draft EIS/EIR has yet to be determined.

The Scoping Process

USACE and SBFCA are working together to combine and coordinate this public scoping process for their two separate environmental documents.

Scoping is a process in which agencies inform the public of a proposed activity and provide an opportunity for public input on the range of alternatives, environmental effects, and issues of concern related to the proposed activity. It also allows agencies to gather insights and local information from the public related to the activity.

Comments received from this public scoping period will be used to inform development of the alternatives; define the environment and resources potentially affected by the alternatives; and analyze effects resulting from the alternatives. The affected environment broadly includes physical, biological, and social topic areas. Effects will be identified and analyzed both for project construction and long-term operations and maintenance. The scoping period is from May 20, 2011 to July 8, 2011.

For more information on these efforts, visit www.spk.usace.army.mil or www.sutterbutteflood.org.

6/23/11

Sutter Basin Project and Feather River West Levee Project

The U.S. Army Corps of Engineers (USACE) and the Sutter Butte Flood Control Agency (SBFCA), in coordination with the California Department of Water Resources (DWR) and the California Central Valley Flood Protection Board (CVFPB), are undertaking two related efforts to study flood risk management measures in Sutter and Butte Counties. USACE is leading a feasibility study for the Sutter Basin Project to determine Federal interest in flood risk management in conjunction with other related purposes in the Sutter Basin study area, while SBFCA is leading the Feather River West Levee Project (FRWLP) to address deficiencies in 44 miles along the west levee of the Feather River.

USACE and SBFCA are studying these two projects in close coordination because they are related in their study areas, purpose, potential measures, and potential effects.

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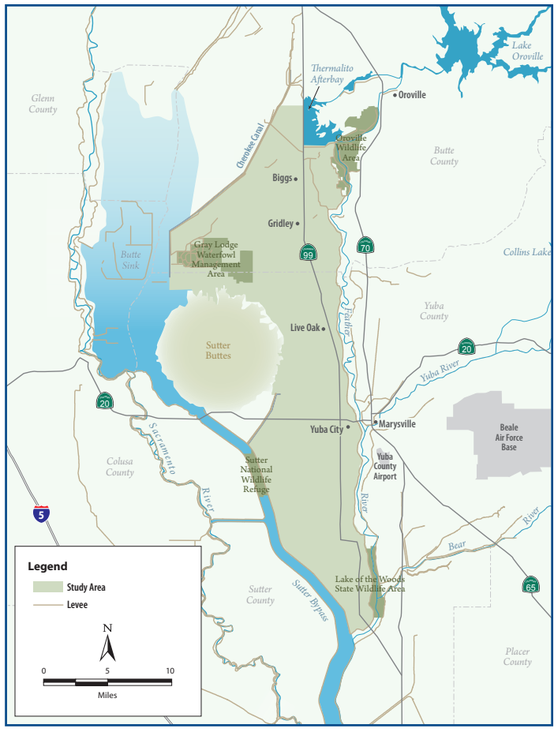
A Closer Look at the Two Projects

The Sutter Basin Project Feasibility Study

In 2000, the State of California and USACE entered into a cost-sharing agreement to initiate a feasibility study within the Sutter Basin. An amendment of the cost-sharing agreement was signed in July 2010 to include SBFCA as a non-Federal sponsor. The purpose of the feasibility study is to address flood risk management, ecosystem restoration, and recreation issues in the study area.

The Sutter Basin Project feasibility study evaluates approximately 285 square miles that are roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The study area is essentially encircled by project levees and the high ground of the Sutter Buttes. Past flood events and geotechnical analysis show these levees have a higher probability of failure related to through-and under-seepage than levees designed to meet current standards. Additionally, the levees are at risk of overtopping from floods greater than they are designed to withstand.

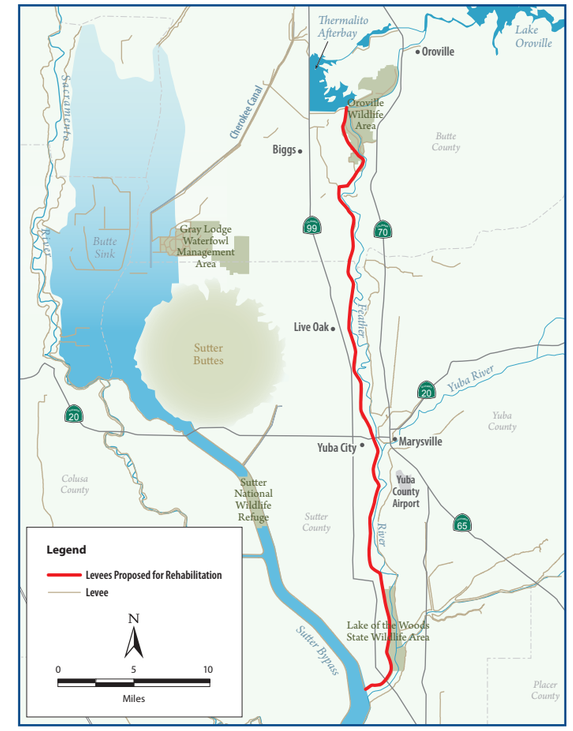


As part of the Sutter Basin Project feasibility study, USACE is evaluating a variety of flood risk management measures that could include re-operation of reservoirs; improvements to existing levees; construction of new levees; other storage, conveyance, and non-structural options; and measures that could potentially restore the ecosystem within the study area and develop or expand recreation facilities. This study will be the basis for a recommendation to Congress to address water resources and related issues within the study area. The feasibility study phase of this project is cost-shared: USACE will fund 50%, and SBFCA and the State of California will fund the remaining 50%.

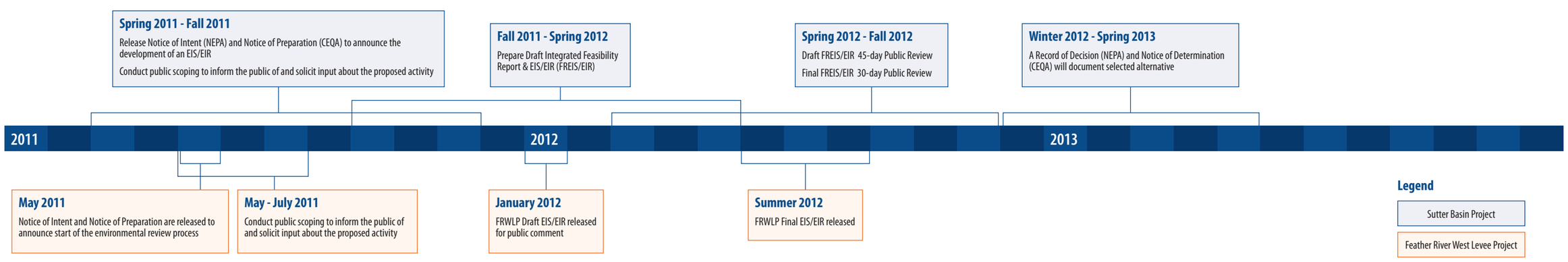
The Feather River West Levee Project

SBFCA is planning the FRWLP to address levee deficiencies found along 44 miles of the Feather River's west levee from the Thermalito Afterbay south to the Sutter Bypass. The west levee provides flood risk management benefits to the cities of Yuba City, Gridley, Live Oak, and Biggs, and portions of Butte and Sutter Counties. Measures are being evaluated to meet Federal, state, and local flood protection criteria and goals.

The west levee is at risk of failure from through- and under-seepage and from overtopping caused by floods greater than the levee is designed to withstand. Alternatives to repair these deficiencies could include slurry walls, seepage berms, stability berms, internal drains, relief wells, sheet-pile walls, slope flattening, and new levee alignments. The goal is to construct the FRWLP as quickly as possible, in advance of and compatible with the Sutter Basin Project, potentially in 2013.



Environmental Review Process Timeline for the Sutter Basin Project and FRWLP



Sutter Basin Project & Feather River West Levee Project

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June 27, 2011 Scoping Meeting Comment Card

Date:_____

Name:_____ Title:_____

Phone:_____ Fax:_____ Affiliation:_____

Email:_____ Street Address_____

City:_____ State:_____ Zip:_____

☐ Please add me to the mailing list to receive future updates.

Thank you for attending the Sutter Basin Project and Feather River West Levee Project (FRWLP) scoping meeting. Please provide your input in the space below about the content of the environmental impact statement/environmental impact report (EIS/EIR) for the Sutter Basin Project and/or for the EIS/EIR for the FRWLP. After you've written your comments in the space below, place this card in one of the designated baskets around the room or hand it to a project team member. Please write legibly.

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Sutter Basin Project & Feather River West Levee Project

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Sacramento District

June 28, 2011 Scoping Meeting Comment Card

Date:_____

Name:_____ Title:_____

Phone:_____ Fax:_____ Affiliation:_____

Email:_____ Street Address_____

City:_____ State:_____ Zip:_____

☐ Please add me to the mailing list to receive future updates.

Thank you for attending the Sutter Basin Project and Feather River West Levee Project (FRWLP) scoping meeting. Please provide your input in the space below about the content of the environmental impact statement/environmental impact report (EIS/EIR) for the Sutter Basin Project and/or for the EIS/EIR for the FRWLP. After you've written your comments in the space below, place this card in one of the designated baskets around the room or hand it to a project team member. Please write legibly.

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Attachment C

- Comments received from all interested parties (including those transcribed by court reporter)
- Attendee sign-in sheet templates

Sutter Basin Project
& Feather River West Levee Project

US Army Corps of Engineers
Sacramento District

June 27, 2011 Scoping Meeting
Comment Card

Date: 6/27/11

Name: Douglas Gault Title: Director of Public Works, Sutter County

Phone: Fax: Affiliation:

Email: Street Address

City: State: Zip:

☐ Please add me to the mailing list to receive future updates.

Thank you for attending the Sutter Basin Project and Feather River West Levee Project (FRWLP) scoping meeting. Please provide your input in the space below about the content of the environmental impact statement/environmental impact report (EIS/EIR) for the Sutter Basin Project and/or for the EIS/EIR for the FRWLP. After you've written your comments in the space below, place this card in one of the designated baskets around the room or hand it to a project team member. Please write legibly.

Meet Spring 2013 scheduled completion of USACE Feasibility study. Do not delay. 104 certification must be issued at that time to allow state to release EIP funding for West Levee Project.

Keep the process for feasibility study on schedule.

ORIGINAL

SUTTER BASIN PROJECT FEASIBILITY STUDY & FEATHER RIVER

WEST LEVEE PROJECT PUBLIC SCOPING MEETING û YUBA CITY, CA

DATE: June 27, 2011

TIME: 3:30 p.m. and 6:30 p.m.

REPORTED BY: Jillian Bassett
Certified Shorthand Reporter No. 13619

NCCR

Northern California Court Reporters

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STAN CLEVELAND, COUNTY SUPERVISOR:

I was told to repeat the comment I made regarding including the DWR Corridor Management Project, which is called The Lower Feather River Corridor Management Project. And there's a management group, and then there's -- I forgot what the other one is; there's two groups. And Aecom, they're the project, I guess, engineer group for that. And making sure that that is coordinated with this here. Because in that corridor of the Feather River, they're doing a lot of environmental planning and setting a foundation, or a level base, to where everybody won't have to come back and start from scratch on any of their studies -- environmental studies.

1 Certificate

2 of

3 Certified Shorthand Reporter

4 The undersigned certified shorthand reporter of the

5 state of California does hereby certify:

6 That the foregoing deposition was taken before me at

7 the time and place therein set forth, at which time the

8 witness was duly sworn by me;

9 That the testimony of the witness and all objections

10 made at the time of the examination were recorded

11 stenographically by me and thereafter transcribed, said

12 transcript being a true copy of my shorthand notes thereof.

13 In witness whereof, I have subscribed my name this

14 date July 25 2011.

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17 Jill Bessett

18 Certificate number 13619

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ORIGINAL

SUTTER BASIN PROJECT FEASIBILITY STUDY & FEATHER RIVER

WEST LEVEE PROJECT PUBLIC SCOPING MEETING û GRIDLEY, CA

DATE: June 28, 2011

TIME: 3:30 p.m. and 6:30 p.m.

REPORTED BY: Jillian Bassett
Certified Shorthand Reporter No. 13619

NCCR

Northern California Court Reporters

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(916) 485-4949 ■ Fax (916) 485-1323 ■ (888) 600-NCCR

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DAVID NEUBERT:

I live in Sutter County. I was speaking with your colleagues, and they mentioned one of the options they're looking at is a levee setback in the area of Nelson slough along Sacramento Avenue in Sutter County. And this would be the area between the Sacramento bypass and the Feather River, right where the Feather River enters the bypass. There's, I don't know, maybe 900,000 acres there that they could sort of cut the corner on the levee the way it exists now, and pick up 1,000 acres of floodplain.

And I'm just -- I think that's a great idea. There's -- I think there might be one house, and it's probably just a rental in that area. So you probably wouldn't have a lot of homeowners that would be hopping mad. And you'd probably pick up 10 or 15,000 acre-feet of flood storage. So it would be something, I think, that would -- engineering-wise, it would be an interesting levee setback to look at.

So the other thing that I think that as a resident of Sutter County, and I live in the LD-1 area -- I'm not sure if LD-1 has the capacity -- management capacity to pull something like that off. You know, maybe setting up something like

trilla (phonetic) like they did in Yuba County. Or maybe this super agency, the Sutter Butte Agency, could do it.

But I just -- I just don't think management capacity, or I should say the planning capacity of the board level -- I think the management, the managers of LD-1 are fine. But the board, I don't think, has vision for projects like this. So hopefully they do.

RICHARD KUCEK:

I guess it goes back to the building of the levee was our first project for the taxpayers to protect everybody from flooding. Okay. They knew after '55 when they finished the levee and had to break in Yuba City, that that wouldn't solve the problem. So they took -- and I wouldn't say they use -- it had scare tactic. But they got the taxpayers to fund another project which was get the dam at Lake Oroville. And the state of California, at that time, from what I understand, did not have enough money to build it. But the taxpayers voted it in, so it went on their tax board. But Southern California funded most of the money for building that in return for surplus water out at the lake.

And somewhere down the line it got turned around that I guess the water's worth more than the people in the houses. So they keep the lake elevation too high. But if they would keep it down, we would never need these projects that they're proposing today, which would be the third ones the taxpayers are going to pay for just for protection.

And like, the slurry would be the right way to fix this right now. If they went with the berm, that would cause a lot of problems, because there would be

1 maintenance, and they can't maintain the levees that there
2 are right now. You can go out there and look at it; kids
3 drive up and down on it, there's gophers and squirrels on
4 it and everything else. And they don't spray it. They
5 don't kill the weeds. They don't do nothing. So if they
6 do, I guess that setback levee, that wouldn't cause a lot
7 more problems on the east side of it, and then what do you
8 do with that? Because you got to be in the floodplain.
9 But the berm, to me, would be too expensive to keep in
10 33 years.
11 So I don't know how they got as far as they did
12 with this project. But it should never happen because the
13 taxpayers shouldn't have to pay three times for flood
14 protection.
15 So I don't know. I guess we'll just go to the
16 meetings and see how it comes out and, you know, if
17 they're going to do all this, and Southern California has
18 the right to all that water, why don't they pay the bills?
19 I mean, why should we have to pay it? If they want to
20 keep that lake full enough so it enables us from flooding,
21 they should have to pay the bill if it does flood. Not
22 raise our taxes and everything else, and our flood
23 insurance, and they get all the water, and we got the
24 bill.
25

BOB BARKHOUSE:

Two concerns I have is the east levee of the Sutter bypass, because, in my lifetime, on the west side -- I've had to live through two floods -- farmland on the other side -- major floods. Those levees on the west side -- east side are no better than west side, yet we're trying to contain the overflow from the Sacramento River between bypass. And we certainly are subject to flooding if the right condition --

And then my second concern was the maps continuously show a perimeter levee around Yuba City, or a J levee on the south and west side. And I'm concerned about building a levee around Yuba City and putting the city of Yuba City in the same parallel as the city of Marysville. Although Marysville has never flooded, but it's always -- the bowl is likely to fill up someday, and it would be a catastrophe.

But I am concerned about that part. They have a strong levee on the Feather River, and let that take care of itself. So that was my two concerns.

1 Certificate

2 of

3 Certified Shorthand Reporter

4 The undersigned certified shorthand reporter of the

5 state of California does hereby certify:

6 That the foregoing deposition was taken before me at

7 the time and place therein set forth, at which time the

8 witness was duly sworn by me;

9 That the testimony of the witness and all objections

10 made at the time of the examination were recorded

11 stenographically by me and thereafter transcribed, said

12 transcript being a true copy of my shorthand notes thereof.

13 In witness whereof, I have subscribed my name this

14 date July 25 2011.

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17 Jill Bassett

18 Certificate number 13619

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Sutter Basin Project & Feather River West Levee Project

June 27, 2011 Scoping Meeting

Sign-in Sheet

US Army Corps of Engineers®
Sacramento District

Name	Title	Affiliation	Street Address	City	Zip Code	How did you hear about the meeting?

Sutter Basin Project & Feather River West Levee Project

June 28, 2011 Scoping Meeting

Sign-in Sheet

US Army Corps of Engineers®
Sacramento District

Name	Title	Affiliation	Street Address	City	Zip Code	How did you hear about the meeting?

Road Construction Emissions Model, Version 6.3.2

Emission Estimates for -> Contract A Project Phases (English Units)	ROG (lbs/day)	CO (lbs/day)	NOx (lbs/day)	Total PM10 (lbs/day)	Exhaust PM10 (lbs/day)	Fugitive Dust PM10 (lbs/day)	Total PM2.5 (lbs/day)	Exhaust PM2.5 (lbs/day)	Fugitive Dust PM2.5 (lbs/day)	CO2 (lbs/day)
Grubbing/Land Clearing	14.3	80.4	117.7	9.7	4.7	5.0	5.1	4.1	1.0	19,633.2
Grading/Excavation	53.2	321.2	419.5	20.8	15.8	5.0	15.0	13.9	1.0	67,500.9
Drainage/Utilities/Sub-Grade	11.8	67.9	93.9	9.0	4.0	5.0	4.5	3.5	1.0	16,672.6
Paving	9.3	57.0	70.6	3.3	3.3	-	2.8	2.8	-	13,616.9
Maximum (pounds/day)	53.2	321.2	419.5	20.8	15.8	5.0	15.0	13.9	1.0	67,500.9
Total (tons/construction project)	1.9	11.2	14.7	0.9	0.6	0.3	0.6	0.5	0.1	2,434.8

Notes:

Project Start Year ->	2013
Project Length (months) ->	6
Total Project Area (acres) ->	183
Maximum Area Disturbed/Day (acres) ->	1
Total Soil Imported/Exported (yd^3/day)->	3054

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Emission Estimates for -> Contract A Project Phases (Metric Units)	ROG (kgs/day)	CO (kgs/day)	NOx (kgs/day)	Total PM10 (kgs/day)	Exhaust PM10 (kgs/day)	Fugitive Dust PM10 (kgs/day)	Total PM2.5 (kgs/day)	Exhaust PM2.5 (kgs/day)	Fugitive Dust PM2.5 (kgs/day)	CO2 (kgs/day)
Grubbing/Land Clearing	6.5	36.5	53.5	4.4	2.1	2.3	2.3	1.9	0.5	8,924.2
Grading/Excavation	24.2	146.0	190.7	9.5	7.2	2.3	6.8	6.3	0.5	30,682.2
Drainage/Utilities/Sub-Grade	5.4	30.8	42.7	4.1	1.8	2.3	2.1	1.6	0.5	7,578.5
Paving	4.2	25.9	32.1	1.5	1.5	-	1.3	1.3	-	6,189.5
Maximum (kilograms/day)	24.2	146.0	190.7	9.5	7.2	2.3	6.8	6.3	0.5	30,682.2
Total (megagrams/construction project)	1.7	10.1	13.4	0.8	0.5	0.3	0.5	0.5	0.1	2,208.5

Notes:

Project Start Year ->	2013
Project Length (months) ->	6
Total Project Area (hectares) ->	74
Maximum Area Disturbed/Day (hectares) ->	0
Total Soil Imported/Exported ($meters^3$/day)->	2335

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sume of exhaust and fugitive dust emissions shown in columns K and L.

Road Construction Emissions Model, Version 6.3.2

Emission Estimates for -> Contract B Project Phases (English Units)	ROG (lbs/day)	CO (lbs/day)	NOx (lbs/day)	Total PM10 (lbs/day)	Exhaust PM10 (lbs/day)	Fugitive Dust PM10 (lbs/day)	Total PM2.5 (lbs/day)	Exhaust PM2.5 (lbs/day)	Fugitive Dust PM2.5 (lbs/day)	CO2 (lbs/day)
Grubbing/Land Clearing	13.3	74.9	107.5	9.3	4.3	5.0	4.8	3.7	1.0	19,516.4
Grading/Excavation	49.2	289.3	372.3	19.1	14.1	5.0	13.4	12.4	1.0	66,559.2
Drainage/Utilities/Sub-Grade	10.9	63.1	85.5	8.7	3.7	5.0	4.2	3.2	1.0	16,555.8
Paving	8.5	52.8	64.3	3.0	3.0	-	2.5	2.5	-	13,462.0
Maximum (pounds/day)	49.2	289.3	372.3	19.1	14.1	5.0	13.4	12.4	1.0	66,559.2
Total (tons/construction project)	1.7	10.1	13.2	0.8	0.5	0.3	0.5	0.5	0.1	2,405.0

Notes: Project Start Year -> 2014
Project Length (months) -> 6
Total Project Area (acres) -> 272
Maximum Area Disturbed/Day (acres) -> 1
Total Soil Imported/Exported (yd^3/day)-> 2925

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Emission Estimates for -> Contract B Project Phases (Metric Units)	ROG (kgs/day)	CO (kgs/day)	NOx (kgs/day)	Total PM10 (kgs/day)	Exhaust PM10 (kgs/day)	Fugitive Dust PM10 (kgs/day)	Total PM2.5 (kgs/day)	Exhaust PM2.5 (kgs/day)	Fugitive Dust PM2.5 (kgs/day)	CO2 (kgs/day)
Grubbing/Land Clearing	6.0	34.0	48.9	4.2	2.0	2.3	2.2	1.7	0.5	8,871.1
Grading/Excavation	22.3	131.5	169.2	8.7	6.4	2.3	6.1	5.6	0.5	30,254.2
Drainage/Utilities/Sub-Grade	5.0	28.7	38.9	4.0	1.7	2.3	1.9	1.4	0.5	7,525.4
Paving	3.9	24.0	29.2	1.4	1.4	-	1.2	1.2	-	6,119.1
Maximum (kilograms/day)	22.3	131.5	169.2	8.7	6.4	2.3	6.1	5.6	0.5	30,254.2
Total (megagrams/construction project)	1.6	9.2	11.9	0.7	0.5	0.3	0.5	0.4	0.1	2,181.4

Notes: Project Start Year -> 2014
Project Length (months) -> 6
Total Project Area (hectares) -> 110
Maximum Area Disturbed/Day (hectares) -> 0
Total Soil Imported/Exported ($meters^3$/day)-> 2236

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sume of exhaust and fugitive dust emissions shown in columns K and L.

Road Construction Emissions Model, Version 6.3.2

Emission Estimates for -> Contract C1 Project Phases (English Units)	ROG (lbs/day)	CO (lbs/day)	NOx (lbs/day)	Total PM10 (lbs/day)	Exhaust PM10 (lbs/day)	Fugitive Dust PM10 (lbs/day)	Total PM2.5 (lbs/day)	Exhaust PM2.5 (lbs/day)	Fugitive Dust PM2.5 (lbs/day)	CO2 (lbs/day)
Grubbing/Land Clearing	12.9	71.4	100.5	9.3	4.3	5.0	4.7	3.7	1.0	19,632.9
Grading/Excavation	41.1	214.6	300.0	16.6	11.6	5.0	11.3	10.2	1.0	59,060.7
Drainage/Utilities/Sub-Grade	10.4	60.2	78.9	8.6	3.6	5.0	4.1	3.1	1.0	16,672.3
Paving	8.1	50.5	59.7	3.0	3.0	-	2.5	2.5	-	13,615.6
Maximum (pounds/day)	41.1	214.6	300.0	16.6	11.6	5.0	11.3	10.2	1.0	59,060.7
Total (tons/construction project)	1.5	8.0	11.0	0.7	0.4	0.3	0.4	0.4	0.1	2,212.0

Notes:	
Project Start Year ->	2015
Project Length (months) ->	6
Total Project Area (acres) ->	150
Maximum Area Disturbed/Day (acres) ->	1
Total Soil Imported/Exported (yd^3/day)->	1719

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Emission Estimates for -> Contract C1 Project Phases (Metric Units)	ROG (kgs/day)	CO (kgs/day)	NOx (kgs/day)	Total PM10 (kgs/day)	Exhaust PM10 (kgs/day)	Fugitive Dust PM10 (kgs/day)	Total PM2.5 (kgs/day)	Exhaust PM2.5 (kgs/day)	Fugitive Dust PM2.5 (kgs/day)	CO2 (kgs/day)
Grubbing/Land Clearing	5.9	32.5	45.7	4.2	1.9	2.3	2.2	1.7	0.5	8,924.0
Grading/Excavation	18.7	97.5	136.4	7.5	5.3	2.3	5.1	4.6	0.5	26,845.8
Drainage/Utilities/Sub-Grade	4.7	27.4	35.8	3.9	1.6	2.3	1.9	1.4	0.5	7,578.3
Paving	3.7	22.9	27.1	1.3	1.3	-	1.1	1.1	-	6,188.9
Maximum (kilograms/day)	18.7	97.5	136.4	7.5	5.3	2.3	5.1	4.6	0.5	26,845.8
Total (megagrams/construction project)	1.4	7.3	10.0	0.7	0.4	0.3	0.4	0.4	0.1	2,006.3

Notes:	
Project Start Year ->	2015
Project Length (months) ->	6
Total Project Area (hectares) ->	61
Maximum Area Disturbed/Day (hectares) ->	0
Total Soil Imported/Exported ($meters^3$/day)->	1314

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sume of exhaust and fugitive dust emissions shown in columns K and L.

Road Construction Emissions Model, Version 6.3.2

Emission Estimates for -> Contract C2 Project Phases (English Units)	ROG (lbs/day)	CO (lbs/day)	NOx (lbs/day)	Total PM10 (lbs/day)	Exhaust PM10 (lbs/day)	Fugitive Dust PM10 (lbs/day)	Total PM2.5 (lbs/day)	Exhaust PM2.5 (lbs/day)	Fugitive Dust PM2.5 (lbs/day)	CO2 (lbs/day)
Grubbing/Land Clearing	12.1	67.8	93.0	9.0	4.0	5.0	4.4	3.4	1.0	19,631.8
Grading/Excavation	40.1	216.4	279.4	15.8	10.8	5.0	10.5	9.5	1.0	61,466.5
Drainage/Utilities/Sub-Grade	9.8	57.2	73.2	8.3	3.3	5.0	3.9	2.8	1.0	16,671.2
Paving	7.6	47.9	55.9	2.8	2.8	-	2.3	2.3	-	13,614.1
Maximum (pounds/day)	40.1	216.4	279.4	15.8	10.8	5.0	10.5	9.5	1.0	61,466.5
Total (tons/construction project)	1.4	8.0	10.2	0.7	0.4	0.3	0.4	0.4	0.1	2,275.5

Notes:

Project Start Year ->	2016
Project Length (months) ->	6
Total Project Area (acres) ->	105
Maximum Area Disturbed/Day (acres) ->	1
Total Soil Imported/Exported (yd^3/day)->	2095

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Emission Estimates for -> Contract C2 Project Phases (Metric Units)	ROG (kgs/day)	CO (kgs/day)	NOx (kgs/day)	Total PM10 (kgs/day)	Exhaust PM10 (kgs/day)	Fugitive Dust PM10 (kgs/day)	Total PM2.5 (kgs/day)	Exhaust PM2.5 (kgs/day)	Fugitive Dust PM2.5 (kgs/day)	CO2 (kgs/day)
Grubbing/Land Clearing	5.5	30.8	42.3	4.1	1.8	2.3	2.0	1.5	0.5	8,923.5
Grading/Excavation	18.2	98.3	127.0	7.2	4.9	2.3	4.8	4.3	0.5	27,939.3
Drainage/Utilities/Sub-Grade	4.5	26.0	33.3	3.8	1.5	2.3	1.8	1.3	0.5	7,577.8
Paving	3.5	21.8	25.4	1.3	1.3	-	1.1	1.1	-	6,188.2
Maximum (kilograms/day)	18.2	98.3	127.0	7.2	4.9	2.3	4.8	4.3	0.5	27,939.3
Total (megagrams/construction project)	1.3	7.2	9.3	0.6	0.4	0.3	0.4	0.3	0.1	2,063.9

Notes:

Project Start Year ->	2016
Project Length (months) ->	6
Total Project Area (hectares) ->	42
Maximum Area Disturbed/Day (hectares) ->	0
Total Soil Imported/Exported ($meters^3$/day)->	1602

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sume of exhaust and fugitive dust emissions shown in columns K and L.

Road Construction Emissions Model, Version 6.3.2

Emission Estimates for -> Contract D1 Project Phases (English Units)	ROG (lbs/day)	CO (lbs/day)	NOx (lbs/day)	Total PM10 (lbs/day)	Exhaust PM10 (lbs/day)	Fugitive Dust PM10 (lbs/day)	Total PM2.5 (lbs/day)	Exhaust PM2.5 (lbs/day)	Fugitive Dust PM2.5 (lbs/day)	CO2 (lbs/day)
Grubbing/Land Clearing	11.4	64.5	85.9	8.7	3.7	5.0	4.2	3.1	1.0	19,630.5
Grading/Excavation	36.3	185.7	247.0	14.7	9.7	5.0	9.5	8.4	1.0	60,502.7
Drainage/Utilities/Sub-Grade	9.2	54.4	67.8	8.1	3.1	5.0	3.7	2.6	1.0	16,670.0
Paving	7.2	45.4	52.3	2.6	2.6	-	2.2	2.2	-	13,612.6
Maximum (pounds/day)	36.3	185.7	247.0	14.7	9.7	5.0	9.5	8.4	1.0	60,502.7
Total (tons/construction project)	1.3	7.0	9.2	0.7	0.4	0.3	0.4	0.3	0.1	2,250.0

Notes:	
Project Start Year ->	2017
Project Length (months) ->	6
Total Project Area (acres) ->	160
Maximum Area Disturbed/Day (acres) ->	1
Total Soil Imported/Exported (yd^3/day)->	1460

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Emission Estimates for -> Contract D1 Project Phases (Metric Units)	ROG (kgs/day)	CO (kgs/day)	NOx (kgs/day)	Total PM10 (kgs/day)	Exhaust PM10 (kgs/day)	Fugitive Dust PM10 (kgs/day)	Total PM2.5 (kgs/day)	Exhaust PM2.5 (kgs/day)	Fugitive Dust PM2.5 (kgs/day)	CO2 (kgs/day)
Grubbing/Land Clearing	5.2	29.3	39.0	3.9	1.7	2.3	1.9	1.4	0.5	8,923.0
Grading/Excavation	16.5	84.4	112.3	6.7	4.4	2.3	4.3	3.8	0.5	27,501.2
Drainage/Utilities/Sub-Grade	4.2	24.7	30.8	3.7	1.4	2.3	1.7	1.2	0.5	7,577.3
Paving	3.3	20.7	23.8	1.2	1.2	-	1.0	1.0	-	6,187.5
Maximum (kilograms/day)	16.5	84.4	112.3	6.7	4.4	2.3	4.3	3.8	0.5	27,501.2
Total (megagrams/construction project)	1.2	6.4	8.3	0.6	0.3	0.3	0.3	0.3	0.1	2,040.8

Notes:	
Project Start Year ->	2017
Project Length (months) ->	6
Total Project Area (hectares) ->	65
Maximum Area Disturbed/Day (hectares) ->	0
Total Soil Imported/Exported ($meters^3$/day)->	1116

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sume of exhaust and fugitive dust emissions shown in columns K and L.

Road Construction Emissions Model, Version 6.3.2

Emission Estimates for -> Contract D2 Project Phases (English Units)	ROG (lbs/day)	CO (lbs/day)	NOx (lbs/day)	Total PM10 (lbs/day)	Exhaust PM10 (lbs/day)	Fugitive Dust PM10 (lbs/day)	Total PM2.5 (lbs/day)	Exhaust PM2.5 (lbs/day)	Fugitive Dust PM2.5 (lbs/day)	CO2 (lbs/day)
Grubbing/Land Clearing	11.4	64.5	85.9	8.7	3.7	5.0	4.2	3.1	1.0	19,630.5
Grading/Excavation	34.9	180.5	229.8	14.0	9.0	5.0	8.9	7.9	1.0	55,338.2
Drainage/Utilities/Sub-Grade	9.2	54.4	67.8	8.1	3.1	5.0	3.7	2.6	1.0	16,670.0
Paving	7.2	45.4	52.3	2.6	2.6	-	2.2	2.2	-	13,612.6
Maximum (pounds/day)	34.9	180.5	229.8	14.0	9.0	5.0	8.9	7.9	1.0	55,338.2
Total (tons/construction project)	1.3	6.9	8.7	0.6	0.4	0.3	0.4	0.3	0.1	2,113.6

Notes:

Project Start Year ->	2017
Project Length (months) ->	6
Total Project Area (acres) ->	90
Maximum Area Disturbed/Day (acres) ->	1
Total Soil Imported/Exported (yd^3/day)->	1601

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Emission Estimates for -> Contract D2 Project Phases (Metric Units)	ROG (kgs/day)	CO (kgs/day)	NOx (kgs/day)	Total PM10 (kgs/day)	Exhaust PM10 (kgs/day)	Fugitive Dust PM10 (kgs/day)	Total PM2.5 (kgs/day)	Exhaust PM2.5 (kgs/day)	Fugitive Dust PM2.5 (kgs/day)	CO2 (kgs/day)
Grubbing/Land Clearing	5.2	29.3	39.0	3.9	1.7	2.3	1.9	1.4	0.5	8,923.0
Grading/Excavation	15.9	82.1	104.5	6.3	4.1	2.3	4.0	3.6	0.5	25,153.7
Drainage/Utilities/Sub-Grade	4.2	24.7	30.8	3.7	1.4	2.3	1.7	1.2	0.5	7,577.3
Paving	3.3	20.7	23.8	1.2	1.2	-	1.0	1.0	-	6,187.5
Maximum (kilograms/day)	15.9	82.1	104.5	6.3	4.1	2.3	4.0	3.6	0.5	25,153.7
Total (megagrams/construction project)	1.2	6.3	7.9	0.6	0.3	0.3	0.3	0.3	0.1	1,917.1

Notes:

Project Start Year ->	2017
Project Length (months) ->	6
Total Project Area (hectares) ->	36
Maximum Area Disturbed/Day (hectares) ->	0
Total Soil Imported/Exported ($meters^3$/day)->	1224

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sume of exhaust and fugitive dust emissions shown in columns K and L.

D3. Species Lists

U.S. Fish & Wildlife Service
Sacramento Fish & Wildlife Office

Federal Endangered and Threatened Species that Occur in or may be Affected by Projects in the Counties and/or U.S.G.S. 7 1/2 Minute Quads you requested

Document Number: 130213053142

Database Last Updated: September 18, 2011

No quad species lists requested.

County Lists

Butte County

Listed Species

Invertebrates

Branchinecta conservatio
- Conservancy fairy shrimp (E)
- Critical habitat, Conservancy fairy shrimp (X)

Branchinecta lynchi
- Critical habitat, vernal pool fairy shrimp (X)
- vernal pool fairy shrimp (T)

Desmocerus californicus dimorphus
- valley elderberry longhorn beetle (T)

Lepidurus packardi
- Critical habitat, vernal pool tadpole shrimp (X)
- vernal pool tadpole shrimp (E)

Fish

Acipenser medirostris
- green sturgeon (T) (NMFS)

Hypomesus transpacificus
- delta smelt (T)

Oncorhynchus mykiss
- Central Valley steelhead (T) (NMFS)
- Critical habitat, Central Valley steelhead (X) (NMFS)

Oncorhynchus tshawytscha
- Central Valley spring-run chinook salmon (T) (NMFS)
- Critical Habitat, Central Valley spring-run chinook (X) (NMFS)
- Critical habitat, winter-run chinook salmon (X) (NMFS)

winter-run chinook salmon, Sacramento River (E) (NMFS)

Amphibians

Ambystoma californiense

California tiger salamander, central population (T)

Rana draytonii

California red-legged frog (T)
Critical habitat, California red-legged frog (X)

Reptiles

Thamnophis gigas

giant garter snake (T)

Plants

Chamaesyce hooveri

Critical habitat, Hoover's spurge (X)
Hoover's spurge (T)

Limnanthes floccosa ssp. californica

Butte County (Shippee) meadowfoam (E)
Critical habitat, Butte County (Shippee) meadowfoam (X)

Orcuttia pilosa

Critical habitat, hairy Orcutt grass (X)
hairy Orcutt grass (E)

Orcuttia tenuis

Critical habitat, slender Orcutt grass (X)
slender Orcutt grass (T)

Senecio layneae

Layne's butterweed (=ragwort) (T)

Tuctoria greenei

Critical habitat, Greene's tuctoria (=Orcutt grass) (X)
Greene's tuctoria (=Orcutt grass) (E)

Candidate Species

Amphibians

Rana muscosa

mountain yellow-legged frog (C)

Birds

Coccyzus americanus occidentalis

Western yellow-billed cuckoo (C)

Mammals

Martes pennanti

fisher (C)

Key:

(E) *Endangered* - Listed as being in danger of extinction.

(T) *Threatened* - Listed as likely to become endangered within the foreseeable future.

(P) *Proposed* - Officially proposed in the Federal Register for listing as endangered or threatened.

(NMFS) Species under the Jurisdiction of the National Oceanic & Atmospheric Administration Fisheries Service. Consult with them directly about these species.

Critical Habitat - Area essential to the conservation of a species.

(PX) *Proposed Critical Habitat* - The species is already listed. Critical habitat is being proposed for it.

(C) *Candidate* - Candidate to become a proposed species.

(V) Vacated by a court order. Not currently in effect. Being reviewed by the Service.

(X) *Critical Habitat* designated for this species

Important Information About Your Species List

How We Make Species Lists

We store information about endangered and threatened species lists by U.S. Geological Survey 7½ minute quads. The United States is divided into these quads, which are about the size of San Francisco.

The animals on your species list are ones that occur within, **or may be affected by** projects within, the quads covered by the list.

- Fish and other aquatic species appear on your list if they are in the same watershed as your quad or if water use in your quad might affect them.
- Amphibians will be on the list for a quad or county if pesticides applied in that area may be carried to their habitat by air currents.
- Birds are shown regardless of whether they are resident or migratory. Relevant birds on the county list should be considered regardless of whether they appear on a quad list.

Plants

Any plants on your list are ones that have actually been observed in the area covered by the list. Plants may exist in an area without ever having been detected there. You can find out what's in the surrounding quads through the California Native Plant Society's online Inventory of Rare and Endangered Plants.

Surveying

Some of the species on your list may not be affected by your project. A trained biologist and/or botanist, familiar with the habitat requirements of the species on your list, should determine whether they or habitats suitable for them may be affected by your project. We recommend that your surveys include any proposed and candidate species on your list. See our Protocol and Recovery Permits pages.

For plant surveys, we recommend using the Guidelines for Conducting and Reporting

was listed before the end of your project.

Species of Concern

The Sacramento Fish & Wildlife Office no longer maintains a list of species of concern. However, various other agencies and organizations maintain lists of at-risk species. These lists provide essential information for land management planning and conservation efforts. More info

Wetlands

If your project will impact wetlands, riparian habitat, or other jurisdictional waters as defined by section 404 of the Clean Water Act and/or section 10 of the Rivers and Harbors Act, you will need to obtain a permit from the U.S. Army Corps of Engineers. Impacts to wetland habitats require site specific mitigation and monitoring. For questions regarding wetlands, please contact Mark Littlefield of this office at (916) 414-6520.

Updates

Our database is constantly updated as species are proposed, listed and delisted. If you address proposed and candidate species in your planning, this should not be a problem. However, we recommend that you get an updated list every 90 days. That would be May 14, 2013.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

In Reply Refer To
08ESMF00-2013-CPA-0012

MAY 08 2013

Alicia E. Kirchner
Chief, Planning Division
Corps of Engineers, Sacramento District
1325 J Street
Sacramento, California 95825-2922

Dear Ms. Kirchner:

The U.S. Army Corps of Engineers has requested coordination under the Fish and Wildlife Coordination Act (FWCA) for the Sutter Basin Feasibility Study and the Feather River West Levee Project. The proposed levee modifications would occur on the west levee of the Feather River, in Sutter and Butte Counties, California. This report has been prepared under the authority of, and in accordance with, the provisions of section 2(b) of the FWCA (48 stat.401, as amended; 16 U.S.C. 661 et seq.).

By copy of this letter, this report is being circulated to the agencies and offices listed below for review and comment. We would appreciate receipt of any comments on this report within 30 days of receipt of this report.

If you have any questions regarding this report, please contact Jennifer Hobbs at (916) 414-6541.

Sincerely,

Daniel Welsh
Assistant Field Supervisor

Enclosure

cc:
Mike Hendrick, NMFS, Sacramento, California
Brad Johnson, Corps of Engineers, Sacramento, California
Jeff Koschak, Corps of Engineers, Sacramento, California
Kursten Sheridan, CDFW, Region 2, Rancho Cordova, California
Jenny Marr, CDFW Region 2, Chico, California

FISH AND WILDLIFE COORDINATION ACT REPORT
SUTTER BASIN FEASIBILITY STUDY/ FEATHER RIVER WEST LEVEE PROJECT

This is the U.S. Fish and Wildlife Service's (Service) Fish and Wildlife Coordination Act report on the effects of the proposed Sutter Basin Feasibility Study/Feather River West Levee Project, Sutter and Butte Counties, California. This report has been prepared under the authority of, and in accordance with, the provisions of the Fish and Wildlife Coordination Act (48 stat. 401, as amended: 16 U.S.C. 661 et seq.).

INTRODUCTION

The information presented in this report is based primarily upon project planning information made available by the Sutter Butte Flood Control Agency (SBFCA) and the U.S. Army Corps of Engineers (Corps). The Corps, Central Valley Flood Protection Board, and SBFCA are coordinating on the feasibility study to reduce flood risk within the study area. In a parallel but separate action, SBFCA is planning the Feather River West Levee Project (FRWLP) which would construct improvements along the Feather River from Thermalito Afterbay downstream to Laurel Avenue. The FRWLP is scheduled to begin construction in 2013, prior to the Sutter Basin Feasibility Study being authorized. In order to implement the FRWLP, SBFCA must obtain permission from the Corps to alter the Federal project under Section 14 of the Rivers and Harbors Act of 1899 (as amended) (33 USC §408 or Section 408). Consequently, two environmental impact statement/environmental impact reports (EIS/EIR) are being prepared, one for the feasibility study and one for the FRWLP. Both projects are being closely coordinated as they involve similar actions and the same participants. This FWCA report analyzes the effects to fish and wildlife and their habitats due to each of the projects, recognizing that only one of the alternatives discussed would be constructed and that this report will be used for both the Sutter Basin Feasibility EIS/EIR and the FRWLP EIS/EIR.

Major flood events have occurred along the Feather River, with the more significant events that caused levee failures and flooding occurring in 1955, 1986, and 1997. In December of 1955, the most significant flood event along the Feather River is reported to have occurred. Several levee embankment failures caused major flooding of nearly all of Yuba City, as well as flooding in Nicolaus. About 156 square miles were flooded during this event. In February of 1986, heavy snow pack and warm rains elevated water levels and caused a levee embankment failure on the adjacent segment of the Yuba River near Linda, flooding nearly 30 square miles including Linda and Olivehurst. The winter of 1996/1997, heavy snow pack and warm rains again elevated water levels. All citizens in Yuba City, Marysville, Linda, and Olivehurst were ordered to evacuate. Ultimately, in January of 1997, a levee embankment failure occurred south of Olivehurst flooding nearly 50 square miles including Olivehurst and Arboga.

Over the past two decades, several studies have been conducted by the Department of Water Resources (DWR), the Corps, and more recently SBFCA to evaluate the condition of the levees protecting the planning area relative to criteria for stability, seepage, erosion, geometry, and levee height. These studies have indicated that the levee system deficiencies include seepage,

slope instability, erosion, and encroachment, and that the consequences of levee failure from a major flood event would be significant. An emergency preparedness mapping study analyzed hypothetical levee failures and determined the rate and depth at which water would flood SBFCA's planning area if a levee failure occurred in the studied reaches. This study predicted flooding depths that could range from about 1-foot to more than 20 feet in some areas.

Further evaluation has demonstrated that much of the existing system does not provide protection from the 100-year flood event, the commonly accepted minimum level of flood protection per the Federal Emergency Management Agency's (FEMA's) National Flood Insurance Program as well as being less than the 200-year level targeted by the State of California for urban areas. The Corps' and SBFCA's goal is to reduce the risk of flooding on the population, property, and critical infrastructure. SBFCA's goal is to achieve a minimum of 200-year flood protection for the more urbanized areas and 100-year for the remaining rural agricultural parts of the planning area.

AREA DESCRIPTION

The Sutter Basin is part of the Sacramento River Flood Control Project, located in north-central California in Sutter and Butte Counties. The elongated, irregularly shaped basin covers about 300 square miles and is about 43 miles long north to south, and up to 14 miles wide east to west. The Sutter Basin is roughly bounded by the Feather River, Cherokee Canal, the Sutter Buttes, and Sutter Bypass. Floodwaters potentially threatening the basin originate from the Feather River watershed or the upper Sacramento River watershed, upstream of the Colusa Weir. These waterways have drainage areas of 5,921 and 12,090 square miles, respectively. In addition to Yuba City, communities in the basin include Biggs, Gridley, Live Oak, and Sutter.

The Corps and SBFCA have determined that flood risk can be reduced by focusing on the Feather River west levee. Consequently, all of the alternatives that they are pursuing deal with remediation of that levee. This portion of the west Feather River Levee extends from Thermalito Afterbay on the north to where the Feather River enters the Sutter Bypass on the south. This corridor is roughly 500 feet from the land side of the existing levees and 100 feet from the water side. The corridor is about 41 miles long.

PROJECT DESCRIPTION

The Sutter Basin Feasibility Study (SBFS) is evaluating two flood-risk reduction alternatives, while the FRWLP is evaluating three flood-risk reduction alternatives. The no-action alternative describes the project without flood-risk reduction measures. All of the alternatives for the SBFS and FRWLP use very similar flood risk-reduction measures. Rather than restate the entire alternatives for SB-7 and SB-8, the FRWLP alternatives will be discussed first and then the SBFS alternative will follow with the differences between these alternatives defined rather than restating the entire alternative.

No Action Alternative

Under the No Action Alternative, the Corps and SBFCA would not implement flood risk-reduction measures. The levees protecting the Sutter Basin would continue to require risk-reduction measures to meet current levee standards, FEMA's minimum acceptable level of flood protection, and State requirements for 200-year for urbanized areas. In addition, the associated risk to human health and safety, property, and the adverse economic impact that serious flooding could cause would continue, and the risk of a catastrophic flood would remain high.

Because of uncertainties in local, State, and federal funding; future state and federal authorization; and other approvals, it is not reasonable to predict construction of levee improvements in the foreseeable future would be completed in a reasonable timeframe. Therefore, for the purpose of evaluating effects under the No Action Alternative, it is assumed that no levee repair or strengthening would be implemented, the purpose and objectives would not be met, and the current level of flood risk would continue.

Alternative 1 (FRWLP)

This alternative would construct a cutoff wall along the centerline of the existing levee to varying depths and a seepage berm along a portion of the landside levee toe. This alternative would predominately keep within the existing footprint of the levee.

For Reaches 2 through 5, Alternative 1 would construct a cutoff wall ranging between 30 feet and 127 feet deep along the centerline of the levee. The levee would be degraded about 50% of its overall height with 2,900 feet of the levee being fully degraded. In addition to the cutoff wall, Alternative 1 would construct a 200-foot-wide seepage berm for 2,268 feet.

For Reaches 7 through 11, Alternative 1 would construct a cutoff wall ranging between 39 feet and 124 feet deep along the centerline of the levee. The levee would be degraded about 50% of its overall height with 1,900 feet of the levee being fully degraded.

SBFCA would acquire a temporary construction easement equal to 50 feet from the existing levee toe or toe of the proposed seepage berm for construction of the levee improvements. An additional 20-foot easement would be obtained where required for the relocation of existing utilities.

For Reaches 13 through 24, Alternative 1 would construct a cutoff wall ranging between 21 and 105 feet deep along the centerline of the levee. The levee would be degraded about 50% of its overall height with about 2,600 feet of the levee being fully degraded. In addition to the cutoff wall, Alternative 1 would include about 11,150 feet of waterside slope flattening, about 5,100 feet of depression infill, and about 1,500 feet of ditch lining.

For Reaches 26 through 41, a cutoff wall ranging between 18 feet and 97 feet deep along the centerline of the levee would be constructed. The levee would be degraded by about 50% of its overall height.

Materials imported to the project site would include water, bentonite, cement, incidental construction support materials, aggregate base rock, hydroseed, and up to 4,343,800 cubic yards of embankment fill material for the new levee surfaces from off-site commercial borrow sites. For backfill of new pipelines crossing the levee, Controlled Low Strength Material (CLSM) (otherwise known as light-weight concrete) is required to be placed to the pipeline's spring line.

Levee improvements are not required for Reaches 6, 14, 15, 29, and 39.

Alternative 2 (FRWLP)

Alternative 2 would construct seepage and stability berms along the landside toe of the levee and a shallow cutoff wall along a portion of the centerline of the levee. The seepage and stability berms would substantially extend beyond the footprint of the current levee, requiring real estate acquisition. In addition, Alternative 2 would include the filling of the existing canal adjacent to the levee in Reaches 26, 27, and 28 with water during periods of high water surface elevation in the river. This would require the construction of regulating structures within the canal to maintain the water level within the canal and create a resistive force against any under-seepage flows.

For Reaches 2 through 5, Alternative 2 would construct an undrained seepage berm ranging between 100 feet and 300 feet wide along the landside toe of the levee. Additionally, an 8-foot high stability berm would be constructed along 20,817 feet of the project. Also, a shallow cutoff wall 20 feet deep would be constructed along the levee centerline for 1,616 feet of the project. The levee would be degraded about 50% of its overall height.

For Reaches 7 through 11, Alternative 2 would construct an undrained seepage berm ranging between 110 feet and 300 feet wide along the landside toe of the levee. A stability berm about 9.5 feet tall would be constructed along 14,163 feet of the project. Also, a shallow cutoff wall ranging between 23 feet and 35 feet deep would be constructed along the levee centerline for 17,800 feet of the project. A portion of the existing Garden Highway would need to be removed and reconstructed to allow construction of the seepage berm.

For Reaches 13 through 24, Alternative 2 would construct an undrained seepage berm ranging between 70 feet and 300 feet wide along the landside toe of the levee. An 8- to 10-foot high stability berm would be constructed along about 24,200 feet of the project. A shallow cutoff wall 20 feet deep would be constructed along the levee centerline for about 14,700 feet of the project. Relief wells would be installed for about 37,400 feet of the project. To facilitate construction of the cutoff wall and to maintain stability of the levee, the levee would be degraded by about 50% of its overall height.

For Reaches 26 through 41, Alternative 2 would construct an undrained seepage berm ranging between 50 feet and 300 feet wide along the landside toe of the levee. A 4- to 10-foot-tall stability berm would be constructed along about 38,600 feet of the project. About 1,300 feet of the existing levee would need to be removed and reconstructed with a zoned filter at the base in combination with a seepage berm. About 15,100 feet of canal would be in-filled.

Materials imported to the project site would include water, bentonite, cement, incidental construction support materials, aggregate base rock, hydroseed, and up to 7,661,100 cubic yards of embankment fill material for the new levee surfaces from off-site commercial borrow sites. For backfill of new pipelines crossing the levee, CLSM is required to be placed to the pipeline's spring line.

Levee improvements are not required for Reaches 6, 14, 15, 29, and 39.

Alternative 3 (FRWLP)

Alternative 3 is the applicant-preferred alternative, combining measures from both Alternative 1 and Alternative 2 to produce the optimized alternative based on screening criteria. This alternative is optimal due to its effectiveness in addressing levee deficiencies, compatibility with land use, minimization of real estate acquisition, avoidance of effects, and cost.

For Reaches 2 through 5, Alternative 3 would construct a cutoff wall ranging between 20 feet and 127 feet deep along the centerline of the levee. The levee would be degraded by about 50% of its overall height. In addition to the cutoff wall, Alternative 3 would construct a 100-foot wide seepage berm for 1,616 feet and a 200-foot wide seepage berm for 2,268 feet.

For Reaches 7 through 11, Alternative 3 would construct a cutoff wall ranging between 39 feet and 124 feet deep along the centerline of the levee. Relief wells with 60 feet spacing and 50 feet deep would be distributed at various locations in Reach 7.

For Reaches 12 through 24, Alternative 3 would construct a cutoff wall ranging between 21 and 105 feet deep along the centerline of the levee. The levee would be degraded by about 50% of its overall height with about 2,600 feet of the levee being fully degraded. In addition to the cutoff wall, Alternative 3 would include relief wells for about 8,200 feet, about 11,150 feet of waterside slope flattening, about 5,100 feet of depression infill and about 1,500 feet of ditch lining. Reach 16 includes waterside slope flattening or other remedial measures.

At Reach 17, a seepage berm 7 feet tall and about 50 feet wide would be constructed beneath the Highway 20 crossing. It extends through the existing abandoned railroad tunnel at the levee landside toe. Pedestrian access through the tunnel will remain after the berms construction.

For Reaches 26 through 41, Alternative 3 would construct a cutoff wall ranging between 18 feet and 97 feet deep along the centerline of the levee. The levee would be degraded by about 50% of its overall height. About 1,300 feet of levee would be degraded and reconstructed with a 5 to 1 slope (horizontal to vertical). Reach 31 includes cutoff walls in addition to waterside slope flattening or other remedial measures. In Reach 38 an adjacent levee with a 20-ft wide crown will be constructed using the tailings materials located along the landside of the existing levee. In Reach 41, a 150-feet wide drained seepage berm will be constructed with a 1-ft thick filter drain along the bottom. The filter drain would provide drainage for seepage through the levee. The existing concrete outfall structure located at the south end of this reach would remain in place and would be backfilled with earth materials. This alternative would also include filling of the waterside pit located at the south end of this reach. A 30-foot wide construction access area

would be provided at the toe of the seepage berm. About 9,500 feet of canal would be monitored with a Flood Safety Plan.

Materials imported to the project site would include water, bentonite, cement, incidental construction support materials, aggregate base rock, hydroseed, and up to 1,150,000 cubic yards of embankment fill material for the new levee surfaces from off-site commercial borrow sites. For backfill of new pipelines crossing the levee, CLSM is required to be placed to the pipeline's spring line.

Levee improvements are not required for Reaches 6, 14, 15, 29, and 39.

SB-7

This alternative for the feasibility study closely aligns with the FRWLP Alternative 3 alternative description except for the easement that would be acquired and the length of levee that would be repaired. The Corps would only acquire a 20-foot easement on the landside of the levee and a 15-foot easement on the waterside. The Corps would require full compliance with the Corps policy regarding woody vegetation on levees (Engineering Technical Letter 1110-2-571 "Guidelines for Landscape Planting and Vegetation Management on Levees, Floodwalls, Embankment Dams, and Appurtenant Structures") which would result in more vegetation removal with this alternative than with Alternative 3.

SB-7 would only extend through reach 21 of the project area, resulting in a proposed repair length of about 24 miles long. Of this length, 2,250 feet of levee improvement would be made downstream of Laurel Avenue and consist of a 100-foot-wide undrained seepage berm (5-foot thick at berm toe) in combination with a cutoff wall extending to an elevation of 25 feet deep. The additional work is proposed because this area is located in an area that is highly conducive to seepage distress.

SB-8

This alternative for the feasibility study closely aligns with the FRWLP Alternative 3 alternative description. Differences include the reduced easement compared to the FRWLP, as described in SB-7 and the full compliance with Corps' vegetation management standards. Relocation of either the levee or the Sutter-Butte Irrigation Canal (SBIC) would occur where the SBIC is adjacent to the levee. This would provide space for an operations and maintenance road between the canal and levee. The relocation of either the SBIC or levee is described below:

a. Area 1a (Reach 21) would involve 483 linear feet of canal relocation landward into adjacent agricultural land to provide space between the canal and the levee for a landside operations and maintenance road.
b. Area 1b (Reach 22) would move 1,900 linear feet of levee waterward into the floodplain to provide sufficient space for the landside operations and maintenance road.
c. Area 2 (Reach 24) would move 1,200 linear feet of levee waterward into the floodplain to provide sufficient space for the landside operations and maintenance road.
d. Area 3a (Reach 28) would move 7,900 linear feet of levee waterward into the floodplain to provide sufficient space for the landside operations and maintenance road.

e. Area 3b (Reach 28) would move 1,200 linear feet of canal landward into adjacent agricultural area to provide space for the operations and maintenance road.

Canal relocation would occur during the regular construction season. The new canal is offset from the old canal and a berm would separate the two. The greatest distance between the old and new canal would be 81 feet. Plugs would remain at each end of the canal where it ties into the existing canal. In the winter following construction, when the irrigators no longer send water through the canal and it is dry for 2 months, the plugs would be removed and the abandoned canal section would be filled. The small relocation of the canal at the sunset pump station can be accomplished by simply excavating the opposite side of the canal (widening the canal) when the canal is dry and filling the opposite side of the canal.

An additional 2,250 feet of levee improvement would be made downstream of Laurel Avenue and consist of a 100-foot wide undrained seepage berm (5-foot thick at berm toe) in combination with a cutoff wall extending to an elevation of 25 feet deep. The additional work is proposed because this area is located in an area that is highly conducive to seepage distress.

To provide protection in the event of water overtopping the levee the Corps is proposing to use Anchored High Performance Turf Reinforced Mat along two levee sections. This would occur for 5,760 linear feet in Reaches 7 and 8 and 1,900 linear feet in Reach 23.

EXISTING BIOLOGICAL RESOURCES

Vegetation

Seven land cover category types can currently be found in the project area: riparian forest, riparian scrub-shrub, oak woodland, wetland, agricultural lands, ruderal, and developed/disturbed areas.

Riparian Forest habitat occurs along the Feather River and its tributaries, and supports an overstory dominated by mature native and nonnative trees. The dominant overstory species are valley oak, Fremont cottonwood, and Gooding's black willow. Other trees commonly observed within the riparian habitat were box elder, arroyo willow, Oregon ash and western sycamore. Understory species include horsetails, mugwort and curly dock.

California grape covers many of the trees and shrubs in the riparian forest and several patches of the invasive giant reed were found to occur along the edges of the riparian areas.

Riparian Scrub-Shrub habitat within the biological study area consists of shrubs such as willows, blue elderberry, coyote brush, Himalayan blackberry, and button bush.

Oak Woodland habitat is found in two small patches just south of Almond and Laurel Avenues in the study area. The oak woodland are dominated by valley oak and have an understory that includes wild oat, soft chess, ripgut brome, field hedge parsley and invasive yellow starthistle.

Wetland habitat in the study area consists of natural and agricultural waterbodies: irrigation ditches, open water, seasonal wetlands, streams, and tailing wetlands. Irrigation and drainage

canals typically occur along the landside of the levee and service the agricultural fields. There tends to be sparse vegetation growing along the edge of the canals. Seasonal wetlands and tailing wetlands typically have aquatic and/or emergent vegetation such as common duckweed, primrose, or narrowleaf cattail. The tailing wetlands are typically bounded by trees and shrubs. Open water areas consist of standing water with little vegetation. These occur at the northern and southern portions of the project area.

Agricultural lands are a predominant habitat in the project area and are made up largely of orchards and field and row crops. Orchards are the dominant land cover-type and occur throughout the study area. The majority of the orchards consist of walnut, plum and peach trees that are actively maintained. Herbaceous ground cover under the tree rows is highly variable and depends on the type and frequency of maintenance. When present, the herbaceous vegetation is mostly nonnative weedy species. Field and row crops can largely be found in the southern portion of the study area. Both active and fallow fields that showed indicators of tillage were included in this habitat type. Common field and row crops in the area include sweet corn, alfalfa, wheat, and tomatoes.

Developed areas within the study area consist of urban (residential and commercial) centers, ranchettes, rural neighborhoods, agricultural outbuildings, farm equipment storage areas, pumping stations, and a plant nursery.

Ruderal areas within the study area occur as swaths on both sides of the centerline of the levee where the native soil has been substantially altered. The largest ruderal areas are located between Vance Avenue and the northern terminus of the study area. These areas represent past and ongoing disturbance associated with agriculture, levee construction and maintenance, and excavation.

Trees found in ruderal areas include valley oak, Fremont cottonwood, and black willow. Common shrubs found consist of coyote bush, tree tobacco, Himalayan blackberry, and blue elderberry. Herbaceous vegetation is dominated by annual grasses such as wild oat, soft chess, ripgut brome, and foxtail barley. Non-native forbs such as yellow star-thistle, prickly lettuce, field hedge parsley, mustard, and rose clover occur in the study site as well as native forbs, Spanish lotus, California poppy, fireweed, and western verbena.

Wildlife

Riparian habitat communities provide wildlife with dispersal and migration corridors, foraging areas, cover, and breeding habitat. Riparian trees provide nesting habitat for a variety of raptors, egrets, herons, songbirds, and bats. Riparian forest also provides foraging habitat for numerous species of migratory and wintering birds. Typical mammal species that can be found in riparian areas include deer, raccoons, beavers, coyotes, and skunks. Reptiles and amphibians are also associated with a riparian habitat. Species of reptiles and amphibians include the giant garter snake, western fence lizard, western pond turtle, Pacific tree frog, western toad, and bullfrog.

Oak Woodland provides nesting habitat for a variety of raptors and other tree nesting migratory birds. Additionally, great-horned owl, barn owl, and yellow-billed magpie are known to utilize

this habitat as well. Reptiles and mammals that occur in the riparian habitat may also utilize oak woodlands for foraging and cover habitat.

Wetland habitats in the affected area include riverine areas, ponds, canals, and small ditches. In addition to providing habitat for fish, open water habitat provides foraging, cover and reproductive sites for a variety of wildlife species. Open water areas provide foraging habitat for raptors, herons, egrets, waterfowl, water birds, and land birds. Many of the reptiles and amphibians that use riparian habitat use open water habitat for breeding, foraging, and cover.

Canals and ditches that contain water through mid-fall, have suitable prey, and adequate cover have the potential to support giant garter snake. Mammals that use the open water habitats include different species of bats that forage for insects over open water. Terrestrial mammals such as deer, raccoon, skunk, and opossum, use open water habitat for water sources. Semi-aquatic and aquatic mammals that are found within open water habitat include beaver, river otter, mink, and muskrat.

Orchards have limited value for wildlife, although certain birds, such as the red-shouldered hawk, American crow, yellow-billed magpie, mourning dove, European starling, and rock pigeon may nest or forage in these areas.

Row and field crops provide foraging opportunities for a variety of raptors and other migratory and resident birds such as sandhill crane, blackbirds, western meadowlark, and rock pigeon. Similar species are known to use irrigated fields for foraging, and birds such as burrowing owl, northern harrier, and western meadowlark are known to nest in these areas.

Developed lands provide limited habitat for wildlife but are known to support common "urban-dwelling species" such as northern mockingbird, rock pigeon, mourning dove, house sparrow, house finch, western scrub jay, Botta's pocket gopher, California ground squirrel, house mouse, black rat, and coyote. Semi-developed areas with grass, trees, and a water source can provide habitat for additional wildlife species.

Ruderal areas in the project site have a variety of native and non-native trees, shrubs, grasses, and forbs like described in the vegetation section. Similar to developed lands, these areas support mostly common wildlife species, although some elderberry bushes, which support valley elderberry longhorn beetle, were found scattered in the area.

Fisheries

The study area includes over 40 miles of the Feather River's western bank, and the various water bodies in the study area provide spawning, rearing, and migratory habitat for a diverse assemblage of native and non-native fish species. Native species present in these streams can be separated into anadromous and resident species. Native anadromous species include two runs of Chinook salmon, steelhead, green and white sturgeon, Pacific and river lamprey. Native resident species include Sacramento pikeminnow, Sacramento splittail, Sacramento sucker, hardhead, California roach, and rainbow trout. Non-native anadromous species include striped bass and American shad. There are numerous non-native resident species such as catfish, black bass, crappie, sunfish and minnows.

There are many factors affecting the abundance of fish species on the Feather River and its tributaries. Riparian and shaded riverine aquatic habitat has decreased significantly with the building of dams, levees, and water diversions, and floodplain access for spawning and rearing has been diminished from what it once was. In addition to habitat alterations, other factors that limit fish species abundance include non-native fish introductions, food availability, entrainment due to water diversions, and water temperature.

Endangered Species

Appendix A provides the Service's biological opinion for the FRWLP, dated May 2, 2013, pursuant to section 7(a) and (c) of the Endangered Species Act (Act) of 1973, as amended.

In addition, the western yellow-billed cuckoo, a candidate species, may occur in the project area. Although candidate species are not protected under the Act, the 1988 amendments require the Service or NOAA Fisheries to monitor their status. If this species declines precipitously during the planning of this project, it could be listed on an emergency basis.

NOAA Fisheries has responsibility for most marine fish and wildlife, including anadromous salmonids, and should be consulted on activities which may affect any such listed or proposed species in the project area. The Service has consultation responsibility for the remaining species.

The California Department of Fish and Wildlife (CDFW) has responsibility for State listed species and species of concern. The CDFW should be contacted regarding any State listed species or species of concern that may be impacted by project activities.

FUTURE CONDITIONS WITH THE NO ACTION ALTERNATIVE

Vegetation

The No Action Alternative represents the continuation of the existing deficiencies in the levee along the west bank of the Feather River between the Sutter Bypass and Thermalito Afterbay. No levee improvements would be made and no construction related effects on vegetation or wetland would occur. Compliance with the Corps levee vegetation policy could lead to permanent loss of woody vegetation which would result in a significant effect on riparian habitat.

Wildlife

Under the No Action Alternative, the aquatic resources of the project area are not expected to change significantly from existing conditions. Since current levee operations and maintenance activities would continue as is, and there would be no change in the geomorphic or flood control regimes, resident and migratory wildlife would continue to use the area as they do today.

Because no levee improvements would be made under the No Action Alternative, the risk that the levees along the west bank of the Feather River could fail due to seepage or slope stability/geometry issues would continue. A catastrophic levee failure would result in flooding and inundation that could significantly affect wildlife and their upland or wetland habitats. A

major flood event could result in damage to the riparian forest, and given the importance of the riparian corridor to numerous special-status species, loss or fragmentation of this habitat would be a significant effect. Given the uncertainty of the occurrence or magnitude of such an event, potential effects on wildlife and their habitats cannot be quantified based on the available information.

Fisheries

Under the No Action Alternative, the aquatic resources of the project area are not expected to change significantly from existing conditions. Since current levee operations and maintenance activities would continue as is, and there would be no change in the geomorphic or flood control regimes, resident and migratory fishes would continue to use the area as they do today. Compliance with the Corps levee vegetation policy could lead to permanent loss of woody vegetation which would result in a significant effect on riparian habitat.

Because no levee improvements would be made under the No Action Alternative, the risk that the Feather River levee could fail and cause major damage would be greater. If the levees were to fail, it could result in the displacement of fish into flooded areas where the potential for stranding and mortality is high. In addition, flooding could cause adverse water conditions due to hazardous materials being released, which could adversely affect fish populations.

FUTURE CONDITIONS WITH THE PROJECT

Vegetation and Wildlife

Given the similarities in all the alternatives the following discussion on vegetation and wildlife applies to all the alternatives. Where there are substantial differences in the alternatives they are discussed below.

Habitat losses would occur linearly along the 41 miles of levee. Currently the position of the levee varies in distance from the river, with a minimum of the levee and bank of the river being the same to a maximum of about 5,000 feet. Using a GIS layer of the footprint of the various alternatives and measuring the lengths of the levee, the Service calculated that about 11 discontinuous miles of levee would be constructed within 300 feet of the Feather River's edge. Because Alternatives 1, 2, and 3 footprints are almost exactly the same on the waterside of the levee the above number applies to all of these alternatives. The SB-8 alternative is longer by 2,250 linear feet; however, the above number would also apply to this alternative because the additional length of levee is more than 300 feet from the edge of the river. The SB-7 alternative is the shortest of all the alternatives with the total length of levee being about 23 miles. Of this about 7 discontinuous miles of riparian habitat would be removed within 300 feet of the edge of the Feather River. The majority of the riparian forest and riparian scrub shrub that would be removed due to any of the alternatives occurs on the waterside. Removing trees and shrubs along these discontinuous segments of riparian habitat where the stand widths are already narrow is a greater loss of the habitat and therefore a larger effect on the wildlife species that would be using this habitat. Narrowing of riparian corridors decreases the diversity of species and vegetative layers that wildlife species can use. Narrowing of riparian habitat could isolate some species that may require contiguous vegetated areas to move up and down the river course.

All of the alternatives address deficiencies in the levees primarily using cutoff walls and seepage berms which result in potential adverse effects on wildlife resources. Effects of construction on wildlife in the area include disturbance from construction activity and noise. Amphibian and reptile species typically are not as mobile as other types of wildlife. Consequently they have a greater chance of being killed during construction activities. Wildlife such as birds and mammals, typically respond to this type of activity by leaving the construction area. It is likely they would move into adjacent habitat outside of the zone of construction noise and disturbance. However they may be forced to move to less than optimal habitat conditions as other animals may have established territories in the surrounding habitat. Pre-construction nesting bird surveys would avoid disturbing or destroying any nests within the vegetation removal area and comply with the Migratory Bird Treaty Act.

Oak woodland would be minimally affected with SB-8 affecting, at most, 1.3 acres. Effects to species from the loss of this habitat would be similar to what is described above during construction. The loss of wetland types varies with alternative. Small farm canals would be filled for all alternatives due to the construction of the seepage berm adjacent to agricultural lands. The majority of these are small (about 3 feet wide) and only have water in them when the farmers irrigate their fields. While some bird species such as herons and egrets can use this habitat for foraging, the inconsistent water regime and yearly disturbance by the farmers keeps most vegetation out of the canals, thus they tend to not provide much habitat value for wildlife species. Alternative 2 is the only alternative affecting pond habitat. There is a privately owned pond at the lower end of the project area which would be filled due to construction of a seepage berm. The loss of this habitat would likely affect bird species such as herons, egrets, and waterfowl, and amphibian species such as toads and frogs. Given the location is on the landside of the levee and the surrounding landuse is predominately agricultural, this habitat type is not common in the area and would adversely affect native wildlife species.

Seasonal wetlands, open water, and tailing wetlands are affected in almost every alternative. This habitat is scattered along the project area, though the tailing wetlands are at the upper end of the project area near Thermalito Afterbay. These areas typically have frequent bird use as well as serve as habitat for native amphibians such as chorus frogs and spadefoot toad. Construction within and around these areas would adversely affect these wildlife species through the direct loss of habitat as well as effects to species using surrounding areas due to noise and construction activity.

Because the construction would be accomplished over a 4-year period and along a long linear footprint and adjacent habitat in the form of riparian forest and scrub shrub would remain unaffected due to the project, it is likely the birds and mammals not dependent on woody vegetation would move back into the area once construction is completed. Species which rely on riparian vegetation would experience a loss of habitat within the corridor. The Corps and SBFCA would mitigate for the loss of riparian habitat by creating the Star Bend Conservation Area. However, there would be a temporal loss of habitat for all of the alternatives until the habitat grows mature enough to be habitat for certain species. For example raptors require large trees to build nests in; the trees at the Conservation Area may not reach a suitable size until 20 or more years post-planting. Species such as woodpeckers which require snags would not have that habitat available to them for a longer period of time. Once established and maturing, new

riparian habitat at Star Bend Conservation Area would connect existing riparian habitat within the corridor providing better connectivity and dispersal corridors than what currently exist.

Effects to ruderal habitat would be primarily temporary, with the habitat disturbed and replaced within a year. However; with SB-7 and SB-8, the Corps is proposing to place 5,760 linear feet and 7,660 linear feet respectively of erosion protection on the landside of the levee face. This would prevent erosion in the event of a levee overtopping. Placement of this material would prevent this area from being used by ground burrowing animals such as ground squirrels. While much of the surrounding area would still be available for these animals, the animals that depend on these burrows may find this loss detrimental since species such as giant garter snakes and burrowing owls do not create burrows themselves, but rely on other species to create them.

Table 1 summarizes the affected habitat types by Alternative.

Table 1. Acreages of Habitat Types Affected by Alternative

Habitat Type	Alternative 1	Alternative 2	Alternative 3	SB-7	SB-8
Riparian Forest	17.83	26.67	22.19	24.40	42.00
Riparian Scrub Shrub	0.39	3.09	1.29	0.02	0.50
Oak Woodland	0.22	0.24	0.22	1.00	1.30
Canal/Ditch	24.96	27.54	.21	1.4	7.1
Pond/Basin	0.00	1.91	0.00	0.00	0.00
Stream/River	0.00	0.00	0.00	0.02	1.9
Tailing Wetlands	0.14	0.58	0.13	0.00	0.13
Seasonal Wetlands	0.18	0.19	0.03	0.18	0.18
Open Water	0.17	0.62	0.04	0.19	0.19
Orchards	223.38	666.70	101.71	37.80	85.80
Field and Row Crops	17.42	92.03	4.76	0.70	3.80
Ruderal	522.01	559.87	550.80	395.50	552.00
Developed	222.40	259.56	196.00	125.00	199.00

Fisheries

Riparian habitat provides nutrients to the water which supports the feeding of many fish species. When immediately adjacent to the water, riparian habitat can provide shade and structure for fish to use for escaping higher velocity flows and predators. The loss of this type of habitat would adversely affect fish species. Other effects include increases in turbidity and suspended sediment due to construction activities, possible contaminant discharge from the construction equipment, and adverse effects caused by construction noise and vibration. Only certain reaches of the project are immediately adjacent to the river. Over the course of the 41 miles, about 11 miles of levee come within 300 feet of the Feather River. It is at these locations where vegetation loss

and its effects to fishes are most critical. In the other locations the remaining riparian vegetation can serve as a buffer and minimize effects to sediment making its way into the river. Where the buffer is lacking, the loss of vegetation would affect the addition of nutrients through leaf drop to the water. In these locations the vegetation loss would not be replaced by creating habitat at Star Bend Conservation Area. However, Star Bend Conservation area is adjacent to the river and a wider band of riparian habitat would be planted along the 1,250 linear feet which borders the Feather River. Ultimately, at the widest point, a 1,250 wide band of riparian habitat would be created at the Star Bend Conservation Area.

Endangered Species

The Corps and SBFCA have completed section 7 consultation with the Service on Alternative 3 of the FRWLP (Appendix A). Consultation with CDFW under California Endangered Species Act (CESA) needs to be completed to determine the effects of this project on State listed species.

DISCUSSION

The Service would like to comment on the lack of incorporating a setback levee into any of the alternatives. All of the current alternatives consist of fixing the existing levee in place. Setting the levee back in strategic locations would benefit both fish and wildlife species, by creating more floodplain habitat, as well as the flood system by increasing channel capacity and decreasing maintenance by lessening levee erosion. While the Service appreciates the attempts to minimize effects to existing habitat, we would like to see active movement toward creating a sustainable, reliable, and resilient flood and riparian system. Would the current levee alignment that is being improved in place be able to withstand changing future conditions such as climate change? While the EIS/EIR addresses climate change it does not address the ability of the flood control system to adapt to climate change and potentially the different precipitation patterns which may occur. DWR's Central Valley Flood Protection Plan also outlines the goals for flood control projects that DWR participates in. One of the secondary goals is promoting ecosystem restoration. Inclusion of setback levees into this project would help DWR progress on that goal as well as meet DWR's Environmental Stewardship Policy. Both SBFCA and the Corps should consider looking at opportunities to expand the floodway and include these within the selected alternative.

The Service's primary concern with the effects to fish and wildlife is the loss of riparian and wetland habitats. These habitat types would have the largest native habitat loss in each alternative. SBFCA completed section 7 consultation on Alternative 3 for species listed under the Service's jurisdiction. This Alternative avoids as much vegetation removal as possible by working around vegetation when possible. Additionally, it minimizes temporary effects to habitats such as canals/ditches and various waters by limiting the amount of time they are disturbed and restoring them once the construction in the area is completed. Any permanent effects to native habitats, riparian, oak woodland, and seasonal wetlands should be mitigated. To mitigate effects to wetlands SBFCA has proposed to buy credits at a wetland mitigation bank at a ratio of 2:1. The Service concurs this would mitigate the effects to wildlife species due to the loss of wetland habitat.

To offset the loss of riparian forest, riparian scrub, and oak woodland, SBFCA has calculated the total diameter at breast height (dbh) of all native trees which would be removed due to the project. They have proposed to plant a variety of native seedlings at the Star Bend Conservation Area to create a diverse riparian habitat which would restore 28 acres of ruderal floodplain habitat to riparian habitat. Restoration of this area would expand riparian habitat within the area because it is immediately upstream of the O'Connor Lakes Unit of the Feather River Wildlife Area which has had riparian habitat planted within the last 10 years. The Service believes the restoration of this area would mitigate for some of the effects to the loss of riparian and oak woodlands; however, the Service does not agree that the 28 acres adequately mitigates for the entire loss. Many large trees would be removed as a result of the project. The trees planted to mitigate this impact would not reach the size of the some of the affected oak, cottonwood, and sycamore trees for 50 years. To mitigate the loss of this habitat for wildlife species the Service believes that a ratio of at least 2:1 should be used to mitigate the loss of riparian forest, riparian scrub shrub, and oak woodland. Even with the increase in riparian habitat within the Feather River Corridor with the Starbend Conservation Area there will still be a temporal loss to species that use large trees for nesting, foraging, or sheltering. The additional acreages should be found within the 41 mile proposed project area in order to maintain or benefit connectivity of the riparian corridor along the Feather River.

The Service also has concerns about effects to wildlife and fish due to ongoing operation and maintenance (O&M) of the flood control facility. Under the SBFS, the Corps has included O&M as part of the project description. The FRWLP is not proposing to change existing O&M activities and therefore they have not covered these activities in their project description. Currently, effects to federally threatened and endangered species due to O&M activities have not been analyzed. As the Corps is a federal agency that requires DWR and the local maintaining agencies to operate and maintain the flood control structures according to the federal guidelines, the Corps should initiate section 7 on these activities if there are effects to listed species. The Service feels that some of the ongoing O&M activities are likely to adversely affect the valley elderberry longhorn beetle and giant garter snake in this area. Should the Corps reinitiate section 7 consultation for the SBFS, they should include O&M activities in the reinitiation. Additionally, the Corps should provide information regarding O&M to the Service so we can update this Fish and Wildlife Coordination Act report and include effects to fish and wildlife due to O&M activities. Should the Corps not reinitiate section 7 consultation under the SBFS they should initiate section 7 consultation with the Service for ongoing O&M activities given their role as a federal agency and their discretion over the O&M manual.

RECOMMENDATIONS

If the project is constructed, the Service recommends that the Corps implement the following:

1) Mitigate the loss of any natural habitat types (riparian forest, riparian scrub shrub, oak woodland, wetland, pond, canal, stream) at a ratio of at least 2:1.

2) Should the Feasibility Study move forward the Corps should work with DWR and SBFCA to develop a variance to allow vegetation within the Corps' vegetation free zone to remain in place.

3) Work with the Service on the development of the mitigation area.

4) Lands disturbed by construction activities, including the staging areas, should be reseeded with native grasses and forbs. Reseeding should be conducted just prior to the rainy season to enhance germination and plant establishment.

5) Conduct pre-construction surveys for breeding birds including the State listed Swainson's hawk and burrowing owl.

6) Develop and implement a vegetation monitoring program as part of the project. Monitoring the riparian restoration effort should focus on (a) recording tree survival rates, (b) the quantification of improved habitat values for wildlife (primarily bird species) by measuring percent tree and shrub cover, average height of overstory trees, canopy layering, and total woody riparian vegetation, and (c) developing recommendations for alternative methods of riparian restoration should initial efforts fail. A vegetation monitoring report should be submitted annually for the first 5 years after planting activities, and on the 10th, 15th, and 20th year after planting. The monitoring reports should also identify any shortcomings in the restoration effort and include remedial actions on how to improve restoration efforts. All phases of the revegetation, and monitoring programs should be coordinated with, and approved by, the Service, CDFW, and NOAA Fisheries.

7) Comply with the Conservation Measures and Terms and Conditions in the biological opinion (Appendix A).

8) Complete the appropriate consultation with the CDFW regarding impacts to State listed species, and NOAA Fisheries, as required under section 7 of the Endangered Species Act, for potential impacts to anadromous fish under NOAA Fishery's jurisdiction.

9) SB-7 or SB-8 (depending on the alternative selected) should mitigate for the loss of upland habitat lost due to erosion protection. Effects resulting from this action should be discussed both under the FWCA as well as the federal and State endangered species acts.

10) Initiate section 7 consultation with the Service on the effects of O&M activities to federally listed species.

Appendix A

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

In Reply Refer To:
08ESMF00-2013-F-0342-1

MAY 02 2013

Ms. Alicia Kirchner
Chief, Planning Division
U.S. Army Corps of Engineers, Sacramento District
1325 J Street
Sacramento, California 95814

Subject: Formal Consultation on the Feather River West Levee Project, Sutter County, California

Dear Ms. Kirchner:

This is in response to your March 22, 2013, request for formal consultation with the U.S. Fish and Wildlife Service (Service) on the Feather River West Levee Project (FRWLP) (proposed project) in Sutter County, California. Your request was received on March 28, 2013. You requested our concurrence that the proposed project may affect, and is likely to adversely affect the federally-listed as threatened valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*)(beetle) and the giant garter snake (*Thamnophis gigas*)(snake). The Service concurs with your determination and this biological opinion addresses the effects of the proposed projec: on these two species. Critical habitat has been designated for the beetle; however, the proposed project is not located within any designated or proposed critical habitat. Critical habitat has not been designated for the snake; therefore, none will be affected. This response is in accordance with section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act).

This biological opinion is based on information provided in the U.S. Army Corps of Engineers' (Corps) letter requesting consultation and their biological assessment. A complete administrative record is on file at the Sacramento Fish and Wildlife Office.

CONSULTATION HISTORY

July 13, 2012. The Service, ICF International, HDR Inc., consultants to Sutter Butte Flood Control Agency (SBFCA), SBFCA, California Department of Fish and Wildlife (CDFW), California Department of Water Resources, and the Corps participated in a site visit to the proposed project. Potential effects to giant garter snake were discussed on the trip.

September 27, 2012. The Service, Corps, HDR, and ICF met to discuss the biological opinion and the level of detail that will be available in order to initiate consultation. The applicant determined that they will have sufficient information to initiate consultation at the project level.

December 18, 2012. The Service, Corps, SBFCA, ICF, and HDR met to discuss effects to giant garter snake. Permanent and temporary effects were discussed as well as the Service providing suggestions on conservation measures that could be incorporated.

February 12, 2013. The Service, Corps, ICF, CDFW, and HDR met to discuss long-term operations and maintenance (O&M). The outcome of this meeting was that the SBFCA FRWLP will not include operations and maintenance in their project description because their project will not be changing O&M. However, the Corps will be initiating consultation on the Sutter Feasibility Study in the next 6 months and this project description will include O&M activities.

March 22, 2013. The Corps initiated section 7 consultation with the Sacramento Fish and Wildlife Office.

BIOLOGICAL OPINION

DESCRIPTION OF ACTION AREA

North to south, the Action Area consists of the 41-mile corridor along the west levee of the Feather River from the Thermalito Afterbay to a point about 4 miles north of the Sutter Bypass. The Action Area includes the project construction area and a 100-foot buffer around this area which includes staging and spoils areas. The project construction area was defined as the area in which levee improvements—such as seepage berms, stability berms, relief wells, sheet-pile walls, and slurry cutoff walls—are likely to be constructed. All direct and indirect effects will occur within this area and the 100-foot buffer around this area.

The corridor is divided into 41 relatively homogeneous reaches for ease of describing existing conditions, project components, land cover-types, and potential effects (note that this number is coincidental and one reach does not correspond to a length of 1 mile; additionally, Reach 1 is not part of the FRWLP) (Figure 1).

The Action Area also includes six potential borrow sites that could supply the borrow material necessary for levee construction and upgrades, and routes from the project construction area to the borrow sites. It is not anticipated that all six sites will be used over the multi-year phased construction period, but until additional geotechnical and soil samplings are completed, all sites will be available for use and are included in the Action Area.

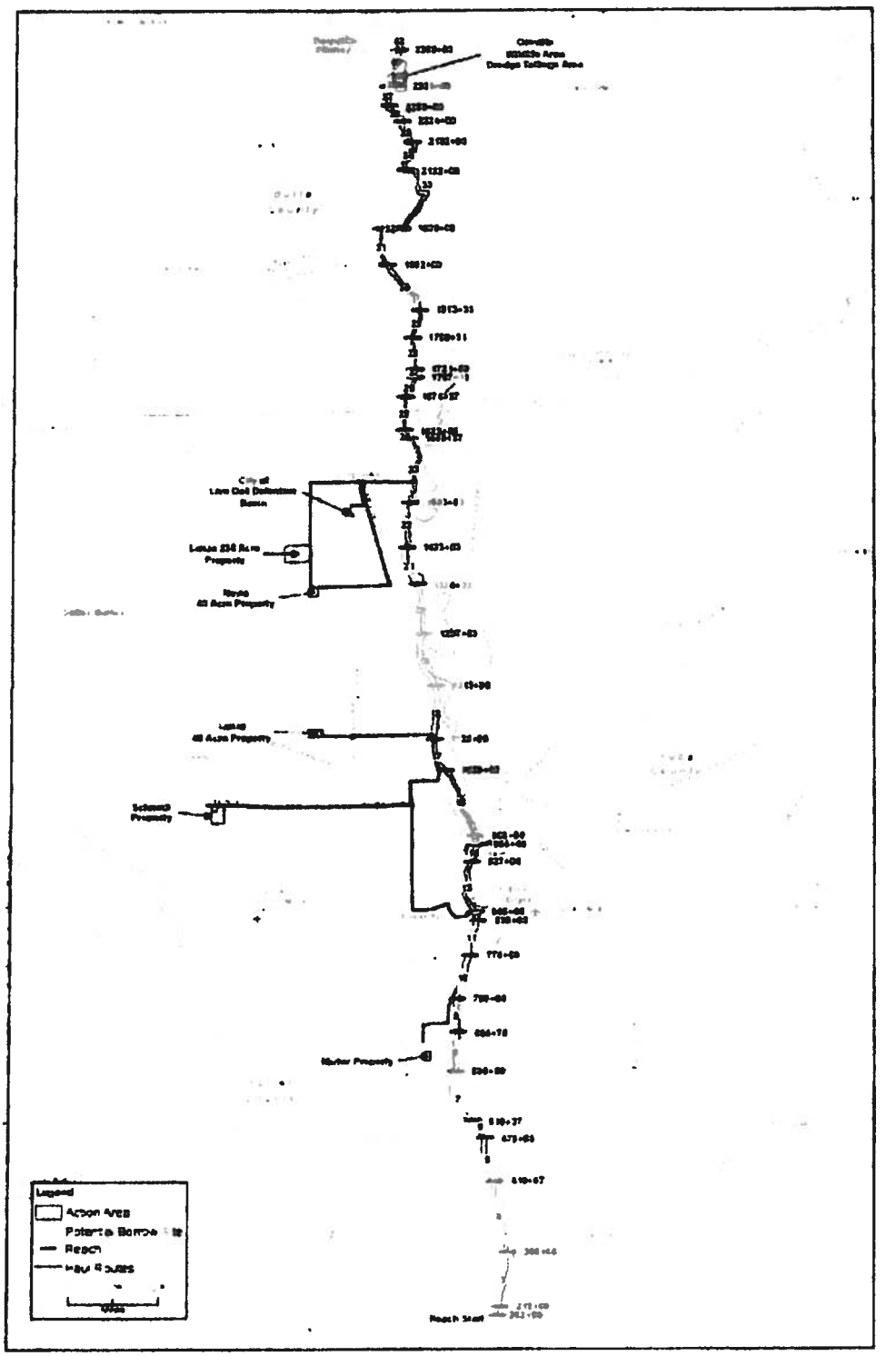

Figure 1. Proposed Project

Finally, the Action Area includes the existing 48.5-acre Star Bend Conservation Area, located on the west levee of the Feather River, about 6 miles south of Yuba City. Compensation for the Proposed Action's effects on the beetle is proposed to occur in a portion of this conservation area, which is discussed below under Conservation Measure 5.

Description of Proposed Action

The primary purpose of the FRWLP is to reduce flood risk in the Sutter Basin by addressing known levee deficiencies along the Feather River West Levee from Thermalito Afterbay downstream to a point about 4 miles upstream of the Feather River's confluence with the Sutter Bypass. While the FRWLP will not by itself reduce all flood risks affecting the Sutter Basin, it will address the most immediate risks based on the following.

- The proximity of the Feather River to population centers and key infrastructure.
- The nature of the Feather River West Levee being the longest and most contiguous portion of the planning area perimeter.
- The location of known levee deficiencies and the clarity and feasibility of available measures to address them.

The construction of the FRWLP will be divided into four separate construction contracts. Contract A begins near the intersection of the Feather River West Levee and Laurel Road. It continues north to the beginning of the improvements constructed as part of the Star Bend Setback Levee Project. The total length of the levee in this portion of the FRWLP is 27,618 linear feet. Contract B begins at the end of the improvements constructed as part of the Star Bend Setback Levee Project, and continues north for 31,963 linear feet. Contract C begins near the north end of the Shanghai Bend Setback Levee, and continues north for a total of 77,886 linear feet. Contract D then begins and continues north for 69,363 linear feet.

For Contract A, a cutoff wall ranging between 10 and 35 feet deep will be constructed along the centerline of the levee for the entire length of levee. The overall height of the levee will be degraded by about 50%. In addition to the cutoff wall, a portion of the levee will have a 9,816-foot-long; 100-foot-wide seepage berm installed.

For Contract B, a cutoff wall ranging between 5 and 25 feet deep will be constructed along the centerline of the levee for 31,600 linear feet. The overall height of the levee will be degraded by about 50%. Relief wells 60 feet apart and 50 feet deep will be installed along a 2,500 linear foot section. Finally, two small sections will involve pipe crossing work.

For Contract C, a cutoff wall ranging between 5 and 65 feet deep will be constructed along the centerline of the levee for 62,117 linear feet. The overall height of the levee will be degraded by about 50%, with about 5,900 linear feet of the levee needing to be fully degraded. A 7-foot tall

and 50-foot-wide seepage berm will be placed near the 10th Street bridge and extend through the existing abandoned railroad tunnel. Finally, there will be a few storm drain pipes replaced within the levee.

For Contract D, a cutoff wall ranging between 10 and 90 feet deep will be constructed along the centerline of the levee for 57,361 linear feet. For all but 317 linear feet of levee, the levee will be degraded by about 50%. The remaining 317 linear feet will have a full levee degrade and reconstruction. A canal runs adjacent to the landside of the levee for 4,723 feet. The landside levee will require reconstruction to the bottom of the canal. Six storm drain and irrigation pipes will need to be replaced along a section of the levee. About 4,800 linear feet of seepage berm will be constructed at the northern end of the proposed project. The berm will very in width between 100 and 170 feet. Additionally, a waterside pit located in this area will be filled.

Materials imported to the construction site will include water, bentonite, cement, incidental construction support materials, aggregate base rock, hydroseed, and up to 1,500,000 cubic yards of embankment fill material for the new levee surfaces from offsite commercial borrow sites or local landowners willing to sell borrow material. For backfill of new pipelines crossing the levee, controlled low strength material (CLSM) (otherwise known as lightweight concrete) will be placed to the pipeline's spring line.

Construction methods for the flood management measures are described in detail below.

Slurry Cutoff Wall

A slurry cutoff wall consists of impermeable material that is placed parallel to the levee, typically through the center of the levee crown. There are three methods for constructing a slurry cutoff wall: (1) conventional slot trench, (2) deep soil mixing (DSM), and (3) jet grouting. The first two are the primary methods for application over longer areas, while jet grouting is a spot application based on limiting conditions. A slurry cutoff wall addresses the deficiency of seepage (through- and under-seepage).

Conventional Slot Trench Method - To begin construction, the construction site and any necessary construction staging or slurry mixing areas are cleared, grubbed, and stripped.
In the conventional slot trench method, a trench is excavated at the top center of the levee and into subsurface materials. The size of the trench is based on the severity of the seepage but can be typically 3 feet wide and up to 80–90 feet deep. As the trench is excavated, it is filled temporarily with bentonite water slurry to prevent cave-in. The soil from the excavated trench is hauled to a nearby location where it is mixed with hydrated bentonite to reduce permeability and cement in some applications where increased strength is desired. The soil-bentonite mixture then is returned to the levee and backfilled into the trench. This mixture hardens and creates the impermeable barrier wall in the levee.

In most cases, degradation of the levee crown is necessary to create a large enough working platform to reduce the risk of hydraulic fracturing from the insertion of slurry fluids, and allowing greater depths to be reached. Dependent on the conditions of the particular levee, it may be necessary to degrade the levee by one- to two-thirds its existing height. The material

from degrading the levee is hauled to a nearby stockpile area. Following completion of the slurry cutoff wall, the material is hauled back to the levee to restore the levee to its original dimensions. The material may need to be hauled offsite to a local landfill, and borrow material may need to be imported if the in-situ levee material is found to be unsuitable for current levee standards.

One construction crew typically is able to construct 75–100 linear feet of slurry wall (about 70–80 feet deep) in an 8-hour shift. Equipment needed for the crew includes a long-reach track hoe, three or four dump trucks (15 cubic yard capacity each), two loaders at the mixing location, bulldozers, excavators, loaders, a rough terrain forklift, compactors, maintainers, and a water truck. Vertical clearance of about 40 feet is needed for the excavator boom. Horizontal clearance of about 30 feet beyond the levee crest may be required for excavator swing when loading dump trucks.

A mixing area is located at the construction staging area. The mixing area is to prepare the soil-bentonite mixture and supply bentonite-water slurry. The mixing area is contained to avoid inadvertent dispersal of the mixing materials. Dump trucks haul material between the excavator and the mixing area along the levee.

An access road made of aggregate base rock is constructed on the levee crown to enable regular levee inspections. Post-construction, areas used for construction staging, mixing, the levee crown, slopes, and any other disturbed areas are hydroseeded.

Deep Soil Mixing Method - The DSM method of constructing a slurry cutoff wall uses a crane-supported set of two to four mixing augers (typically 36 inches in diameter) set side by side. These augers are drilled through the levee crown and foundation to the required depth (capable of a maximum depth of about 200 feet). As the augers are inserted and withdrawn, a soil-bentonite grout is injected through the augers and mixed with the native soil. An overlapping series of mixed columns is drilled to create a continuous seepage cutoff barrier.

To provide a wide enough working platform on the levee crown, the upper portion of some segments of the levee requires excavation with a paddle wheel scraper. Material is scraped and stockpiled at a nearby stockpile area. Dependent on the depth of the wall required, vertical clearance for the crane also may be needed. An excavator manipulates injector return spoils near the DSM rig, and transport trucks are used to haul spoils offsite. A crane is used for in-place sampling of DSM material and also for loading bentonite into the batch plant hopper. A mobile batch plant (diesel-powered) is required near each DSM rig at the work area to prepare the cement-bentonite grout. The grout is transported to the DSM rig through flexible hoses. Each batch plant requires a pad of 50 by 100 feet. Hauling at the work area involves scraper runs along the levee to the staging area and cement and bentonite deliveries to the batch plant.

During DSM slurry wall construction, one DSM rig typically can construct 50 linear feet of DSM wall per 8-hour shift (for wall depths up to 135 feet). Post-construction, areas used for construction staging, the levee slopes, and any other disturbed areas are hydroseeded.

Jet Grouting Method - Jet grouting involves injecting fluids or binders into the soil at very high pressure. The injected fluid can be grout; grout and air; or grout, air, and water. Jet grouting breaks up soil and, with the aid of a binder, forms a homogenous mass that solidifies over time to create a mass of low permeability. Jet grouting typically is used in constructing a slurry cutoff wall to access areas other methods cannot. In this regard, it is typically a spot application rather than a treatment to be applied on a large scale along an entire reach.

Equipment required for jet grouting consists of a drill rig fitted with a special drill string; a high pressure, high flow pump; and an efficient batching plant with sufficient capacity for the required amount of grout and water. The high-pressure pump conveys the grout, air, and/or water through the drill string to a set of nozzles located just above the drill bit. The diameter of the jet grout column is dependent on site-specific variables such as soil conditions, grout mix, nozzle diameter, rotation speed, withdrawal rate, and grout pressure. Jet grouted columns range from 1 to 16 feet in diameter and are typically interconnected to form cutoff barriers or structural sections. Under ideal conditions, one construction crew—consisting of a site supervisor, pump operator, batch plant operator, chuck tender, and driller—can construct two 6-foot diameter, 50-foot columns per day consisting of about 100 cubic yards of grout injected per 8-hour shift. Ideal conditions will be characterized by no technical issues occurring at either the batch plant or the drilling site, such as loss of fluid pressure, breakdown of equipment, or subsurface obstructions to drilling operations.

To initiate jet grouting, a borehole is drilled through the levee crown and foundation to the required depth (to a maximum depth of about 130 feet) by rotary or rotary-percussive methods using water, compressed air, bentonite, or a binder as the flushing medium. When the required depth is reached, the grout is injected at a very high pressure as the drill string is rotated and slowly withdrawn. Use of the double, triple, and superjet systems create eroded spoil materials that are expelled out of the top of the borehole, this material is frequently used as a construction fill.

To provide a wide enough working platform on the levee crown, the upper portion of some segments of the levee may require degradation with a paddle wheel scrapper. Material is scraped and stockpiled at a nearby stockpile area. Hauling at the work area involves scraper runs along the levee to the staging area and grout, bentonite, and water deliveries to the batch plant.

Batch plants are typically centrally located to the injection site, with pipelines for mixed grout that run the length of the work. Grout mixing and injection equipment consists of grout mixers, high powered grout pumps and supporting generators and air compressors, holding tanks, and water tanks, with bulk silos of grout typically used to feed large mixers. Smaller equipment can be used in combination with the single phase-fluid system and can be permanently trailer-mounted to permit efficient mobilization and easy movement at the job site.

Prior to commencing production jet grouting, a field test program is typically completed to evaluate injection parameters and to assess jet grout column geometries, and mechanical and permeability properties. Where possible, jet grout test elements are exposed by excavation and properties are obtained by direct measurement. Where excavation is not possible, core drilling is employed to obtain samples from the jet grout test columns for strength testing.

Areas used for construction staging, the levee slope, and any other disturbed areas are restored and hydroseeded following construction.

Slope Flattening

Slope flattening is a mechanical method to repair or reshape slopes that do not meet standards for geometry and stability. Levee slopes are typically subject to a standard of 3:1 (horizontal to vertical), but this may vary based on site-specific conditions and supporting engineering analysis. Slope flattening addresses the deficiency of slope stability and geometry. To begin slope flattening activities, the area is cleared, grubbed, and stripped to provide space for construction and reshaping of slopes. Additional embankment fill material may be necessary to achieve slope flattening—if so, bulldozers excavate and stockpile borrow material from a nearby permitted borrow site. Front-end loaders load haul trucks with the borrow material. The haul trucks transport the material to slope flattening site. Motor graders spread material evenly according to levee design plans, and sheepsfoot rollers compact the material. Water trucks distribute water over the material to ensure proper moisture for compaction.

To reshape a waterside slope, the existing crown of the levee is shifted farther landward and the waterside slope is trimmed and reshaped to a 3:1 slope. The shifted levee crown will be a minimum of 20 feet wide, with a 3:1 slope on the landward side. An access road made of aggregate base rock is constructed on the levee crown. Post-construction, the construction staging areas, levee slopes, and any other disturbed areas will be hydroseeded.

Stability Berm

A stability berm will be constructed against the landside slope of the existing levee with the purpose of supplying support as a buttress. The height of the stability berm is generally two-thirds the height of the levee; the structural needs of the levee determine the distance it extends along that reach. A stability berm addresses the deficiency of stability. To begin the construction of a stability berm, the site is cleared, grubbed, and stripped to provide space for construction and shaping of the berm. Embankment fill material necessary to construct the berm is excavated by a bulldozer from a nearby borrow site. Front-end loaders load haul trucks with the borrow material, and the haul trucks transport the material to the stability berm site. Motor graders spread the material evenly according to design specifications, and a sheepsfoot roller compacts the material. Water trucks distribute water over the material to ensure proper moisture for compaction.

Stability berms may be drained or undrained. An undrained berm consists of embankment fill only. A drained berm includes a layer of drain rock placed along the ground surface underneath the fill material, separated by a casing of filter fabric. Drainage water seeping from the berm will sheetflow on the adjacent landside surface.

Levee Reconstruction

Levee reconstruction will be necessary where a levee has been degraded to facilitate implementation of another measure (such as a slurry cutoff wall), where a substantial

encroachment has been removed from within the levee prism, or otherwise where the levee is found to be deficient and needs to be replaced with materials and methods that meet current engineering standards. The existing levee is first cleared, grubbed, and stripped to the desired surface to allow a working platform for other measures (such as a slurry cutoff wall), to remove an encroachment, or to remove substandard material. Embankment fill material necessary to construct the new levee is excavated by a bulldozer from a nearby borrow site. Front-end loaders load haul trucks with the borrow material and the haul trucks transport the material to the stability berm site. Motor graders spread the material evenly according to design specifications, and a sheepsfoot roller compacts the material. Water trucks distribute water over the material to ensure proper moisture for compaction. The new levee will be built in cross section to meet current engineering standards.

Sheet-Pile Wall

A sheet-pile wall is a series of vertical panels of interlocking steel that is placed parallel to the levee, typically through the center of the levee crown to provide an impermeable barrier. A sheet-pile wall addresses the deficiencies of seepage and will be used only as a site-specific treatment (rather than applied on a reach-wide basis) such as at roadway or railroad crossings. The site where sheet piles are to be installed is cleared, grubbed, and stripped to allow for construction activities, including removal of the roadway or railroad. A hydraulic- or pneumatically-operated pile-driving head attached to a crane drives the sheet pile into the levee crown to the desired depth (up to 135 feet). If the levee material is particularly solid, pre-drilling may be necessary. The conditions of the site and the desired life of the project determine the thickness and configuration of the sheet piles.

Post-construction, construction staging areas, the levee crown, slopes, and any other disturbed areas are hydroseeded and the roadway or railroad will be replaced in-kind to the pre-project condition.

Seepage Berm

Seepage berms are wide embankment structures made up of low-permeability materials that resist accumulated water pressure and safely release seeping water. A seepage berm is typically one-third the height of the levee, extending outward from the landside levee toe for 300–400 feet, and laterally along the levee as needed relative to the seepage conditions. A seepage berm addresses the deficiency of under-seepage. A seepage berm can vary in width, from a minimum of four times the levee height to a maximum of 300 feet. Berm heights can also vary but are typically a minimum of 5 feet tall at the landside toe of the levee and generally taper down to 3 feet at the end of the berm.

Construction consists of clearing, grubbing, and stripping the ground surface. Bulldozers then excavate and stockpile borrow material from a nearby borrow site. Front-end loaders load haul trucks, and the haul trucks subsequently transport the borrow material to the berm site. The haul trucks dump the material and motor graders spread it evenly, placing 3–5 feet of embankment fill material. Sheepsfoot rollers compact the material, and water trucks distribute water over the material to ensure proper moisture for compaction.

Seepage berms may have an optional feature of a drainage relief trench under the toe of the berm. Drained seepage berms include the installation of a drainage layer (gravel or clean sand) beneath the seepage berm backfill and above the native material at the levee landside toe. A drained seepage berm does not increase the overall footprint of the berm. Post-construction, areas used for construction staging, the levee, the berm, and any other disturbed areas are hydroseeded.

Relief Wells

Relief wells are passive systems that are constructed near the levee landside toe to provide a low-resistance pathway for under-seepage to exit to the ground surface in a controlled and observable manner. A low-resistance pathway allows under-seepage to exit without creating sand boils or piping levee foundation materials. Relief wells are an option only in reaches where geotechnical analyses have identified continuous sand and gravel layers. Relief wells are constructed using soil-boring equipment to drill a hole vertically through the fine-grained blanket layer (sand) into the coarse-grained aquifer layer (gravel) beneath. Pipe casings and gravel/sand filters are installed to allow water to flow freely to the ground surface, relieving the pressure beneath the clay blanket without transporting fine materials to the surface, which can undermine the levee foundation. Relief wells will be designed to discharge onto a cobble splash, and the water will then sheet flow into adjacent agricultural fields. In areas where sheet flow is not feasible, a swale will be excavated and connected to a drainage canal.

Relief wells generally are spaced at 50- to 100-foot intervals, dependent upon the amount of under-seepage, and extend to depths of 150 feet. Areas for relief well construction are cleared, grubbed, and stripped. During relief well construction, a typical well-drilling rig is used to drill to the required depth and construct the well (including well casing, gravel pack material, and well seal) beneath the ground surface. The drill rig likely will be an all-terrain, track-mounted rig that could access the well locations from the levee toe.

Piezometers, also called monitoring wells, could be installed between relief wells to allow monitoring of groundwater levels to ensure the wells are relieving the pressure within the aquifer.

Areas along the levee toe may be used to store equipment and supplies during construction of each well. Construction of each well and the lateral drainage system typically takes 10–20 days. Additional time may be required for site restoration. Post-construction, areas used for construction staging, the levee slopes, and any other disturbed areas are hydroseeded.

Depression/Ditch Infilling

Landside depressions and ditches can contribute to risk of levee failure if a seepage pathway forms under the levee and the water then surfaces through the depression or ditch, exploiting its less resistive nature compared to surrounding soil mass. This measure involves placing fill soil in such depressions and ditches to remove localized susceptibility to seepage. Construction consists of clearing, grubbing, and stripping the ditch or depression surface to remove vegetative material. Bulldozers then excavate and stockpile borrow material from a nearby borrow site.

Front-end loaders load haul trucks, and the haul trucks subsequently transport the borrow material to the fill site. The depression or ditch may be further excavated to provide a surface that the fill soil may be keyed into. The haul trucks dump the material and motor graders or bulldozers smooth the material level with the surrounding land surface. An excavator may also be used for placement. Sheepsfoot rollers compact the material, and water trucks distribute water over the material to ensure proper moisture for compaction.

Removal and Relocation of Pacific Gas & Electric Facilities

Prior to and/or concurrent with levee rehabilitation construction, Pacific Gas and Electric Company (PG&E) will need to remove and relocate facilities located within the footprint of the FRWLP. PG&E's utility relocations will need to occur in advance of SBFCA's construction activities at any given location. Construction sequencing for SBFCA's work will be dynamic throughout SBFCA's project planning and design. PG&E's construction schedule will be determined by further engineering to clarify and determine efficacy of site-specific measures; the availability of funding for FRWLP; easement and right-of-way acquisition; availability of borrow material for the levee improvement activities; and/or environmental clearances based on wildlife presence, lifecycle activity, and location of habitats. PG&E's construction schedule will be further influenced by utility operation and maintenance constraints, particularly for relocation activities that require taking existing facilities temporarily out of service. As necessary, geotechnical mitigation measures will be incorporated into construction design to ensure that utility facilities effectively co-exist with the FRWLP, relocation will be done where this is not feasible.

For PG&E's electrical transmission and distribution activities, PG&E will install and remove new electrical transmission and distribution poles. Electrical transmission and distribution pole removal is conducted by a line crew, who typically access each pole site with a line truck and trailer or a boom truck, except in those instances when the pole is located on the levee crown (a crane may be used in those instances). On average, removal of vegetation up to 50 feet from the toe of the levee will need to occur to accommodate pole installation activities; this distance may be greater in instances where the installation activity is located further than 30 feet from the levee toe. After vegetation is cleared, PG&E will remove and replace the existing wood distribution and power poles and related equipment.

For PG&E's natural gas transmission and distribution activities, PG&E will install gas transmission and distribution steel pipe. This also typically includes the removal and disposal of existing pipe. Other typical types of gas transmission and distribution equipment that may be installed include Electric Test System/ Gas Cathodic Test System meter stations for future pipe monitoring purposes, and pipeline markers at angle points and at levee crossing locations. Clearing and grading operations in support of installation of natural gas facilities typically involve preparation of the right-of-way, including vegetation removal, debris disposal, and land leveling. Installation sites are backfilled using sand to create a 6-inch insulation zone around the pipe and then covered by native soil from the project area. In some instances, a crane may be required to place pipe at crossing sites located at the crowns of the levees. Dump trucks will be used to transport sand and soil materials. Spoil piles may be temporarily placed onsite while the installation activities are occurring.

Hydrostatic testing associated with installation of natural gas facilities will be performed to test the strength of the new pipeline. Test water intake and discharge will be performed in accordance with all regulations and permit requirements.

Typical electrical and natural gas transmission and distribution project work schedules are comprised of an average 9-hour day, at an average of 6 days per week per crew. Typical crews consist of 3 to 5 members.

PG&E work areas will be about 125 feet by 125 feet in diameter and located in close proximity to installation activity locations. On average, PG&E will require up to 10 work areas per contract phase. PG&E will utilize the work areas identified by SBFCA whenever possible. Typically, PG&E project access is achieved through existing public and private roads. Removal of vegetation to utilize access roads by PG&E equipment and transport of facilities may be required. PG&E currently owns easements along the entire project corridor. However, temporary and/or permanent easements as required for construction and maintenance of these facilities are being acquired by SBFCA.

Encroachment and Vegetation Removal

Encroachments - Existing facilities found within the footprint of an alternative may require removal and replacement nearby, abandonment, or relocation. Encroachments are numerous (over 400 identified) along the Feather River West Levee and may need to be addressed if they present a threat to the stability of the levee, do not currently comply with the levee encroachment criteria, or will be disrupted or otherwise impacted by construction activities. Typical encroachments include pressure pipelines (water supply pipelines from waterside pump stations and drainage pipelines from landside drainage pump stations), gravity drainage pipes, gas lines, telephone utilities, overhead utilities, structural encroachments, and other types and variations. Debris from structure and embankment fill material of poor quality will be hauled offsite to a permitted disposal site within 20 miles of the removal location.

Vegetation Removal - Vegetation removal will involve stripping of herbaceous (non-woody) vegetation by bulldozer. Vegetation will be removed only from within the direct construction footprint and the minimum areas necessary for staging and access. Consistent with the Central Valley Flood Protection Plan guidance for levee repair or improvement, vegetation will be removed to meet specific project objectives. Any vegetation removed as part of direct construction activities will not be replaced at that location, but will involve offsite, in-kind mitigation, to be determined in consultation with the appropriate resource agencies.

In accordance with the State of California's Urban Levee Design Criteria, at a minimum, all roots larger than 1.5 inches in diameter that are within 3 feet of the perimeter of the tree trunk will be removed. Immature trees less than 4 inches in diameter at breast height that will be removed may be cut off at or below ground level, generally without root removal. Any excavation will be

backfilled with engineered fill using appropriate placement, moisture conditioning, and compaction methods. Additional measures for removing non-compliant vegetation are listed below.

- Ensure that the resulting void is free of organic debris.
- Cut poles to salvage propagation materials for replanting, such as willows and cottonwoods.
- Conduct hand clearing using chainsaws and trimmers.
- Conduct mass clearing using bulldozers.

Debris from vegetation removal will be hauled offsite to a permitted disposal site within 20 miles of the removal location.

Construction Staging, Access, and Temporary Facilities

Staging areas will only be provided within the Action Area. Staging areas will be used for staging construction activities and to provide space to house construction equipment and materials, offices, employee parking, and other uses needed for construction of the proposed project.

To facilitate construction, temporary earthen ramps will be constructed for equipment access between the levee crown and the staging area(s). The earthen ramps will be removed when construction is complete.

Cutoff wall construction requires temporary establishment of an onsite slurry batch plant that will occupy about 1–2 acres. Batch plants will be located at about 1-mile intervals along the levee. The batch plant site will likely contain tanks for water storage, bulk bag supplies of bentonite, bentonite storage silos, a cyclone mixer, pumps, and two generators that meet air quality requirements. Slurry ingredients will be mixed with water and the mixture will be pumped from tanks through pipes to the construction work sites. The batch plant will produce two different slurry mixes, one for trench stabilization and one for the soil backfill mix. Therefore, two slurry pipes or hoses, typically 4- or 6-inch high-density polyethelene pipes, will be laid on the ground and will extend to all work sites. An additional pipe may be used to supply water to the work sites.

Staging, access, and other temporary construction areas will be located away from wetlands, woody vegetated areas, wildlife species habitat, known cultural resources, or other sensitive areas and will be limited to disturbed or ruderal grasslands subject to review by Corps and resource agencies.

Material Importation, Reuse, and Borrow

Materials imported to the FRWLP construction area will include water, bentonite, cement, incidental construction support materials, aggregate base rock, asphalt, concrete, hydroseed, and embankment fill soil. Large quantities of fill soil, or borrow will be required. To meet borrow demands, embankment fill material excavated as part of construction will be evaluated for reuse. Embankment fill material deemed suitable will be used as part of levee reconstruction and berms. The total volume of material required is 1,500,000 cubic yards.

SBFCA has explored the option of purchasing fill or borrow material from a local commercial quarry or other permitted source; however, there are not currently any sites near the Action Area that could supply the volume and type of material required. Consequently, SFBCA plans to purchase fill from local landowners willing to sell borrow material.

Six borrow sites have been identified in the Action Area. Each site was investigated to determine the quantity of available material, hauling distance, material composition, groundwater elevation, and prospects for acquisition. Sufficient fill volume is estimated to be present within an approximate 10-mile, one-way haul distance from the area of construction.

SBFCA will maximize the potential borrow sites' use through gradation, placement, and treatment so that they could continue to be used for their current use or otherwise returned to their pre-project condition. As part of borrow operations, the upper 4–6 inches of topsoil will be set aside and replaced after construction in each construction season. After the FRWLP is completed, the borrow site will be re-contoured and reclaimed.

Through outreach efforts, SBFCA identified a number of sites owned by individuals or government agencies willing to sell their property or provide material on a cubic yard basis. Each borrow site is described below.

North Valley Property - The North Valley property is owned by North Valley Properties, LLC and is located south of Ella Road between Feather River Boulevard and Arboga Road. The Wheeler Ranch housing development is proposed at the site. Borrow for the FRWLP will be taken from the northeast corner of the property to create a 24.5 acre detention pond (referred to as the Drainage Basin C Regional Detention Pond, but commonly referred to as the South Ella Detention Pond). The Ella Basin is being constructed as part of Reclamation District No. 784's Master Drainage Plan. Historically, the site was cultivated for agricultural purposes. Currently, the site is disked ruderal grassland with some roads cut in the southern portion of the property for the Wheeler Ranch development. The depth of excavation is anticipated to be 15–20 feet and the yield of material from this site could be 400,000–500,000 cubic yards. Borrow material from this site will be used for work in Contracts B and C. If borrow material is remaining, it may also be used for Contract D. The haul route to Contract C will use existing roads. The post-project land use of the site will be a regional detention pond for Reclamation District No. 784.

Marler Property - The Marler property is a 10-acre property at Johnson Road near Messick Road, north of Star Bend and south of Shanghai Bend. The site is currently an orchard. The depth of

excavation could be upwards of 6 feet. The yield of material from this site could be 75,000 cubic yards. The haul route will use existing roads. The post-project land use for the property will be agricultural production, likely row crops or orchard.

Lanza Property - The Lanza property is 40 acres in size and is currently farmed in field/row crops. It is located at North Township Road and Pease Road south of Live Oak and north of Yuba City. The site has not yet been investigated to determine the types of materials present. Excavation of the site to a depth of 6 feet may occur. The yield of material from this site could be 200,000 cubic yards. The likely haul route will be along Pease Road directly east to the levee. The post-project land use for the property will be rice production.

City of Live Oak Detention Basin - Live Oak owns the property formerly known as the Caltrans Detention Basin Site located west of SR 99 and south of Paseo Avenue. The site is currently fallow. Live Oak intends to construct soccer fields and a stormwater detention basin at the site in 2013 or later. Although the site will require hauling for a short distance through a residential neighborhood, it is anticipated the residents will be amenable to the hauling as it will be a part of the public amenity constructed by Live Oak. This site is about 25 acres, and the depth of excavation is anticipated to be 3–6 feet. The yield of material from this site could be 125,000 cubic yards, and will likely be used for Contract C. Haul routes will use existing roads.

Live Oak (2012) reports that land at this location has historically been cultivated for agricultural purposes and reported that there was no evidence of any wetland or other sensitive plant or wildlife areas remaining onsite. No wetland features were identified during a preliminary wetland delineation of the area in December 2012. The previous agricultural use has displaced native species of plants and animals except those varieties capable of co-existing with humans in urban settings. The post-project use of the site will be a community park and stormwater detention basin facility.

Oroville Wildlife Area Dredge Tailings Area - This site is within the Oroville Wildlife Area and consists of several mounds of dredge tailings waterside of the existing levee. The material is suitable for use in seepage berms in Contract D. The availability of tailings in the area should be sufficient to meet the total deficit for berm material in these reaches. The excavation of the material will be coordinated to maximize hydraulic benefits from the reshaping of the overbank area. The site also represents an opportunity to provide waterside habitat enhancements. The useful area of this site could be about 75 acres and the depth of excavation could be upwards of 10 feet. The yield of material from this site could be 375,000 cubic yards. Hauling from this site will not take place on public roads. It is anticipated the contractor will use an existing waterside levee ramp (or create one), directly accessing the levee patrol road. The future land use for this site will be similar to its present day use (managed habitat area).

Construction Timing

Specific sequencing of construction will be dynamic throughout planning and design of the FRWLP, subject to change based on factors including the following.

- Further engineering in determining the clarity and efficacy of site-specific measures.

- Easement and right-of-way acquisition (where necessary).
- Availability of proximate, suitable, and cost-effective borrow material.
- Environmental clearances based on wildlife presence, lifecycle activity, and location of habitats.

Based on current planning analysis for the FRWLP, construction will occur in more than one annual construction season (typically April 15 to November 30, subject to conditions). Although subject to change, the four contracts and their respective areas for construction of the FRWLP are identified below.

- Contract A, 2016 – 2017
- Contract B, 2014 – 2015
- Contract C, 2013 – 2014
- Contract D, 2014 – 2015

Construction is anticipated to occur in single 10-hour shifts, 6 days per week. An exception to this schedule is slurry cutoff wall construction, which is anticipated to occur in two 10-hour shifts (essentially 24-hour construction), 6 days per week. While actual construction will not occur between the two 10-hour shifts, equipment maintenance and preparations for the upcoming work shift will occur.

Conservation Measures

SBFCA will implement the following conservation measures to avoid and minimize effects on federally listed species. To ensure their implementation, the measures listed below will be included in the project specifications.

General

Conservation Measure 1: Conduct Mandatory Biological Resources Awareness Training for All Project Personnel and Implement General Requirements

Before any ground-disturbing work (including vegetation clearing and grading) occurs in the Action Area, a Service-approved biologist will conduct a mandatory biological resources awareness training for all construction personnel about federally-listed species that could potentially occur onsite (beetle and snake). The training will include the natural history, representative photographs, and legal status of each federally-listed species and avoidance and minimization measures to be implemented. Proof of personnel attendance will be provided to the Service within 1 week of the training. If new construction personnel are added to the project, the contractor will ensure that the new personnel receive the mandatory training before starting work. The subsequent training of personnel can include videotape of the initial training and/or the use of written materials rather than in-person training by a biologist. Requirements that will be followed by construction personnel are listed below.

- Where suitable habitat is present for listed species, SBFCA will clearly delineate the construction limits through the use of survey tape, pin flags, orange barrier fencing, or other means, and prohibit any construction-related traffic outside these boundaries.
- Project-related vehicles will observe the posted speed limit on hard-surfaced roads and a 10-mile-per-hour speed limit on unpaved roads during travel in the project construction area. Project-related vehicles and construction equipment will restrict off-road travel to the designated construction areas.
- All food-related trash will be disposed of in closed containers and removed from the project construction area at least once per week during the construction period. Construction personnel will not feed or otherwise attract fish or wildlife to the project site.
- No pets or firearms will be allowed in the project construction area.
- To prevent possible resource damage from hazardous materials such as motor oil or gasoline, construction personnel will not service vehicles or construction equipment outside designated staging areas.
- Any worker who inadvertently injures or kills a federally-listed species or finds one dead, injured, or entrapped will immediately report the incident to the biological monitor and construction foreman. The construction foreman will immediately notify SBFCA, who will provide verbal notification to the Sacramento Fish and Wildlife Office and the local CDFW warden or biologist within 1 working day. SBFCA will follow up with written notification to Service and CDFW within 5 working days. The biological monitor will follow up with SBFCA to ensure that the wildlife agencies were notified.
- The biological monitor will record all observations of federally-listed species on California Natural Diversity Database (CNDDB) field sheets and submit to CDFW.

Valley Elderberry Longhorn Beetle

Conservation measures for the beetle are based on Service's 1999 *Conservation Guidelines for the Valley Elderberry Longhorn Beetle* (Conservation Guidelines) (U.S. Fish and Wildlife Service 1999a).

Conservation Measure 2: Fence Elderberry Shrubs to be Protected and Monitor Fencing during Construction

Elderberry shrubs/clusters within 100 feet of the construction area that will not be removed will be protected during construction. A qualified biologist (i.e., with elderberry/beetle experience), under contract to SBFCA, will mark the elderberry shrubs and clusters that will be protected during construction. Orange construction barrier fencing will be placed at the edge of the respective buffer areas. The buffer area distances will be proposed by the biologist and approved by the Service. No construction activities will be permitted within the buffer zone other than those activities necessary to erect the fencing. Signs will be posted every 50 feet (15.2 meters) along the perimeter of the buffer area fencing. The signs will contain the following information:

This area is habitat of the valley elderberry longhorn beetle, a threatened species, and must not be disturbed. This species is protected by the Endangered Species Act of 1973, as amended. Violators are subject to prosecution, fines, and imprisonment.

In some cases, where the elderberry shrub dripline is within 10 feet of the work area, k-rails will be placed at the shrub's dripline to provide additional protection to the shrub from construction equipment and activities. Temporary fences around the elderberry shrubs and k-rails at shrub driplines will be installed as the first order of work. Temporary fences will be furnished, constructed, maintained, and later removed, as shown on the plans, as specified in the special provisions, and as directed by the project engineer. Temporary fencing will be 4 feet (1.2 meters) high, commercial-quality woven polypropylene, orange in color.

Buffer area fences around elderberry shrubs will be inspected weekly by a qualified biological monitor during ground-disturbing activities and monthly after ground-disturbing activities until project construction is complete or until the fences are removed, as approved by the biological monitor and the resident engineer. The biological monitor will be responsible for ensuring that the contractor maintains the buffer area fences around elderberry shrubs throughout construction. Biological inspection reports will be provided to the project lead and the Service.

Conservation Measure 3: Conduct Beetle Surveys Prior to Elderberry Shrub Transplantation

Surveys of elderberry shrubs to be transplanted will be conducted by a qualified biologist prior to transplantation. Surveys will be conducted in accordance with the Conservation Guidelines (U.S. Fish and Wildlife Service 1999a). The biologist will survey the area surrounding the shrub to be transplanted to ensure that there are not additional elderberry shrubs that need to be removed. Surveys will consist of counting and measuring the diameter of each stem, and examining elderberry shrubs for the presence of beetle exit holes. Survey results and an analysis of the number of elderberry seedlings/cuttings and associated native plants based on the survey results will be submitted to the Service. SBFCA plans to plant elderberry seedlings/cuttings and associated native plants prior to transplantation of elderberry shrubs. The data collected during the surveys prior to transplantation will be used to determine if SFBCA is exceeding their compensation needs or if additional plantings are necessary. Because the Proposed Action will be constructed in four separate contracts, elderberry survey data for each contract will be used to rectify any discrepancies in compensation for the previous contract and to ensure that SBFCA has minimized effects to the beetle.

Conservation Measure 4: Water Down Construction Area to Control Dust

SFBCA or the contractor will ensure that the project construction area will be watered down as necessary to prevent dirt from becoming airborne and accumulating on elderberry shrubs within the 100–foot buffer.

Conservation Measure 5: Compensate for Direct and Indirect Effects on Valley Elderberry Longhorn Beetle Habitat

Before construction begins, SBFCA will compensate for direct effects on elderberry shrubs by transplanting shrubs that cannot be avoided to a Service-approved conservation area (described below). Elderberry seedlings or cuttings and associated native species will also be planted in the conservation area. Each elderberry stem measuring 1 inch or greater in diameter at ground level that is adversely affected (i.e., transplanted or destroyed) will be replaced, in the conservation

area, with elderberry seedlings or cuttings at a ratio ranging from 1:1 to 8:1 (new plantings to affected stems). The numbers of elderberry seedlings/cuttings and associated riparian native trees/shrubs to be planted as replacement habitat are determined by stem size class of affected elderberry shrubs, presence or absence of exit holes, and whether the shrub lies in a riparian or non-riparian area. Stock of either seedlings or cuttings will be obtained from local sources (including the Action Area if acceptable to the Service).

At the discretion of the Service, shrubs that are unlikely to survive transplantation because of poor condition or location, or a plant that will be extremely difficult to move because of access problems, may be exempted from transplantation. In cases where transplantation is not possible, compensation ratios will be increased to offset the additional habitat loss.

The relocation of the elderberry shrubs will be conducted according to Service-approved procedures outlined in the Conservation Guidelines (U. S. Fish and Wildlife Service 1999a). Elderberry shrubs within the project construction area that cannot be avoided will be transplanted during the plant's dormant phase (November through the first 2 weeks of February). A qualified biological monitor will remain onsite while the shrubs are being transplanted.

Property inaccessibility and the high density of vegetation along portions of the Feather River riparian corridor limited the number of elderberry shrubs that could be surveyed (73 shrubs were surveyed). For this reason, compensation for the removal of 91 shrubs was estimated based on the average number of stems in each stem diameter range for the 73 shrubs that could be surveyed. Those average shrub stem counts are as follows.

- Number of stems $\geq$1 inch and $\leq$3 inches = 4.
- Number of stems >3 inches and <5 inches = 1.
- Number of stems $\geq$5 inches = 1.

Table 1 shows the estimated compensation. Because the shrubs are located in riparian habitat and did not have exit holes, the compensation ratios for these conditions were used. As noted in Table 1, one elderberry shrub will need to be transplanted prior to the start of work in 2013 (in Reach 13) and outside of the elderberry dormancy period.

Based on the information in Table 1, the conservation area will be at least 12.15 acres in size to accommodate about 91 elderberry shrubs, 1,470 elderberry cuttings or seedlings, and 1,470 native plants. The conservation area in which the transplanted elderberry shrubs and seedlings are planted will be protected in perpetuity as habitat for the beetle.

Evidence of beetle occurrence in the conservation area, the condition of the elderberry shrubs in the conservation area, and the general condition of the conservation area itself will be monitored over a period of 10 consecutive years or for 7 years over a 15-year period from the date of transplanting. SBFCA will be responsible for funding and providing monitoring reports to the Service in each of the years in which a monitoring report is required. As specified in the Conservation Guidelines, the report will include information on timing and rate of irrigation, growth rates, and survival rates and mortality.

Table 1. Elderberry Stem Sizes and Compensation

Location	Stems (maximum diameter at ground level)	Exit Hole on Shrub (Yes or No)	Elderberry Seedling Ratio	Associated Native Plant Ratio	Multiplier for transplanting between June 15 – August 15	Number of Stems	Required Elderberry Plantings	Required Associated Native Plant Plantings
Riparian	stems ≥1" & ≤3"	No	2:1	1:1	No	360	720	720
Riparian	stems > 3" & <5"	No	3:1	1:1	No	90	270	270
Riparian	stems > 5"	No	4:1	1:1	No	90	360	360
2013 Construction - Reach 13								
Riparian	stems ≥1" & ≤3"	No	2:1	1:1	2.5	1	5	5
Riparian	stems > 3" & <5"	No	3:1	1:1	2.5	2	15	15
Riparian	stems > 5"	No	4:1	1:1	2.5	10	100	100
Total replacement plantings							1,470	1,470
Total elderberry shrubs to be transplanted								91
2940 /10 = 294 valley elderberry longhorn beetle credits or 12.15 acres								

To meet the success criteria specified in the Conservation Guidelines, a minimum survival rate of 60% of the original number of elderberry replacement plantings and associated native plants must be maintained throughout the monitoring period.

Proposed Conservation Area

SBFCA proposes to transplant elderberry shrubs to the existing 48.5-acre Star Bend Conservation Area, located on the west levee of the Feather River, about 6 miles south of Yuba City. In 2009, Levee District 1 of Sutter County proposed to construct the Feather River Setback Levee and Habitat Enhancement Project at Star Bend to replace a portion of existing levee that poses a high risk of failure in order to decrease the flood stage, velocity, and scour potential; increase and improve floodplain habitat; and improve habitat connectivity between the Abbot Lake and O'Connor Lakes Units of CDFW's Feather River Wildlife Area. The Star Bend project created 48.5 acres of floodplain habitat, which included habitat enhancement and onsite compensation for impacted elderberry shrubs.

In 2009, River Partners and Stillwater Sciences prepared a *Habitat Enhancement Plan for the Feather River Setback Levee and Habitat Enhancement Project at Star Bend* to be implemented by Levee District 1. It provides further information on the conditions at the time the site was proposed. About 20 acres have been used for elderberry transplants and associated native plants. In early 2012, a fire at the Star Bend site damaged portions of the site; however, elderberry shrub

planting losses were minimal. The remaining 28.5 acres are available at the conservation area for compensating for impacts on elderberry shrubs from construction of the FRWLP. The long-term goal of the conservation area is to merge this area with CDFW's adjoining O'Conner Lakes and Abbott Lakes Wildlife Units. SBFCA will prepare a mitigation and monitoring plan for the 28.5 acres that are available and will be used as a conservation area for effects to the beetle, as well as riparian impacts. This plan is currently being coordinated with the Service, Corps, and CDFW. Additionally, SBFCA will obtain a conservation easement for the 28.5 acre conservation area.

Giant Garter Snake

Conservation Measure 6: Conduct Construction Activities during the Active Period for Giant Garter Snake

Construction activity within giant garter snake aquatic and upland habitat (200 feet of aquatic habitat) will be conducted during the snake's active period (May 1–October 1). During this timeframe, potential for injury and mortality are lessened because snakes are actively moving and avoiding danger. The only work that will be conducted outside of the active season is levee slope flattening within the Sutter-Butte Canal in Reaches 26–28 (scheduled for 2016) and pipe reconstruction at two sites in the same reaches because these activities must be conducted when the canal is dry (February–March). Additional protective measures will be implemented at these locations (see Conservation Measure 14 below).

Conservation Measure 7: Install and Maintain Exclusion and Construction Barrier Fencing around Suitable Giant Garter Snake Habitat

To reduce the likelihood of giant garter snakes entering the construction area, SBFCA will install exclusion fencing and orange construction barrier fencing along the portions of the construction area that are within 200 feet of suitable aquatic and upland habitat. The exclusion and construction barrier fencing will be installed during the active period for giant garter snakes (May 1–October 1) to reduce the potential for injury and mortality during this activity.

The construction specifications will require that SBFCA or its contractor retain a qualified biologist to identify the areas that are to be avoided during construction. Areas adjacent to the directly affected area required for construction, including staging and access, will be fenced off to avoid disturbance in these areas. Before construction, the contractor will work with the qualified biologist to identify the locations for the barrier fencing and will place flags or flagging around the areas to be protected to indicate the locations of the barrier fences. The protected area will be clearly identified on the construction specifications. The fencing will be installed the maximum distance practicable from the aquatic habitat areas and will be in place before construction activities are initiated.

The exclusion fencing will consist of 3-foot-tall silt fencing buried 6 inches below ground level. The exclusion fencing will ensure that giant garter snakes are excluded from the construction area and that suitable upland and aquatic habitat is protected throughout construction. The construction barrier fencing will be commercial-quality, woven polypropylene, orange in color,

and 4 feet high (Tensor Polygrid or equivalent). The fencing will be tightly strung on posts with a maximum of 10-foot spacing.

Barrier and exclusion fences will be inspected daily by a qualified biological monitor during ground-disturbing activities and weekly after ground-disturbing activities until project construction is complete or until the fences are removed, as approved by the biological monitor and the resident engineer. The biological monitor will be responsible for ensuring that the contractor maintains the buffer area fences around giant garter snake habitat throughout construction. Biological inspection reports will be provided to the project lead and the Service.

Conservation Measure 8: Minimize Potential Impacts on Giant Garter Snake Habitat

SBFCA will implement the following measures to minimize potential impacts on giant garter snake habitat.

- Staging areas will be located at least 200 feet from suitable giant garter snake habitat.
- Any dewatered habitat will remain dry for at least 15 consecutive days after April 15 and prior to excavating or filling of the dewatered habitat.
- Vegetation clearing within 200 feet of the banks of suitable giant garter snake aquatic habitat will be limited to the minimum area necessary. Avoided giant garter snake habitat within or adjacent to the Action Area will be flagged and designated as an environmentally sensitive area, to be avoided by all construction personnel.
- The movement of heavy equipment within 200 feet of the banks of suitable giant garter snake aquatic habitat will be confined to designated haul routes to minimize habitat disturbance.

Conservation Measure 9: Prepare and Implement a Stormwater Pollution Prevention Plan

SBFCA will prepare a stormwater pollution prevention plan (SWPPP) that describes the BMPs that will be implemented to control accelerated erosion, sedimentation, and other pollutants during and after project construction. The SWPPP will be prepared prior to commencing earth-moving construction activities. This will also comply with the U.S. Environmental Protection Agency's National Pollutant Discharge Elimination System (NPDES) general construction activity stormwater permit.

The specific BMPs that will be incorporated into the erosion and sediment control plan and SWPPP will be site-specific and will be prepared by the construction contractor in accordance with the California Regional Water Quality Control Board Field Manual. However, the plan likely will include, but not be limited to, one or more of the following standard erosion and sediment control BMPs.

- **Timing of construction.** The construction contractor will conduct all construction activities during the typical construction season to avoid ground disturbance during the rainy season.
- **Staging of construction equipment and materials.** To the extent possible, equipment and materials will be staged in areas that have already been disturbed.

- **Minimize soil and vegetation disturbance.** The construction contractor will minimize ground disturbance and the disturbance/destruction of existing vegetation. This will be accomplished in part through the establishment of designated equipment staging areas, ingress and egress corridors, and equipment exclusion zones prior to the commencement of any grading operations.
- **Stabilize grading spoils.** Grading spoils generated during the construction will be temporarily stockpiled in staging areas. Silt fences, fiber rolls, or similar devices will be installed around the base of the temporary stockpiles to intercept runoff and sediment during storm events. If necessary, temporary stockpiles may be covered with an appropriate geotextile to increase protection from wind and water erosion.
- **Install sediment barriers.** The construction contractor may install silt fences, fiber rolls, or similar devices to prevent sediment-laden runoff from leaving the construction area. Natural/biodegradable erosion control measures (i.e., coir rolls, straw wattles or hay bales) will be used. Plastic monofilament netting (erosion control matting) will not be allowed because animals can become caught in this type of erosion control material.
- **Stormwater drain inlet protection.** The construction contractor may install silt fences, drop inlet sediment traps, sandbag barriers, and/or other similar devices.
- **Permanent site stabilization.** The construction contractor will install structural and vegetative methods to permanently stabilize all graded or otherwise disturbed areas once construction is complete. Structural methods may include the installation of biodegradable fiber rolls and erosion control blankets. Vegetative methods may involve the application of organic mulch and tackifier and/or the application of an erosion control seed mix. Implementation of a SWPPP will substantially minimize the potential for project-related erosion and associated adverse effects on water quality.

Conservation Measure 10: Prepare and Implement a Bentonite Slurry Spill Contingency Plan (Frac-Out Plan)

Before excavation begins, SBFCA will ensure the contractor will prepare and implement a bentonite slurry spill contingency plan (BSSCP) for any excavation activities that use pressurized fluids (other than water). The plan will be subject to approval by the Corps, Service, and SBFCA before excavation can begin. The BSSCP will include measures intended to minimize the potential for a frac-out (short for "fracture-out event") associated with excavation and tunneling activities; provide for the timely detection of frac-outs; and ensure an organized, timely, and "minimum-effect" response in the event of a frac-out and release of excavation fluid (i.e., bentonite). The BSSCP will require, at a minimum, the following measures.

- If a frac-out is identified, all work will stop, including the recycling of the bentonite fluid. In the event of a frac-out into water, the location and extent of the frac-out will be determined, and the frac-out will be monitored for 4 hours to determine whether the fluid congeals (bentonite will usually harden, effectively sealing the frac-out location).
- NMFS, the Service, CDFW, and the RWQCB will be notified immediately of any spills and will be consulted regarding clean-up procedures. A Brady barrel will be onsite and used if a frac-out occurs. Containment materials, such as straw bales, also will be onsite prior to and during all operations, and a vacuum truck will be on

retainer and available to be operational onsite within notice of 2 hours. The site supervisor will take any necessary follow-up response actions in coordination with agency representatives. The site supervisor will coordinate the mobilization of equipment stored at staging areas (e.g., vacuum trucks) as needed.

- If the frac-out has reached the surface, any material contaminated with bentonite will be removed by hand to a depth of 1-foot, contained, and properly disposed of, as required by law. The drilling contractor will be responsible for ensuring that the bentonite is either properly disposed of at an approved Class II disposal facility or properly recycled in an approved manner.
- If the bentonite fluid congeals, no other actions, such as disturbance of the streambed, will be taken that will potentially suspend sediments in the water column.
- The site supervisor has overall responsibility for implementing this BSSCP. The site supervisor will be notified immediately when a frac-out is detected. The site supervisor will be responsible for ensuring that the biological monitor is aware of the frac-out, coordinating personnel, response, cleanup, regulatory agency notification and coordination to ensure proper clean-up, disposal of recovered material, and timely reporting of the incident. The site supervisor will ensure all waste materials are properly containerized, labeled, and removed from the site to an approved Class II disposal facility by personnel experienced in the removal, transport, and disposal of drilling mud.
- The site supervisor will be familiar with the contents of this BSSCP and the conditions of approval under which the activity is permitted to take place. The site supervisor will have the authority to stop work and commit the resources (personnel and equipment) necessary to implement this plan. The site supervisor will ensure that a copy of this plan is available (onsite) and accessible to all construction personnel. The site supervisor will ensure that all workers are properly trained and familiar with the necessary procedures for response to a frac-out, prior to commencement of excavation operations.

Conservation Measure 11: Prepare and Implement a Spill Prevention, Control, and Counter-Measure Plan

A spill prevention, control, and counter-measure plan (SPCCP) is intended to prevent any discharge of oil into navigable water or adjoining shorelines. SBFCA or its contractor will develop and implement an SPCCP to minimize the potential for and effects from spills of hazardous, toxic, or petroleum substances during construction and operation activities. The SPCCP will be completed before any construction activities begin. Implementation of this measure will comply with State and Federal water quality regulations. The SPCCP will describe spill sources and spill pathways in addition to the actions that will be taken in the event of a spill (e.g., an oil spill from engine refueling will be immediately cleaned up with oil absorbents). The SPCCP will outline descriptions of containments facilities and practices such as doubled-walled tanks, containment berms, emergency shut-offs, drip pans, fueling procedures and spill response kits. It will also describe how and when employees are trained in proper handling procedure and spill prevention and response procedures.

SBFCA will review and approve the SPCCP before onset of construction activities and routinely inspect the construction area to verify that the measures specified in the SPCCP are properly implemented and maintained. SBFCA will notify its contractors immediately if there is a non-compliance issue and will require compliance.

The Federal reportable spill quantity for petroleum products, as defined in 40 CFR 110, is any oil spill that results in one or more of the following.

- Violates applicable water quality standards.
- Causes a film or sheen on or discoloration of the water surface or adjoining shoreline.
- Causes a sludge or emulsion to be deposited beneath the surface of the water or adjoining shorelines.

If a spill is reportable, the contractor's superintendent will notify SBFCA, and SBFCA will take action to contact the appropriate safety and cleanup crews to ensure that the SPCCP is followed. A written description of reportable releases must be submitted to the Central Valley RWQCB. This submittal must contain a description of the release, including the type of material and an estimate of the amount spilled, the date of the release, an explanation of why the spill occurred, and a description of the steps taken to prevent and control future releases. The releases will be documented on a spill report form.

Conservation Measure 12: Conduct Preconstruction Surveys and Monitoring for Giant Garter Snake

Prior to ground-disturbing activities within 200 feet of suitable habitat, a Service-approved biological monitor will conduct a preconstruction survey of suitable aquatic and upland habitat and inspect exclusion and orange barrier fencing to ensure they are both in good working order each morning. If any snakes are observed within the construction area at any other time during construction the Service-approved biological monitor will be contacted to survey the site for giant garter snakes. The biological monitor will have the authority to stop construction activities until appropriate corrective measures have been completed or it is determined that the snake will not be harmed. Giant garter snakes encountered during construction activities will be allowed to move away from construction activities on their own. If unable to move away on their own, trapped or injured giant garter snakes will be only be removed by a biologist with a federal 10(a)1(a) permit which allows them to handle the snake and will be placed in a location determined through discussions with the Service. The biological monitor will immediately report the finding of a snake to Service by phone and will provide a written account of the details of the incident within 24 hours.

Once all initial ground-disturbing activities are completed, the biological monitor will perform weekly checks of the site for the duration of construction in order to ensure that construction barrier fences and exclusion fences are in good order, trenches are being covered, project personnel are conducting checks beneath parked vehicles prior to their movement, and that all other required biological protection measures are being complied with. The biological monitor will document the results of monitoring on construction monitoring log sheets, which will be provided to the Service within 1 week of each monitoring visit.

Conservation Measure 13: Provide Escape Ramps or Cover Open Trenches at the End of Each Day

To avoid entrapment of giant garter snake, thereby preventing injury or mortality resulting from falling into trenches, all excavated areas more than 1 foot deep will be provided with one or more escape ramps constructed of earth fill or wooden planks at the end of each workday. If escape ramps cannot be provided, then holes or trenches will be covered with plywood or other hard material. The biological monitor or construction personnel designated by the contractor will be responsible for thoroughly inspecting trenches for the presence of giant garter snakes at the beginning of each workday. Capture and relocation of trapped or injured individuals can only be attempted by personnel or individuals with current Service recovery permits pursuant to section 10(a)1(A) of the Act.

Conservation Measure 14: Implement Additional Protective Measures during Work in Suitable Habitat during the Giant Garter Snake Dormant Period

SBFCA will implement additional protective measures during time periods when work must occur during the giant garter snake dormant period (October 2–April 30), when snakes are more vulnerable to injury and mortality. It is expected that these additional measures will be implemented during levee slope flattening within the Sutter-Butte Canal in Reaches 26–28 (scheduled for 2016) and pipe reconstruction adjoining the canal at two sites in the same reaches during February–March, and if construction activities extend to the period between October 2 and November 1. SBFCA will implement additional protective measures when conducting work in suitable giant garter snake habitat between October 2 and April 30.

- A full-time Service-approved biological monitor will be onsite for the duration of construction activities.
- All emergent vegetation within the Sutter-Butte Canal on the levee side, and vegetation within 200 feet of the canal will be cleared prior to the giant garter snake hibernation period (i.e., vegetation clearing must be completed by October 1 for following winter work).
- Exclusion fencing will be installed around the perimeter of the work area and across the Sutter-Butte Canal where construction activities associated with levee slope flattening and pipe reconstruction activities will occur. The fencing should enclose the work area to the maximum extent possible to prevent giant garter snakes from entering the work area. Fencing will be installed during the active period for giant garter snakes (May 1–October 1) to reduce the potential for injury and mortality during fence installation. The Service-approved biological monitor will work with the contractor to determine where fencing should be placed and will monitor fence installation. The exclusion fencing will consist of 3-foot-tall erosion fencing buried 4– 6 inches below ground level. The exclusion fencing will minimize opportunities for giant garter snake hibernation in the adjacent upland area (between canal and existing levee).
- Portions of the Sutter-Butte Canal that are temporarily disturbed during construction will be revegetated with emergent vegetation and adjacent disturbed upland habitat will be revegetated with native grasses and forbs after construction is complete.

Conservation Measure 15: Restore Temporarily Disturbed Aquatic and Upland Habitat to Pre-Action Conditions

Upon completion of the proposed project, SBFCA will restore 42.52 acres of suitable aquatic habitat and 118.80 acres of suitable upland habitat for the giant garter snake to pre-project conditions. Restoration of aquatic vegetation and annual grassland will be detailed in a mitigation and monitoring plan that will be reviewed and approved by the Corps and Service prior to the start of construction. Habitat will be restored within one season (defined as May 1–October 1) and providing vegetative cover within 1 year of construction beginning in that area.

Conservation Measure 16: Compensate for Permanent Loss of Aquatic Habitat for Giant Garter Snake

SBFCA will compensate for the permanent loss of 0.004 acre of suitable aquatic habitat for giant garter snake by purchasing preservation credits equal to 0.012 acre of giant garter snake habitat at Westervelt Ecological Services' Sutter Basin Conservation Bank in Sutter County. This bank has available giant garter snake credits and is approved by both the Service and CDFW.

The 0.012 acre of habitat at the conservation bank will be protected in perpetuity for giant garter snake. Prior to the start of construction (excluding Reach 13, as there is no giant garter snake habitat in this reach), SBFCA will provide funding to Westervelt Ecological Services for preservation credits equivalent to 0.012 acre of giant garter snake habitat at the Sutter Basin Conservation Bank. The transaction will take place through a purchase and sale agreement, and funds must be transferred within 30 days, and before any construction activities are initiated. SBFCA will provide the Service and CDFW with copies of the credit sale agreement and fund transfer.

Analytical Framework for the Jeopardy Analysis

In accordance with policy and regulation, the jeopardy analysis in this biological opinion relies on four components: (1) the *Status of the Species*, which evaluates the beetle's and snake's range-wide condition, the factors responsible for that condition, and their survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the beetle and the snake in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the beetle and snake; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed federal action and the effects of any interrelated or interdependent activities on the beetle and snake; and (4) the *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the beetle and snake.

In accordance with policy and regulation, the jeopardy determination is made by evaluating the effects of the proposed Federal action in the context of the beetle's and snake's current status, taking into account any cumulative effects, to determine if implementation of the proposed

action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the beetle and snake.

The jeopardy analysis in this biological opinion places an emphasis on consideration of the range-wide survival and recovery needs of the beetle and snake and the role of the action area in the survival and recovery of the beetle and snake as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

Status of the Species

Valley Elderberry Longhorn Beetle

Please refer to the *Valley Elderberry Longhorn Beetle (Desmocerus californicus dimorphus) 5-year Review: Summary and Evaluation* (Service 2006) for the current status of the species.

Giant Garter Snake

Please refer to the *Giant Garter Snake (Thamnophis gigas) 5-year Review: Summary and Evaluation* (Service 2012) for the current status of the species.

Environmental Baseline

Valley Elderberry Longhorn Beetle

The closest beetle occurrence in the CNDDB (2013) is about 0.5 mile from the proposed project. Suitable habitat for the beetle (in the form of elderberry shrubs) exists in numerous places along the 41 miles of proposed levee repair. A total of 267 elderberry shrubs were mapped within the action area. Many others exist at various locations between the levee and the river. Of these SBFCA is proposing to avoid 175 elderberry shrubs and transplant 91 elderberry shrubs. Because the action area is within the range of the species, there are known occurrences from the vicinity of the action area, and suitable habitat is present, the Service concludes that it is reasonably likely for the beetle to occupy the action area.

Giant Garter Snake

The *Draft Recovery Plan for the Giant Garter Snake* subdivides the range of the species into four recovery units (Service 1999b). The action area for the proposed project is located within the Sacramento Valley Recovery Unit. There are 20 records of the snake within 5 miles of the action area. The closest occurrence documented in the CNDDB is 2 miles from the action area. Snakes have the potential to occur within the action area because suitable aquatic and upland habitat is present as it is hydrologically connected to areas that support rice agriculture and areas where the snake has previously been detected. The action area is a long corridor that occasionally has irrigation ditches, which run parallel to the levee for limited stretches. The main threat to the snake in the action area is loss of habitat or connectivity due to channel and levee maintenance.

Effects of the Proposed Action

Valley Elderberry Longhorn Beetle

Ninety-one elderberry shrubs will be removed and transplanted. The 91 affected shrubs have 361 stems between 1 and 3 inches, 92 stems between 3 and 5 inches and 100 stems greater than 5 inches at ground level.

Loss of an elderberry shrub or even a stem can affect the beetle breeding and feeding because adult beetles rely solely on elderberry foliage and flowers for food and must lay their eggs on elderberry stems to successfully reproduce.

Transplantation of elderberry shrubs that are or could be used by beetle larvae is expected to adversely affect the beetle. Beetle larvae will be killed or the beetle's life cycle will be interrupted during or after the transplanting process. For example:

1. Transplanted elderberry shrubs may experience stress or become unhealthy due to changes in soil, hydrology, microclimate, or associated vegetation. This may reduce their quality as habitat for the valley elderberry longhorn beetle, or impair their production of habitat-quality stems in the future.

2. Elderberry shrubs may die as a result of transplantation.

3. Branches containing larvae may be cut, broken, or crushed as a result of the transplantation process.

SBFCA has proposed to transplant one shrub outside of the elderberry shrub's dormant season (November 1 to February 15). To offset the increased risk of the transplantation not being successful SBFCA has proposed to plant 2.5 times the number of elderberry seedlings at the Star Bend Conservation Area.

Temporal loss of habitat will occur. Although conservation measures for effects on the beetle will involve creation or restoration of habitat, it generally takes 5 or more years for elderberry plants to become large enough to support beetles, and it may take 25 years or longer for riparian habitats to reach their full value. Temporal loss of habitat may cause fragmentation of habitat and isolation of subpopulations.

Permanent and temporary habitat loss adversely affects the beetles breeding and foraging requirements. Habitat creation and transplantation of the shrubs will minimize these effects. Success of a restoration site has been linked to presence of transplanted elderberry shrubs that have served to colonize a newly created riparian habitat. Transplants that survive also provide diversity within the conservation area as they are older, larger shrubs within the plantings of young small elderberry seedlings. The Star Bend Conservation Area will be protected with a conservation easement and managed in perpetuity for riparian habitat including valley elderberry longhorn beetle habitat, through development of the *Feather River West Levee Project Mitigation and Monitoring Plan.*

Giant garter snake

Aquatic habitat for the snake near the levee construction varies along the 41 miles of the proposed project. Small areas of aquatic habitat are present in Contract A and C and they are hydrologically connected to areas that support habitat for the snake (rice). Contract D has the largest amount of snake aquatic habitat as the Sutter Butte Canal parallels the levee for longer lengths. Canal filling due to cutoff wall construction will permanently fill 0.004 acre of snake aquatic habitat. Upland habitat around this aquatic habitat will be temporarily disturbed but returned to pre-project condition within one year. Temporary effects will result from temporary fill of aquatic habitat for construction access, reshaping the slope of the Sutter Butte Canal and adjacent levee, and degradation and reconstruction of the levee. These activities will temporarily affect 6.81 acres of aquatic habitat. Levee degradation and reconstruction will temporarily affect 112.47 acres of upland habitat. All temporarily affected areas will be restored to pre-project conditions within the same year the disturbance will occur. This will minimize effects to giant garter snakes because the amount of time the habitat will be unavailable to the snake will be minimized. Permanently affected habitat, such as the canals that will be made smaller will be offset by purchasing 0.012 acre of giant garter snake habitat at Westervelt Ecological Services' Sutter Basin Conservation Bank in Sutter County. None of the borrow sites in the project description have upland or aquatic giant garter snake habitat.

The majority of the construction work will occur during the giant garter snake active season (May 1 to October 1). Increased construction activity in areas where snakes are known to occur could expose snakes to increased risks of injury and mortality from predation, exposure, vehicular traffic, and construction equipment. Because snakes are more mobile during the active season, these effects should be lessened. There are a few activities which SBFCA could not construct during the active season. Because of cooler temperatures in the inactive season (October 1 to May 1), the snake is not as mobile and is most frequently found within burrows. Ground disturbing activities during this timeframe will increase the likelihood of snake mortality when the burrows are disturbed with heavy equipment. SBFCA has proposed to disturb (clear and grub) the out of season work area and place exclusion fencing around the work area during the active season which will create an area that will not support overwintering snakes (lack of burrows). This will minimize the chance of injuring or killing an overwintering snake during out of season construction. This will only occur on one side of the canal, leaving the other side of the canal available as overwintering habitat for the snake.

Temporary effects within the action area will affect both aquatic and upland snake habitat. In some locations degradation of the levee could cause soil to fall into the aquatic habitat or fuel or oil leaks could also adversely affect the habitat and the snake. Placement of sediment fencing and implementing sediment and contaminant BMPs will lessen this effect. Levee degradation will temporarily make upland habitat unavailable to the snake during the active season. Snakes use upland habitat for thermoregulation both as a place to bask and as a place to escape extreme heat (burrows) and cover for shedding and giving birth to young. While snakes are more active during the summer months and more likely to move away from construction, some snakes may choose to remain where they are and therefore will be subject to mortality when construction activities are occurring. In addition to direct mortality, the upland habitat will be temporarily unavailable to the snake during construction. Even once construction is completed it will take a

year or two for the upland habitat to become completely functional for the snake, with burrows or crevices available for them to use. This is likely to result in disturbance, displacement, injury, and/or mortality of snakes. To lessen these effects SBFCA is implementing the conservation measures described above as well as affecting only one side of the canal. This will leave the other side of the canal intact and available to the snake for use, minimizing displacement of snakes. Additionally, because of the staging of construction not all of the upland habitat will be unavailable for use at one time. It will be staged as construction progresses through the various contracts.

Cumulative Effects

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed project are not considered in this section, because they require separate consultation pursuant to section 7 of the Act. Any future land use conversions and routine agricultural practices are not subject to Federal authorization or funding and may alter the habitat or result in take of listed valley elderberry longhorn beetle or giant garter snake and are, therefore, cumulative to the proposed project.

Conclusion

After reviewing the current status of the valley elderberry longhorn beetle and giant garter snake, the environmental baselines for these species, the effects of the proposed project, and the cumulative effects on this species, it is the Service's biological opinion that the proposed FRWLP, as described herein, is not likely to jeopardize the continued existence of these species. Although critical habitat has been designated for the beetle, the proposed action will not affect critical habitat.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harass is defined by the Service as an intentional or negligent act or omission which creates the likelihood of injury to a listed species by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. Harm is defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by impairing behavioral patterns including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act, provided that such taking is in compliance with this Incidental Take Statement.

The measures described below are nondiscretionary for listed species of this biological opinion and must be implemented by the Corps and SBFCA in order for the exemption in section 7(o)(2)

to apply. The Corps has a continuing duty to regulate the activity that is covered by this incidental take statement. If the Federal agency (1) fails to adhere to the terms and conditions of the incidental take statement, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

Amount or Extent of Take

Valley Elderberry Longhorn Beetle

The Service expects that incidental take of the valley elderberry longhorn beetle will be difficult to detect or quantify. The cryptic nature of this species and their relatively small body size make the finding of an injured or dead specimen unlikely. The species occurs in habitats that make them difficult to detect. Due to the difficulty in quantifying the number of beetles that will be taken as a result of the proposed action, the Service is quantifying take incidental to the project as the number of elderberry stems one inch or greater in diameter at ground level (beetle habitat) that will become unsuitable for beetles due to direct or indirect effects as a result of levee construction. Therefore, the Service estimates that all beetles inhabiting 91 elderberry plants containing stems 1 inch or greater at ground level (361 stems between 1-3 inches, 92 stems between 3 and 5 inches and 100 stems $\geq$5 inches; see Table 1 in the text) will be taken as a result of the proposed action.

Giant Garter Snake

The Service anticipates that incidental take of the snake will be difficult to detect or quantify for the following reasons: the snake is cryptically colored, secretive, and known to be sensitive to human activities. Snakes may avoid detection by retreating to burrows, soil crevices, vegetation, or other cover. Individual snakes are difficult to detect unless they are observed, undisturbed, at a distance. Most close-range observations represent chance encounters that are difficult to predict. It is not possible to make an accurate estimate of the number of snakes that will be harassed, harmed or killed during construction activities (staging areas, work on canal banks, levee degradation and reconstruction, soil borrow areas, and vehicle traffic to and from borrow areas). In instances when take is difficult to detect, the Service may use the quantification of acreage as a surrogate for the individuals that will be taken. Therefore, the Service anticipates take incidental to this project as the 0.004 acre of suitable habitat that will be permanently lost and the 119.28 acres (6.81 acres aquatic and 112.47 acres upland) of suitable snake habitat that will be temporarily lost. Upon implementation of the Reasonable and Prudent Measure, Terms and Conditions, and the Proposed Conservation Measures considered herein, incidental take within this acreage for the proposed project, will be exempt from the prohibitions described under Section 9 of the Act.

Effect of the Take

The Service has determined that this level of anticipated take is not likely to result in jeopardy to the beetle or snake.

Reasonable and Prudent Measures

The Service has determined that the following reasonable and prudent measure is necessary and appropriate to minimize the adverse effects of the Feather River West Levee Project to the beetle and snake and their habitat in the action area.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, the Corps and SBFCA must ensure compliance with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are nondiscretionary.

The following Terms and Conditions implement the Reasonable and Prudent Measure:

1. All the conservation measures as described in the project description, and as restated here in this biological opinion, must be fully implemented and adhered to.

2. The Corps, SBFCA, and PG&E shall include full implementation and adherence to the conservation measures as outlined in the biological opinion as a condition of any permit or contract issued for the project.

3. In order to monitor whether the amount or extent of take anticipated from implementation of the proposed project is approached or exceeded, the Corps and SBFCA shall adhere to the following reporting requirement. Should this anticipated amount or extent of incidental take be exceeded, the Corps must immediately reinitiate formal consultation as per 50 CFR 402.16.

    a. For those components of the proposed project that will result in habitat degradation or modification whereby incidental take in the form of harm or mortality is anticipated, the Corps and SBFCA will provide weekly updates to the Service with a precise accounting of the total acreage of habitat effected or number of elderberry shrubs and size of stems at ground level transplanted. Updates shall also include any information about changes in the Project Description and not analyzed in this biological opinion.

4. SBFCA shall provide a photo documentation report showing pre- and post-project area conditions for giant garter snake.

Salvage and Disposition of Individuals

The Sacramento Fish and Wildlife Office will be notified within 1 day of the finding of any dead or injured snake or beetle to determine the appropriate measures for salvage and disposition. The Service contact person is the Habitat Conservation Division Chief. In addition, the Recovery Division Chief shall also be notified within 1 day of the procedures implemented for salvage and disposition of the snake or beetle. The applicant must report to the Service immediately any information about take or suspected take of listed species not authorized in this biological

opinion. Notification must include the date, time, and location of the incident or of the finding of a dead or injured listed species. The Habitat Conservation and Recovery Divisions Chiefs can be contacted at (916) 414-6600. The California Department of Fish and Wildlife should also be contacted at (916)358-2900.

CONSERVATION RECOMMENDATIONS

Conservation recommendations are suggestions of the Service regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of new information. These measures may serve to further minimize or avoid the adverse effects of a proposed action on listed, proposed, or candidate species, or on designated critical habitat. They may also serve as suggestions on how action agencies can assist species conservation in furtherance of their responsibilities under section 7(a)(1) of the Act, or recommend studies improving an understanding of a species' biology or ecology. Wherever possible, conservation recommendations should be tied to tasks identified in recovery plans. The Service is providing you with the following conservation recommendations:

1. The Corps and SBFCA should assist in the implementation of the draft, and when published, the final Recovery Plan for the snake.

2. The Corps and SBFCA should provide funding to researchers studying topics identified by the Service in the draft, and when published, the final Recovery Plan for the snake.

3. The Corps should use environmental restoration authorities to acquire and restore beetle and snake habitat.

To be kept informed of actions minimizing or avoiding adverse effects or benefiting listed and proposed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION - CLOSING STATEMENT

This concludes formal consultation with the Corps on the Feather River West Levee Project. As provided in 50 CFR 402.16, re-initiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been maintained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the proposed action may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in this opinion; or (4) a new species or critical habitat is designated that may be affected by the proposed action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending re-initiation.

If you have any questions regarding this Feather River West Levee Project biological opinion, please contact Jennifer Hobbs, at (916) 414-6541 or Doug Weinrich, Deputy Assistant Field Supervisor, at (916) 414-6563.

Sincerely,

Roberta Gerson

for Jan C. Knight
Acting Field Supervisor

cc:
Jeff Koschak, Corps, Sacramento, CA
Jenny Marr, CDFW, Chico, CA
Jennifer Haire, ICF, Sacramento, CA

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U.S. Fish & Wildlife Service
Sacramento Fish & Wildlife Office

Federal Endangered and Threatened Species that Occur in or may be Affected by Projects in the Counties and/or U.S.G.S. 7 1/2 Minute Quads you requested

Document Number: 130213052954

Database Last Updated: September 18, 2011

No quad species lists requested.

County Lists

Sutter County

Listed Species

Invertebrates

Branchinecta conservatio
Conservancy fairy shrimp (E)

Branchinecta lynchi
Critical habitat, vernal pool fairy shrimp (X)
vernal pool fairy shrimp (T)

Desmocerus californicus dimorphus
valley elderberry longhorn beetle (T)

Lepidurus packardi
Critical habitat, vernal pool tadpole shrimp (X)
vernal pool tadpole shrimp (E)

Fish

Acipenser medirostris
green sturgeon (T) (NMFS)

Hypomesus transpacificus
delta smelt (T)

Oncorhynchus mykiss
Central Valley steelhead (T) (NMFS)
Critical habitat, Central Valley steelhead (X) (NMFS)

Oncorhynchus tshawytscha
Central Valley spring-run chinook salmon (T) (NMFS)
Critical Habitat, Central Valley spring-run chinook (X) (NMFS)
Critical habitat, winter-run chinook salmon (X) (NMFS)
winter-run chinook salmon, Sacramento River (E) (NMFS)

Amphibians

Ambystoma californiense
California tiger salamander, central population (T)

Rana draytonii
California red-legged frog (T)

Reptiles

Thamnophis gigas
giant garter snake (T)

Birds

Charadrius alexandrinus nivosus
western snowy plover (T)

Plants

Cordylanthus palmatus
palmate-bracted bird's-beak (E)

Pseudobahia bahiifolia
Hartweg's golden sunburst (E)

Candidate Species

Birds

Coccyzus americanus occidentalis
Western yellow-billed cuckoo (C)

Key:

(E) *Endangered* - Listed as being in danger of extinction.

(T) *Threatened* - Listed as likely to become endangered within the foreseeable future.

(P) *Proposed* - Officially proposed in the Federal Register for listing as endangered or threatened.

(NMFS) Species under the Jurisdiction of the National Oceanic & Atmospheric Administration Fisheries Service. Consult with them directly about these species.

Critical Habitat - Area essential to the conservation of a species.

(PX) *Proposed Critical Habitat* - The species is already listed. Critical habitat is being proposed for it.

(C) *Candidate* - Candidate to become a proposed species.

(V) Vacated by a court order. Not currently in effect. Being reviewed by the Service.

(X) *Critical Habitat* designated for this species

Important Information About Your Species List

How We Make Species Lists

We store information about endangered and threatened species lists by U.S. Geological

Survey 7½ minute quads. The United States is divided into these quads, which are about the size of San Francisco.

The animals on your species list are ones that occur within, **or may be affected by** projects within, the quads covered by the list.

- Fish and other aquatic species appear on your list if they are in the same watershed as your quad or if water use in your quad might affect them.
- Amphibians will be on the list for a quad or county if pesticides applied in that area may be carried to their habitat by air currents.
- Birds are shown regardless of whether they are resident or migratory. Relevant birds on the county list should be considered regardless of whether they appear on a quad list.

Plants

Any plants on your list are ones that have actually been observed in the area covered by the list. Plants may exist in an area without ever having been detected there. You can find out what's in the surrounding quads through the California Native Plant Society's online Inventory of Rare and Endangered Plants.

Surveying

Some of the species on your list may not be affected by your project. A trained biologist and/or botanist, familiar with the habitat requirements of the species on your list, should determine whether they or habitats suitable for them may be affected by your project. We recommend that your surveys include any proposed and candidate species on your list. See our Protocol and Recovery Permits pages.

For plant surveys, we recommend using the Guidelines for Conducting and Reporting Botanical Inventories. The results of your surveys should be published in any environmental documents prepared for your project.

Your Responsibilities Under the Endangered Species Act

All animals identified as listed above are fully protected under the Endangered Species Act of 1973, as amended. Section 9 of the Act and its implementing regulations prohibit the take of a federally listed wildlife species. Take is defined by the Act as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any such animal.

> Take may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or shelter (50 CFR §17.3).

Take incidental to an otherwise lawful activity may be authorized by one of two procedures:

- If a Federal agency is involved with the permitting, funding, or carrying out of a project that may result in take, then that agency must engage in a formal consultation with the Service.

  During formal consultation, the Federal agency, the applicant and the Service work together to avoid or minimize the impact on listed species and their habitat. Such consultation would result in a biological opinion by the Service addressing the anticipated effect of the project on listed and proposed species. The opinion may authorize a limited level of incidental take.

- If no Federal agency is involved with the project, and federally listed species may be taken as part of the project, then you, the applicant, should apply for an incidental take permit. The Service may issue such a permit if you submit a satisfactory conservation plan for the species that would be affected by your project.

Should your survey determine that federally listed or proposed species occur in the area and are likely to be affected by the project, we recommend that you work with this office and the California Department of Fish and Game to develop a plan that minimizes the project's direct and indirect impacts to listed species and compensates for project-related loss of habitat. You should include the plan in any environmental documents you file.

Critical Habitat

When a species is listed as endangered or threatened, areas of habitat considered essential to its conservation may be designated as critical habitat. These areas may require special management considerations or protection. They provide needed space for growth and normal behavior; food, water, air, light, other nutritional or physiological requirements; cover or shelter; and sites for breeding, reproduction, rearing of offspring, germination or seed dispersal.

Although critical habitat may be designated on private or State lands, activities on these lands are not restricted unless there is Federal involvement in the activities or direct harm to listed wildlife.

If any species has proposed or designated critical habitat within a quad, there will be a separate line for this on the species list. Boundary descriptions of the critical habitat may be found in the Federal Register. The information is also reprinted in the Code of Federal Regulations (50 CFR 17.95). See our Map Room page.

Candidate Species

We recommend that you address impacts to candidate species. We put plants and animals on our candidate list when we have enough scientific information to eventually propose them for listing as threatened or endangered. By considering these species early in your planning process you may be able to avoid the problems that could develop if one of these candidates was listed before the end of your project.

Species of Concern

The Sacramento Fish & Wildlife Office no longer maintains a list of species of concern. However, various other agencies and organizations maintain lists of at-risk species. These lists provide essential information for land management planning and conservation efforts. More info

Wetlands

If your project will impact wetlands, riparian habitat, or other jurisdictional waters as defined by section 404 of the Clean Water Act and/or section 10 of the Rivers and Harbors Act, you will need to obtain a permit from the U.S. Army Corps of Engineers. Impacts to wetland habitats require site specific mitigation and monitoring. For questions regarding wetlands, please contact Mark Littlefield of this office at (916) 414-6520.

Updates

Our database is constantly updated as species are proposed, listed and delisted. If you address proposed and candidate species in your planning, this should not be a problem. However, we recommend that you get an updated list every 90 days. That would be May 14, 2013.

D5. Draft Mitigation and Monitoring Proposal

Sutter Basin Pilot Feasibility Study
Draft Mitigation and Monitoring Plan

DRAFT

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May 2013

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ICF International. 2013. Sutter Basin Pilot Feasibility Study Draft Mitigation and Monitoring Plan. (ICF 00165.12.) Sacramento, CA. Prepared for U.S. Army Corps of Engineers, Sacramento, CA.

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List of Abbreviated Terms

AEP	annual exceedance probability
BSSCP	bentonite slurry spill contingency plan
CAPP	Conceptual Area Protection Plans
CDFW	California Department of Fish and Wildlife
CH	fat clay
CL	lean clay
CLSM	controlled low strength material
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CWA	Clean Water Act
DBH	diameter at breast height
DSM	deep soil mixing
DWR	Department of Water Resources
EIR	environmental impact report
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESAs	Environmentally Sensitive Areas
feasibility study	Sutter Basin Pilot Feasibility Study
FR	Federal Register
FRWLP	Feather River West Levee Project
GGS	giant garter snake
GPS	global positioning system
ICF	ICF International
LAE	Land Acquisition Evaluations
LD1	Levee District 1
LL	Liquid Limit
ML	silt
MMP	mitigation and monitoring proposal
MOU	Memorandum of Understanding
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OHWM	ordinary high water mark
PI	Plasticity Index

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RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SBFCA	Sutter Butte Flood Control Agency
SC	clayey sand
SM	silty sand
SPCCP	spill prevention, control, and counter-measure plan
SR	State Route
SWPPP	stormwater pollution prevention plan
TSP	Tentative Selected Plan
UPRR	Union Pacific Railroad
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VELB	valley elderberry longhorn beetle

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Chapter 1
Responsible Parties

This document describes the mitigation and monitoring plan (MMP) for effects associated with implementation of the Sutter Basin Pilot Feasibility Study (feasibility study). Implementation of flood risk reduction projects outlined in the feasibility study will create permanent and unavoidable impacts to habitats and species that require mitigation. This document identifies responsible parties for the mitigation project, describes the location and nature of the project, and discusses the types, functions, and values of United States. Army Corps of Engineers (USACE) jurisdictional wetlands and other waters of the United States.

In addition to the mitigation plan for impacted Section 404 jurisdictional features, this MMP also includes impacts and mitigation for riparian and non-riparian native trees, and special status species habitat for valley elderberry longhorn beetle (VELB) and permanent impacts to giant garter snake (GGS), for which compensatory mitigation is required.

Compensatory mitigation for riparian forest, non-riparian native trees and VELB will occur at the Star Bend Conservation Area and the TRLIA Feather River Floodway Corridor Restoration Site, both located on the Feather River. Mitigation for GGS and Section 404 jurisdictional features will occur at off-site private banking lands.

1.1 Mitigation Planning Guidance

As part of the feasibility study, a MMP was developed based on the following USACE and State guidance and the recommendations of the USFWS and other resource agencies.

1.1.1 USACE Mitigation Planning Guidance

In accordance with Council on Environmental Quality (CEQ) Regulations for Implementing NEPA (40 CFR 1500-1508), and with Appendix C, paragraph C-3 of ER 1105-2-100, "Policy and Planning Guidance for Conducting Civil Works Planning Studies (Planning Guidance Notebook)", the planning of USACE projects must ensure that project-related adverse environmental impacts (i.e., impacts to fish and wildlife resources) have been avoided or minimized to the extent practicable, and that remaining unavoidable significant adverse impacts are compensated to the extent justified. Corps regulations stipulate that the Recommended Plan must contain sufficient mitigation measures to ensure that the plan selected will have no more than negligible net adverse impacts on fish and wildlife resources. Furthermore, a Cost Effectiveness Incremental Cost Analysis must be performed to identify the most cost-effective mitigation plan.

Under WRDA 2007, Section 2036(a) , the Corps must fully develop a mitigation plan that includes the following: 1) monitoring until successful, 2) criteria for determining ecological success, 3) a description of available lands for mitigation and the basis for the determination of availability, 4) the development of contingency plans (i.e., adaptive management), 5) identification of the entity responsible for monitoring; and 6) establishing a consultation process with appropriate Federal and State agencies in determining the success of mitigation.

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1.1.2 California Department of Fish and Wildlife Compliance

This document follows the format and contains the elements described in USACE report *Mitigation and Monitoring Proposal Guidelines, December 30, 2004* (USACE 2004). Because this report also includes mitigation for non-Section 404 jurisdictional features and will utilize land at the Star Bend Conservation Area, the document also complies with the California Department of Fish and Wildlife's (CDFW) own guidelines outlined in *Policy for Mitigation on Publicly Owned, Department Owned, and Conserved Lands* (CDFW 2012). The policy statement contained within the CDFW's report states:

> *Mitigation for impacts to fish and wildlife resources may occur on publicly owned, Department owned, and conserved lands if it has been determined by the Department that: 1) the mitigation is consistent with requirements of the law under which the mitigation is being sought; 2) its relative value as mitigation is equal to or greater than it would be if the same mitigation were situated on non-public or non-conserved lands; 3) it results in a clear and quantifiable improvement or positive change above that currently present or reasonably expected to exist under current conditions on the site; 4) the future uses of the land, including encumbrances or easements, will not preclude or diminish the mitigation; 5) the mitigation will not preclude, diminish or interfere with the funding or purpose of acquisition, encumbrances, or management plan for the property; and 6) it will not result in a net loss of existing conservation values.*

CDFW Guidelines for Implementing Mitigation on Department Owned or Conserved Lands

The following guidelines are addressed throughout the MMP below. Items 1 through 4 have been fully addressed in this MMP. Item 5 is addressed in the project's incremental cost analysis. The Memorandum of Understanding described in item 6 below is still a work in progress and will be finalized before the MMP is complete.

1. Mitigation is consistent with the current and future uses of the land including any encumbrances, easements or public use values.
    a. To find information on encumbrances, easements or public use values the following documents should be checked:
        i. Management plan for the property
        ii. Any Conceptual Area Protection Plans (CAPP) or Land Acquisition Evaluations (LAE) written for the property
        iii. Easements can be found on the California Natural Resources Agency website and at the County Recorders office. The Lands Program should also be checked.
        iv. Title search – this should be performed by the entity proposing the mitigation
        v. Site visits should be performed
2. Mitigation is consistent with the purpose for which the land was acquired and the funding source used for acquisition.

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3. Mitigation will not preclude, diminish or interfere with encumbrances, or the management plan for the property.
4. Mitigation maintains and or enhances the current ecological and public use values of the land.
    a. Entity proposing the mitigation needs to provide documentation of how placing the mitigation on the land is going to maintain or enhance the ecological and public use values of the land.
5. The full cost of the mitigation is accounted for (this includes but is not limited to all capital improvements, restoration, enhancement, monitoring, long term management and maintenance and reimbursement for any Department staff time including enforcement, on all lands).
6. A Memorandum of Understanding (MOU) is in place prior to the project sponsors undertaking the project. The MOU will be developed in cooperation with the land manager, reviewed for statewide consistency by the Department's Lands Program in the Wildlife Branch and signed by the District Assistant Chief and the Department Regional Manager, the land management agency or non-profit (if other than the Department), and the project sponsor. The MOU will define the mitigation purpose, permit requirements, agreement term, scope of work, schedule, management and/or maintenance requirements, monitoring, and responsibilities of the parties to the agreement.

1.2 Lead Agency

USACE is the lead agency and implementing agency for the feasibility study. USACE is preparing the Environmental Impact Statement (EIS) for the purposes of compliance with the National Environmental Policy Act (NEPA). USACE is also completing Section 7 Endangered Species Act consultation with the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) for the project. USACE is the lead Federal agency with financial responsibility for implementing the MMP and satisfying the success criteria.

The project proponent is:

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Chapter 2
Project Requiring Mitigation

2.1 Project Location

North to south, the feasibility study area is located in the 41-mile corridor along the west levee of the Feather River that begins at the Thermalito Afterbay and ends approximately 4 miles north of the Sutter Bypass (Figure 1). The project area consists of the project construction footprint plus a 100-foot-wide buffer zone. The feasibility project construction area was defined as the area in which levee improvements—such as seepage berms, stability berms, relief wells, and slurry cutoff walls—are likely to be constructed. All direct and indirect effects would occur within the project area.

The feasibility study area corridor is divided into 41 relatively reaches for ease of describing existing conditions, project components, land cover types, and potential effects (note that this number is coincidental and one reach does not correspond to a length of 1 mile). The levee stations, lengths, landmarks, and dominant land uses for the reaches are listed in Table 2-1. Table 2-1

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Table 2-1. Summary of Reaches in the Feasibility Study Area

Reach	Beginning Station	Ending Station	Length (feet)	Landmark(s)	Dominant Land Uses
1	189+00	202+50	2,250	Laurel Avenue	
2	202+50	218+66	1,616		Ruderal grassland; open space
3	218+66	300+66	8,200	Cypress Avenue	Ruderal grassland; open space
4	300+66	410+67	11,001	Central Street; Wilkie Avenue	Orchard; ruderal grassland; riparian forest
5	410+67	478+68	6,801	Wilkie Avenue	Orchard
6	478+68	510+37	3,169	Star Bend	Orchard
7	510+37	596+00	8,563	Abbott Lake	Ruderal grassland; open space
8	596+00	654+75	5,875		Ruderal grassland; open space
9	654+75	706+50	5,175	Boyd's Boat Launch; Nursery	Ruderal grassland; open space
10	706+50	774+00	6,750	Barry Road	Ruderal grassland; open space
11	774+00	830+00	5,600		Ruderal grassland; open space
12	830+00	845+00	1,500	Shanghai Bend	Ruderal grassland; open space
13	845+00	927+00	8,200		Ruderal grassland; open space
14	927+00	954+40	2,740	Airport	Ruderal grassland; open space
15	954+40	968+50	1,410	Airport	Developed; ruderal grassland
16	968+50	1080+00	11,150	Garden Highway, 2nd Street; Twin Cities Memorial Bridge; Colusa Avenue	Developed; ruderal grassland
17	1080+00	1130+86	5,086	Live Oak Boulevard; Union Pacific Railroad	Developed; ruderal grassland
18	1130+86	1213+85	8,299	Live Oak Boulevard; Union Pacific Railroad; Rednall Road	Orchard
19	1213+85	1297+83	8,398		Orchard
20	1297+83	1374+33	7,650		Orchard; ruderal grassland
21	1374+33	1433+83	5,950		Ruderal grassland
22	1433+83	1503+83	7,000		Riparian forest; ruderal grassland
23	1503+83	1609+37	10,554		Orchard
24	1609+37	1623+86	1,449		Riparian forest; ruderal grassland
25	1623+86	1674+37	5,051		Orchard; ruderal grassland
26	1674+37	1707+11	3,274		Orchard
27	1707+11	1721+60	1,449		Ruderal grassland
28	1721+60	1769+31	4,771		Orchard
29	1769+31	1813+33	4,402		Orchard; riparian forest
30	1813+33	1902+00	8,867		Orchard
31	1902+00	1958+00	5,600		Orchard; ruderal grassland
32	1958+00	1989+00	3,100		Orchard
33	1989+00	2122+00	13,300		Orchard
34	2122+00	2182+00	6,000		Orchard
35	2182+00	2224+00	4,200		Orchard; ruderal grassland
36	2224+00	2259+00	3,500		Orchard; ruderal grassland
37	2259+00	2290+00	3,100		Orchard; ruderal grassland
38	2290+00	2303+00	1,300		Ruderal grassland
39	2303+00	2319+00	1,600		Ruderal grassland
40	2319+00	2359+00	4,000		Ruderal grassland
41	2359+00	2368+00	900	Thermalito Afterbay	Ruderal grassland

Note: Certain planning and engineering studies for the feasibility study area make reference to segments within the planning area under which the reaches above are grouped. These segment designations do not have substantial bearing on the alternatives descriptions, environmental setting, or determination of effects and thus for simplicity are not used in this document.

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The new study paradigm recognizes that no single factor, including net national economic development benefit, should provide the basis for the USACE decision for a recommendation for Federal investment. Alternative comparison and selection recognizes that there is no single "best" plan, and there are a variety of approaches (quantitative and qualitative) to multi-criteria decision making.

2.1.1 Project Purpose and Need

The purpose of the Sutter Basin Pilot Feasibility Study is to investigate and determine the extent of Federal interest in plans that reduce flood risk to the Sutter Basin in Sutter and Butte Counties. This report: (1) assesses the risk of flooding; (2) describes a range of alternatives formulated to reduce flood risk; and (3) identifies a tentatively selected plan (TSP) for implementation. This report constitutes both a draft Feasibility Report that describes a USACE "pilot" planning process followed to identify the TSP, and an Environmental Impact Statement/Environmental Impact Report (EIS/EIR) required to comply with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). Following public and governmental agency review, this draft report will be finalized and submitted to Headquarters, USACE, for review and approval, then transmitted to Congress for recommended project authorization. Project construction would also be dependent upon Congressional appropriation of funding for the Federal share of the project.

A high risk of flooding from levee failure threatens the public safety of approximately 95,000 people, as well as property and critical infrastructure throughout the Sutter Basin study area. Past flooding events have caused loss of life and extensive economic damages. Recent geotechnical analysis and evaluation of past levee performance indicate the existing project levees, which are part of the authorized Sacramento River Flood Control Project, do not meet current U.S. Army Corps of Engineers (USACE) levee design criteria, and are at risk of breach failure at stages less than overtopping of the levees, as has been shown to be true of many of the existing levees within California's Central Valley.

2.1.2 Federal Objectives

In the Flood Control Act of 1970, Congress identified four equal national objectives for use in water resources development planning. These objectives are national economic development (NED), regional economic development (RED), environmental equality (EQ), and social well being (other social effects or OSE). These four categories are known as the System of Accounts, whereby each proposed plan can be easily compared with the no-action plan and other alternatives. The Federal objective identified in the P&G is:

> "The Federal objective of water and related land resources planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statues, applicable executive orders, and other Federal planning requirements."

In Section 2031 of Water Resources Development Act of 2007, Congress instructed the Secretary of the Army to develop a new P&G for USACE (Public Law 110-114). As a result, the P&G is being revised to include a number of important changes. These changes are expressed in the following proposed new Federal objectives statement:

> "The national objective of water and related land resources planning is to foster environmentally sound, efficient use of the Nation's resources consistent with public safety. This can be accomplished through watershed analyses that recognize the interdependency of water uses. This is strengthened by capitalizing on a collaborative planning and implementation process which incorporates fully

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> informed participation from Federal agencies, non-Federal interests, non-governmental organizations, State and local and Tribal governments, and a full range of water users and stakeholders."
>
> "Water and related land resources planning that is consistent with the national planning objective seeks to incorporate some or all of these elements: facilitate sustainable national economic development, encourage wise use of water and related land resources – including flood plains, and flood-prone coastal areas, support the protection and restoration of significant aquatic ecosystems, promote the integration and improvement of how the Nation's water resources are managed; and reduce vulnerabilities and losses due to natural disasters."

The Federal objective is not specific enough for the development of a water resource project. The formulation of alternative plans requires the identification of study-specific planning objectives.

2.1.3 Non-Federal Objectives

The State of California, recognizing the continuing risk of flooding within the Central Valley, has enacted the Central Valley Flood Protection Act (CVFPA) and related legislation that establishes in California law the objective of providing 200-year (1/200 or 0.5% annual exceedance probability) protection to urban and urbanizing areas. Additionally, the CVFPA requires an immediate analysis of the condition of the system levees, an action plan for achieving the desired level of protection, and associated actions to reduce residual risks to development within the protected area.

In addition to complying with the state requirement, the non-Federal sponsors seek to reduce residual risk to the rural south portion of the Sutter Basin for sustainable high-value agricultural operations.

2.1.4 Planning Objectives

Planning objectives for the SBPFS are more specific than the Federal and non-Federal objectives and reflect the problems and opportunities in the study area; an objective is developed to address each of the identified problems and opportunities. Planning objectives represent desired positive changes to the future without-project conditions. All of the objectives focus on activity within the study area and within the 50-year period of analysis.

The planning objectives are:

- Reduce the risk to life, health, public safety and critical infrastructure due to flooding.
- Reduce the risk of property damage due to flooding.
- In conjunction with FRM, improve ecosystem functions and values.
- In conjunction with FRM, improve the public's access to and use of outdoor recreational opportunities in the study area.

As discussed above, it is anticipated the construction of the project would be divided into six separate construction contracts (i.e., A, B, C-1, C-2, D-1 and D-2). Although subject to change, the most current information for the six contracts and their respective areas is provided in Table 2-2.

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Table 2-2. Feasibility Study Proposed Construction by Contract, Reach, and Year of Construction

Contract	A	*Star Bend	B	C1	C2	D1	D2
Corresponding Reach	2–5	6	7–12	13–18	19–25	26–33	34–41
Proposed Year of Construction	2018–2019	2018–2019	2017–2018	2013–2014	2014–2015	2015–2016	2016–2017

* Included as part of Contract A analysis.

2.1.5 Project Description

The two construction alternatives analyzed in detail through the NEPA process would each accomplish the identified project purpose. However, they would accomplish the project purpose to varying extents, with varying levels of benefits and varying adverse impacts to the aquatic ecosystem.

The following is a summary of project elements for each alternative. In general, Alternative SB-8 entails the greatest amount of levee improvement work and SB-7 the least amount. These alternatives are described in greater detail in Chapter 3 of the integrated report and EIS/EIR.

Alternative SB-8 includes:

41 reaches (2A-North to 41) along the FRWL alignment, beginning at station 180+00 (approximately 2,500 feet south of Laurel Avenue) and ending at station 2368+00 (Thermalito Afterbay). The proposed project features and measures for this alternative include:

- Soil-Bentonite Cutoff Walls
- Deep Soil Mix Cutoff Walls
- Jet Grouting Cutoff Walls
- Seepage Berms
- Levee Relocations
- Canal Relocations
- Embankment Reconstruction/Landside Toe Fill
- Erosion Protections
- Closure Structure
- Utility Improvements
- Utility Relocations
- Structural Relocations

These proposed features and measures will rehabilitate, replace, or tie in and function in junction with the existing system. The existing system includes the following features:

- Existing Embankment
- Existing Cutoff Walls

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- Existing Stability Berms
- Existing Relief Wells
- Existing Closure Structures
- Existing Toe Drains

Table 2-3 identifies the construction activities that would occur with each reach.

Table 2-3. SBFS Flood Management Measures by Reach

Reach	Length (feet)	Proposed Action Flood Management Measure
2A	2,250	180+00 to 202+50, 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 180+00 to 202+50, Cutoff wall extending to an elevation of 25 ft.
2B	1,616	202+50 to 218+66, cutoff wall extending to an elevation of 25' with 100'-wide undrained seepage berm. Seepage berm 5' thick at berm toe.
3	8,200	218+66 to 230+00, cutoff wall extending to an elevation of 25' with 100'-wide undrained seepage berm. Seepage berm 5' thick at berm toe. 230+00 to 250+00, cutoff wall tip elevation (-)35'. 250+00 to 289+00, cutoff wall tip elevation (-)20'. 289+00 to 300+66, cutoff wall tip elevation (-)12'.
4	11,001	300+66 to 312+00 cutoff wall tip elevation 15'. 312+00 to 349+00 cutoff wall tip elevation 15'. 349+00 to 368+00 cutoff wall tip elevation 10'. 368+00 to 410+67 cutoff wall tip elevation 20'.
5	6,801	410+67 to 417+00, cutoff wall tip elevation 20'. 417+00 to 425+00, cutoff wall tip elevation 10'. 425+00 to 456+00, cutoff wall tip elevation 15'. 456+00 to 475+35, cutoff wall tip elevation 15' with 300' wide undrained seepage berm. Seepage berm 5' thick at berm toe. 475+35 to 478+68 cutoff wall tip elevation 15'.
6	3,169	478+68 to 510+00, No Proposed Flood Management Measures 510+00 to 510+50, potential pipe crossing work to install positive closure device and correct pipe size.
7	8,563	510+37 to 512+00, no flood management required. 512+00 to 514+00, cutoff wall 514+00 to 526+00, cutoff wall tip elevation 15'. 526+00 to 570+00, cutoff wall tip elevation (-)5'. 545+00 to 570+00, relief wells with 60' spacing and 50' depth over one half of the length, distributed at various locations over this stretch of levee. 570+00 to 575+00, cutoff wall tip elevation 5'. 575+00 to 595+00, cutoff wall tip elevation (-)10'. 595+00 to 596+00, cutoff wall tip elevation 15'.

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Reach	Length (feet)	Proposed Action Flood Management Measure
8	5,875	596+00 to 654+75, cutoff wall tip elevation 15'.
9	5,175	654+75 to 670+00, cutoff wall tip elevation 15'. 670+00 to 697+00, cutoff wall tip elevation 20'. 697+00 to 706+50: cutoff wall tip elevation 10'.
10	6,750	706+50 to 726+00, cutoff wall tip elevation (-)10'. 726+00 to 746+00, cutoff wall tip elevation (-)5'. 746+00 to 754+50, cutoff wall tip elevation 5'. 754+50 to 774+00, cutoff wall tip elevation 25'
11	5,600	774+00 to 784+50, cutoff wall tip elevation 25'. 784+50 to 827+50, cutoff wall tip elevation 5'. 827+50 to 830+00, cutoff wall tip elevation 25'
12	1,500	832+30, relocate two 24-inch sewer pipes.
13	8,200	844+50 to 923+75: cutoff wall tip elevation (-)38'. Full levee degrade from 844+50 to 897+50.
14	2,740	952+00 investigation of 12 kV cable to determine if it meets Title 23 requirements.
15	1,410	No flood management measures required.
16	11,150	Closure of gap in cutoff wall at 5th Street bridge crossing around Station 1007+00, cutoff wall tip elevation 40'. Closure of gap in cutoff wall at 10th Street bridge crossing around Station 1026+00, by using a seepage berm within the abandoned railroad tunnel. 1077+85 to 1080+00, cutoff wall tip elevation 30' and backfill landside toe depression. Miscellaneous landside encroachment relocations/removals.
17	5,086	1080+00 to 1089+00, cutoff wall tip elevation 30' and backfill landside toe depression. 1089+00 to 1125+00, cutoff wall tip elevation 35' and backfill landside toe depression. 1125+00 to 1130+86, cutoff wall tip elevation 0'.
18	8,299	1130+86 to 1151+50, cutoff wall tip elevation 0'. 1151+50 to 1159+50: cutoff wall tip elevation 30'. 1159+50 to 1169+50: cutoff wall tip elevation 25'. 1169+50 to 1189+50: cutoff wall tip elevation 30'. 1189+50 to 1209+50: cutoff wall tip elevation 40'. 1209+50 to 1213+85: cutoff wall tip elevation 35'.
19	8,398	1213+85 to 1219+75, cutoff wall tip elevation 35'. 1219+75 to 1224+00, cutoff wall tip elevation 5'. 1224+00 to 1238+00, cutoff wall tip elevation (-)28'. 1238+00 to 1248+00, cutoff wall tip elevation (-)42'. 1248+00 to 1268+75, cutoff wall tip elevation 3'. 1268+75 to 1297+83, cutoff wall tip elevation 35'.

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Reach	Length (feet)	Proposed Action Flood Management Measure
20	7,650	1297+83 to 1298+75, cutoff wall tip elevation 35'. 1298+75 to 1359+00, cutoff wall tip elevation 50'. 1359+00 to 1369+00: cutoff wall tip elevation 40'. 1369+00 to 1374+33: cutoff wall tip elevation 32'.
21	5,950	1374+33 to 1386+00 cutoff wall tip elevation 32'. 1386+00 to 1408+00: cutoff wall tip elevation 55'. 1408+00 to 1432+50: cutoff wall tip elevation 40'. 1432+50 to 1433+83: Levee relocation (20 ft riverward, transition only) 1429+00 to 1433+83 Sutter Butte Main Canal relocation.
22	7,000	1433+83 to 1450+00: Levee relocation (20ft riverward) 1451+50 to 1451+50: Levee relocation (20ft riverward, transition only) 1451+50 to 1468+83, cutoff wall tip elevation 50'. 1455+00 to 1461+00, full levee degrade and reconstruction. 1468+83 to 1503+83, cutoff wall tip elevation 55'.
23	10,554	1503+83 to 1508+50, cutoff wall tip elevation 55'. 1508+50 to 1528+75, cutoff wall tip elevation 60'. 1528+75 to 1566+50, cutoff wall tip elevation 55'. 1566+50 to 1608+75, cutoff wall tip elevation 60'. 1608+50 to 1609+37: Levee relocation (20ft riverward, transition only)
24	1,449	1609+37 to 1612+00: Levee relocation (20ft riverward, transition only) 1612+00 to 1623+00: Levee relocation (20ft riverward) 1623+00 to 1623+86: Levee relocation (20ft riverward, transition only)
25	5,051	1623+86 to 1624+50: Levee relocation (20ft riverward, transition only) 1673+00 to 1674+37: Levee relocation (20ft riverward, transition only) 1639+00, replace two 24-inch steel storm drain pipes.
26	3,274	1674+37 to 1675+00: Levee relocation (20ft riverward, transition only) 1675+00 to 1707+11: Levee relocation (20ft riverward) Reconstruction of landside slope extends down to elevation of bottom of canal.
27	1,449	1707+11 to 1721+60: Levee relocation (20ft riverward)
28	4,771	1721+60 to 1753+00: Levee relocation (20ft riverward) 1753+00 to 1754+50: Levee relocation (20ft riverward, transition only) 1752+00 to 1766+00: Sutter Butte Main Canal Relocation 1766+00 to 1769+31, cutoff wall tip elevation 45'.
29	4,402	1770+00, 1785+24, 1785+55, 1792+96, 1799+44, 1809+65, storm drain and irrigation pipe replacements.
30	8,867	1813+33 to 1816+50, cutoff wall tip elevation 80', with full levee degrade and reconstruction. 1816+50 to 1848+25, cutoff wall tip elevation 30'. 1848+25 to 1866+00, cutoff wall tip elevation 70'. 1866+00 to 1877+75, cutoff wall tip elevation 47'. 1877+75 to 1883+00, cutoff wall tip elevation 40'. 1883+00 to 1902+00, cutoff wall tip elevation 27'.

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Reach	Length (feet)	Proposed Action Flood Management Measure
31	5,600	1902+00 to 1907+50, cutoff wall tip elevation 27'. 1907+50 to 1917+50, cutoff wall tip elevation 44'. 1907+92 to 1909+42, waterside slope flattening or other remedial measure. 1917+50 to 1927+50, cutoff wall tip elevation 75'. 1927+50 to 1937+00, cutoff wall tip elevation 50'. 1937+00 to 1958+00, cutoff wall tip elevation 40'.
32	3,100	1958+00 to 1971+80, cutoff wall tip elevation 40'. 1971+80 to 1987+25, cutoff wall tip elevation 48'. 1987+25 to 1989+00, cutoff wall tip elevation 10'.
33	13,300	1989+00 to 2002+00, cutoff wall tip elevation 10'. 2002+00 to 2016+75, cutoff wall tip elevation 90'. 2016+75 to 2036+75, cutoff wall tip elevation 20'. 2036+75 to 2041+00, cutoff wall tip elevation 53'. 2041+00 to 2067+00, cutoff wall tip elevation 38'. 2067+00 to 2088+00, cutoff wall tip elevation 33'. 2088+00 to 2122+00, cutoff wall tip elevation 90'.
34	6,000	2122+00 to 2137+00, cutoff wall tip elevation 90'. 2137+00 to 2148+00, cutoff wall tip elevation 20'. 2148+00 to 2164+00, cutoff wall tip elevation 90'. 2164+00 to 2182+00, cutoff wall tip elevation 50'.
35	4,200	2182+00 to 2196+50, cutoff wall tip elevation 40'. 2196+50 to 2212+00, cutoff wall tip elevation 45'. 2212+00 to 2218+25, cutoff wall tip elevation 50'. 2218+25 to 2224+00, cutoff wall tip elevation 55'.
36	3,500	2224+00 to 2233+50, cutoff wall tip elevation 55'. 2233+50 to 2245+75, cutoff wall tip elevation 70'. 2245+75 to 2259+00, cutoff wall tip elevation 42'.
37	3,100	2259+00 to 2277+00, cutoff wall tip elevation 42'. 2277+00 to 2290+00, cutoff wall tip elevation 45'.
38	1,300	2290+00 to 2292+00 cutoff wall to elevation +45'. 2290+00 to 2303+00 construct 11' high seepage berm, 50' wide at the top and 170' wide from levee centerline.
39	1,600	2312+10, remove 24" storm drain pipe.
40	4,000	2331+00 to 2335+00, construct 120'-wide seepage berm. 2335+00 to 2359+00, 100'-wide seepage berm. Berms are 9' thick at the levee toe and 3' thick at the berm toe.
41	900	2359+00 to 2368+00, construct 100'-wide seepage berm with 1'-thick drain layer. 2360+00; fill waterside pit (up to elevation 130').

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Encroachments

Existing facilities found within the footprint of an alternative may require removal and replacement nearby, abandonment, or relocation. Encroachments are numerous (over 400 identified) along the Feather River West Levee and may need to be addressed if they present a threat to the stability of the levee, do not currently comply with the levee encroachment criteria, or would be disrupted or otherwise impacted by construction activities. Typical encroachments include pressure pipelines (water supply pipelines from waterside pump stations and drainage pipelines from landside drainage pump stations), gravity drainage pipes, gas lines, telephone utilities, overhead utilities, structural encroachments, and other types and variations. Debris from structure and embankment fill material of poor quality would be hauled offsite to a permitted disposal site within 20 miles of the removal location.

Vegetation Removal

Bulldozers would be used to remove woody and herbaceous vegetation from the direct construction footprint and the minimum areas needed for project staging and access routes. Any vegetation removed as part of direct construction activities would not be replaced at that location and would require offsite, in-kind mitigation, to be determined in consultation with the appropriate resource agencies.

More extensive root removal may be required, depending upon the location, size, and type of tree; the quantity, orientation, and size of the roots; the dimensions of the levee (or floodwall); the composition of the levee and foundation; and the levee features that address seepage and underseepage. Less extensive root removal may be justified where roots from adjacent trees would be unduly damaged. Any excavation resulting from the above actions would be backfilled with engineered fill using appropriate placement, moisture conditioning, and compaction methods. Additional measures for removing non-compliant vegetation are listed below.

- Ensure that the resulting void is free of organic debris.
- Cut poles to salvage propagation materials for replanting, such as willows and cottonwoods.
- Conduct hand clearing using chainsaws and trimmers.
- Conduct mass clearing using bulldozers.

Debris from vegetation removal would be hauled offsite to a permitted disposal site within 20 miles of the removal location.

Construction Staging, Access, and Temporary Facilities

The contractor would be responsible for obtaining all required local, state, and Federal permits for any staging areas outside of these limits. Staging areas would be used for equipment staging, storage of equipment and materials, mobile project offices, construction staff parking, etc.

To facilitate project construction, temporary earthen ramps would be constructed for equipment access between the levee crown and the staging area(s). The earthen ramps would be removed when construction is complete.

Cutoff wall construction requires temporary establishment of an onsite slurry batch plant that would occupy approximately 1–2 acres. Batch plants would be located at approximately 1-mile

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intervals within the project footprint. The batch plant site would likely contain tanks for water storage, bulk bag supplies of bentonite, bentonite storage silos, a cyclone mixer, pumps, and two generators that meet air quality requirements. The site would also accommodate slurry tanks to store the blended slurries temporarily until they are pumped to the work sites. Slurry ingredients would be mixed with water at the batch plant and the mixture would be pumped from the tanks through pipes to the cutoff wall construction work sites. The batch plant would produce two different slurry mixes, one for trench stabilization and one for the soil backfill mix. Therefore, two slurry pipes or hoses, typically 4- or 6-inch high-density polyethelene pipes, would be laid on the ground and would extend to all work sites. An additional pipe may be used to supply water to the work sites.

Staging areas, access routes, and other temporary construction areas would be located away from wetlands, riparian habitat, oak woodlands, special-status wildlife habitat, known cultural resources, or other sensitive areas and would be limited to disturbed or ruderal grasslands subject to review by USACE and Federal and state resource agencies.

Material Importation, Reuse, and Borrow

Materials imported to the project site would include water, bentonite, cement, incidental construction support materials, aggregate base rock, asphalt, concrete, hydroseed, and embankment fill soil. Each alternative would require the use of large quantities of fill soil, or borrow. To meet borrow demands, embankment fill material excavated as part of construction would be evaluated for reuse. Embankment fill material deemed suitable would be used as part of levee reconstruction and berms.

Borrow Volume

The total volume of material required is 1,619,250 cubic yards. The quantities were calculated assuming a 20% shrinkage factor between excavation at the borrow site and placement at the levee. Only material suitable for placement in levee construction may be borrowed (HDR et al. 2012). These materials are identified as low to medium plasticity soils classified in accordance with American Society for Testing and Materials D 2487 as silty sand (SM) and clayey sand (SC), silt (ML), or clay (lean clay [CL] or fat clay [CH]). The materials should have a Liquid Limit (LL) less than or equal to 45 (may be extended up to 55 with justification and approval from USACE and the CVFPB), a Plasticity Index (PI) greater than or equal to 12 and less than 40, and a fines content greater than or equal to 30%. The material should be free from visible organics and be no greater than 2 inches in any dimension.

Borrow Site Selection Factors

The first choice for fill or borrow material would be from a local commercial quarry or other permitted source. In the event that material is desired from a source that is not presently permitted, for reasons such as quality, proximity, or volume available, soil supply protection measures would be implemented. One such measure would be maximizing on-site use through gradation, placement, and treatment. Another measure would be the preservation and replacements of topsoil at borrow sites, so that they could be continued to be used for their current use or otherwise returned to their pre-project condition. As part of borrow operations, the upper 12 inches of topsoil would be set aside and replaced after project construction in each construction season. After the project is

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completed, the borrow site would be re-contoured and reclaimed. An additional measure would be independent environmental documentation and regulatory compliance, as required.

Factors determining borrow sources and sites are (followed by a description of each factor and discussion of potential borrow sources).

- Hauling distance and haul route
- Depth to groundwater
- Royalty fees
- Post-construction land use
- Environmental factors

Hauling Distance and Routes. The cost for borrow site excavation and hauling is directly related to the distance required to haul the material and the route by which the materials must be transported. To the extent possible, sites should be selected that minimize haul route length and the use of public roadways (Wood Rodgers 2011).

Depth to Groundwater. Because the top layer of a borrow site must be removed and stockpiled to exclude organics from the borrow material, it is economical to maximize the depth of the excavation. This maximum depth is typically governed by the normal seasonal depth of groundwater. Once excavation extends to within a few feet of the groundwater table, additional expense is incurred to implement dewatering at the site. Groundwater elevations generally fluctuate throughout the year and can be influenced by standing water or irrigation activities on adjacent lands. Typically, groundwater depths are higher at the beginning of spring, and become deeper toward the end of summer (Wood Rodgers 2011).

Royalty Fees. Royalty fees for material excavated directly affect the cost of the borrow and also typically trigger more substantial permitting requirements. It is desirable to find a property owner who wishes to have excavation carried out for his own purposes, such as creating a detention basin to support future development, so that royalty fees and a SMARA permit are avoided (Wood Rodgers 2011).

Post-Construction Land Use. The post-construction use of the property can also effect the depth of excavation. Borrow sites must be free draining after the material is excavated, and therefore cannot be extended deeper than the offsite drainage facilities can accommodate (Wood Rodgers 2011).

Environmental Factors. Environmental factors, including the need for mitigation for special-status species and wetlands encroachments, are also a factor in selecting borrow sites. Consideration should also be given to haul routes when evaluating environmental effects. Routes which could be unavailable during the early months of the construction season due to the presence of nesting raptors should be avoided (Wood Rodgers 2011). If waterside borrow sites outside the construction footprint are needed, only sites that do not impact woody vegetation associated with fish-inhabited waters should be considered. All sites will be surveyed for potential wildlife habitat, jurisdictional waters, cultural resources, and other environmental regulatory triggers prior to use, and environmental documentation and permits will be secured independently or supplemental to the project documentation and permits.

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Borrow Sources and Proposed Borrow Sites

Fill or borrow material may be purchased from a local commercial quarry or other permitted source; however, there are not currently any sites near the project area that would supply the volume and type of material required. Consequently, the most likely possibility is for fill to be purchased from local landowners willing to sell borrow material.

Five borrow sites have been identified in the project area. Each site was investigated to determine the quantity of available material, hauling distance, material composition, groundwater elevation, and prospects for acquisition. The purpose of the investigation was to identify the sites with the greatest potential to economically provide material for the project. Economical hauling has been determined to be within a 2-miles radius and marginally economic hauling within a 10-mile radius. As a result of the borrow analysis, sufficient fill volume is present within an approximate 10-mile, one-way haul distance from the area of construction.

A potential borrow sites' utilization would be maximized through gradation, placement, and treatment so that they could continue to be used for their current use or otherwise returned to their pre-project condition. As part of borrow operations, the upper 4–6 inches of topsoil would be set aside and replaced after construction in each construction season. After the project is completed, the borrow site would be re-contoured and reclaimed.

Through outreach efforts, a number of sites owned by individuals or government agencies willing to sell their property or provide material on a cubic yard basis. Figure 1 shows the locations of the five potential borrow sites identified and the proposed haul routes to the construction area.

North Valley Property

The North Valley property is owned by North Valley Properties, LLC and is located south of Ella Road between Feather River Boulevard and Arboga Road. The Wheeler Ranch housing development is proposed at the site. Borrow for the project would be taken from the northeast corner of the property to create a 24.5 acre detention pond (referred to as referred to as the Drainage Basin C Regional Detention Pond but commonly referred to as the South Ella Detention Pond). The Ella Basin is being constructed as part of Reclamation District No. 784's Master Drainage Plan. Historically, the site was cultivated for agricultural purposes. Currently, the site is disked ruderal grassland with some roads cut in the southern portion of the property for the Wheeler Ranch development. The material at this site is anticipated to be CL from a depth of 18–22 feet, followed by silt-sand material below a depth of 22–25 feet. The depth of excavation is anticipated to be 15–20 feet and the yield of material from this site could be 400,000–500,000 cubic yards. Borrow material from this site would be used for work in Contract C-1 and C-2, and Contract B. If borrow material is remaining, it may also be used for Contract D-1 and D-2.

The haul route to the northern portion of Contract C from the North Valley Property would be west on Ella Avenue to north on Feather River Boulevard to north on SR70 to west on SR20/Colusa Avenue to north on Live Oak Boulevard to north on SR99 to east on Paseo Avenue. Additional access route to the levee along northbound SR99 would be north on Kent Avenue to east on Koch Lane. Additional access routes to the levee along northbound Live Oak Boulevard would be east on Morse Road, east on Rednall Road and east on Market Street to east on Lynn Way. Additional access routes to the levee along westerly SR20/Colusa Avenue would be North on Sutter Street/Market Street to east on Lynn Way.

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The haul route to the southern portion of Contract C from the North Valley Property would be west on Ella Avenue to north on Feather River Boulevard to north on SR70 to west on SR20/Colusa Avenue to south on Sutter Street to south on 2nd Street to levee access. Additional access route to the levee along westerly SR20/Colusa Avenue would be south on SR99 to east on Bogue Road to south on Garden Highway to east on Shanghai Bend Road.

The post-project land use of the site would be a regional detention pond for Reclamation District No. 784.

Marler Property

The Marler property is a 10-acre property at Johnson Road near Messick Road north of Star Bend and south of Shanghai Bend. The site is currently an orchard. The depth of excavation could be upwards of 6 feet. The yield of material from this site could be up to 75,000 cubic yards. The likely haul route would be Johnson Road to Messick Road to the Garden Highway, accessing the levee near Oswald Road. The post-project land use for the property would be agricultural production, likely row crops or orchard.

Lanza Property

The Lanza property is 40 acres in size and is currently farmed in field/row crops. It is located at North Township Road and Pease Road south of Live Oak and north of Yuba City. The site has not yet been investigated to determine the types of materials present. Excavation of the site to a depth of 6 feet may occur. The yield of material from this site could be up to 200,000 cubic yards. The likely haul route would be along Pease Road directly east to the levee. The post-project land use for the property would be rice production.

City of Live Oak Detention Basin

The City of Live Oak owns the property formerly known as the Caltrans Detention Basin Site located west of SR 99 and south of Paseo Avenue. The site is currently fallow. The City of Live Oak intends to construct soccer fields and a stormwater detention basin at the site in 2013 or later. Although the site would require hauling for a short distance through a residential neighborhood, it is anticipated the residents would be amenable to the hauling as it would be a part of the public amenity constructed by the City of Live Oak. The material at this site is anticipated to be CL from a depth of 1–2.5 feet, followed by more sandy material to a depth of 6 feet. This site is approximately 25 acres, and the depth of excavation is anticipated to be 3–6 feet. The yield of material from this site could be up to 125,000 cubic yards, and would likely be used for Contract C. The haul route to the northern portion of Contract C from the City of Live Oak Detention Basin would be west crossing the canal to north to Treatment Plant Access road and west on Treatment Plant Access Road to north on Farm Access Road to north on Richards Avenue to east on Pennington Road. Additional access routes to the levee from eastbound on Pennington Road are south on SR99 to east on Paseo Avenue and north on Metteer Road to east on Riviera Road. Additional routes to the levee along northerly Metteer Road would be east on Campbell Road and east on Cooley Road.

The City of Live Oak (Schmidt, pers. comm.) reports that land at this location has historically been cultivated for agricultural purposes and that there was no evidence of any wetland or other sensitive plant or wildlife areas remaining onsite. A preliminary wetland delineation of the area conducted by HDR Engineering in December 2012 did not identify any wetland features. The previous agricultural use has displaced native species of plants and animals except those varieties capable of co-existing

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with humans in urban settings. The post-project use of the site would be a community park and stormwater detention basin facility.

Oroville Wildlife Area Dredge Tailings Area

This site is within the Oroville Wildlife Area and consists of several mounds of dredge tailings on the waterside of the existing levee. The material is suitable for use in seepage berms at Reaches 40 and 41 and an adjacent levee at Reach 38. The availability of tailings in the area should be sufficient to meet the total deficit for berm material in these reaches. The excavation of the material would be coordinated to maximize hydraulic benefits from the reshaping of the overbank area. The site also represents an opportunity to provide waterside habitat enhancements. The useful area of this site could be approximately 75 acres and the depth of excavation could be upwards of 10 feet. The yield of material from this site could be up to 375,000 cubic yards. Hauling from this site would not take place on public roads. It is anticipated the contractor would use an existing waterside levee ramp (or create one), directly accessing the levee patrol road. The future land use for this site would be similar to its present day use (managed habitat area).

Post-Construction Operations and Maintenance

After construction completion, the levee and staging areas and levee slopes would be hydroseeded for erosion protection, dust abatement, and to prevent colonization of exotic vegetation.

In accordance with Federal Flood Control Regulations (33 CFR 208.10) and State requirements (California Water Code Section 8370), each year the Federal flood control facilities are inspected four times, at intervals not exceeding 90 days. DWR would inspect the system twice per year, and the local maintaining authorities would inspect it twice per year and immediately following major high water events. The findings of these inspections would be reported to the CVFPB's Chief Engineer through DWR's Flood Project Integrity and Inspection Branch.

Permanent facilities associated with relief wells include the wells themselves and surface drainage trenches to control the discharge. Inspection of the relief wells is required at least annually, and observation of flow from the wells is required during high river stages. The wells are test-pumped periodically. The collection ditch is maintained to allow free flow of water.

Because operations and maintenance activities are conducted by DWR and local flood protection districts, the effects of these activities are not part of the project and are not discussed further in this MMP.

2.1.6 Conservation Measures

The following conservation measures will be implemented during project construction to avoid and minimize effects on federally listed species.

General

Conservation Measure 1: Conduct Mandatory Biological Resources Awareness Training for All Project Personnel and Implement General Requirements

Before any ground-disturbing work (including vegetation clearing and grading) occurs in the project area, a biologist approved by USFWS, NMFS, and CDFW will conduct a mandatory biological

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resources awareness training for all construction personnel about federally listed species that could potentially occur onsite (VELB, giant garter snake, and fish species). The training will include the natural history, representative photographs, and legal status of each federally listed species and avoidance and minimization measures to be implemented. Proof of personnel attendance will be provided to USFWS, NMFS, and CDFW within 1 week of the training. If new construction personnel are added to the project, the contractor will ensure that the new personnel receive the mandatory training before starting work. The subsequent training of personnel can include videotape of the initial training and/or the use of written materials rather than in-person training by a biologist. Requirements that will be followed by construction personnel are listed below.

- Where suitable habitat is present for listed species, the construction limits will be thoroughly delineated with survey tape, pin flags, orange barrier fencing, or other means, and prohibit any construction-related traffic outside these boundaries.
- Project-related vehicles will observe the posted speed limit on hard-surfaced roads and a 10-mile-per-hour speed limit on unpaved roads during travel in the project construction area.
- Project-related vehicles and construction equipment will restrict off-road travel to the designated construction areas.
- All food-related trash will be disposed of in closed containers and removed from the project construction area at least once per week during the construction period. Construction personnel will not feed or otherwise attract fish or wildlife to the project site.
- No pets or firearms will be allowed in the project construction area.
- To prevent possible resource damage from hazardous materials such as motor oil or gasoline, construction personnel will not service vehicles or construction equipment outside designated staging areas.
- Any worker who inadvertently injures or kills a federally listed species or finds one dead, injured, or entrapped will immediately report the incident to the biological monitor and construction foreman. The construction foreman will immediately notify the implementing agency, who will provide verbal notification to the USFWS Sacramento Endangered Species Office and/or the local CDFW warden or biologist within 1 working day. The implementing agency will follow up with written notification to USFWS or CDFW within 5 working days. The biological monitor will follow up with implementing agency to ensure that the wildlife agencies were notified.
- The biological monitor will record all observations of federally listed species on CNDDB field sheets and submit to CDFW.

Valley Elderberry Longhorn Beetle

Conservation measures for VELB are based on USFWS's 1999 *Conservation Guidelines for the Valley Elderberry Longhorn Beetle* (Conservation Guidelines) (U.S. Fish and Wildlife Service 1999a).

Conservation Measure 2: Fence Elderberry Shrubs to be Protected and Monitor Fencing during Construction

Elderberry shrubs/clusters within 100 feet of the construction area that will not be removed will be protected during construction. A qualified biologist (i.e., with elderberry/VELB experience), under contract to the implementing agency, will mark the elderberry shrubs and clusters that will be

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protected during construction. Orange construction barrier fencing will be placed at the edge of the respective buffer areas. The buffer area distances will be proposed by the biologist and approved by USFWS. No construction activities will be permitted within the buffer zone other than those activities necessary to erect the fencing. Signs will be posted every 50 feet (15.2 meters) along the perimeter of the buffer area fencing. The signs will contain the following information:

This area is habitat of the valley elderberry longhorn beetle, a threatened species, and must not be disturbed. This species is protected by the Endangered Species Act of 1973, as amended. Violators are subject to prosecution, fines, and imprisonment.

In some cases, where the elderberry shrub dripline is within 10 feet of the work area, k-rails will be placed at the shrub's dripline to provide additional protection to the shrub from construction equipment and activities. Temporary fences around the elderberry shrubs and k-rails at shrub driplines will be installed as the first order of work. Temporary fences will be furnished, constructed, maintained, and later removed, as shown on the plans, as specified in the special provisions, and as directed by the project engineer. Temporary fencing will be 4 feet (1.2 meters) high, commercial-quality woven polypropylene, orange in color.

Buffer area fences around elderberry shrubs will be inspected weekly by a qualified biological monitor during ground-disturbing activities and monthly after ground-disturbing activities until project construction is complete or until the fences are removed, as approved by the biological monitor and the resident engineer. The biological monitor will be responsible for ensuring that the contractor maintains the buffer area fences around elderberry shrubs throughout construction. Biological inspection reports will be provided to the project lead and USFWS.

Conservation Measure 3: Conduct VELB Surveys Prior to Elderberry Shrub Transplantation

Surveys of elderberry shrubs to be transplanted will be conducted by a qualified biologist prior to transplantation. Surveys will be conducted in accordance with the Conservation Guidelines for the VELB (U.S. Fish and Wildlife Service 1999a). The biologist will survey the area surrounding the shrub to be transplanted to ensure that there aren't additional elderberry shrubs that need to be removed. Surveys will consist of counting and measuring the diameter of each stem, and examining elderberry shrubs for the presence of VELB exit holes. Survey results and an analysis of the number of elderberry seedlings/cuttings and associated native plants based on the survey results will be submitted to USFWS. The data collected during the surveys prior to transplantation will be used to determine if the implementing agency is exceeding their compensation requirements or if additional plantings are necessary. Because the project would be constructed in separate contracts, elderberry survey data for each contract will be used to rectify any discrepancies in compensation for the previous contract and to ensure that impacts to VELB are fully mitigated.

Conservation Measure 4: Water Down Construction Area to Control Dust

The implementing agency or the contractor will ensure that the project construction area will be watered down as necessary to prevent dirt from becoming airborne and accumulating on elderberry shrubs within the 100–foot buffer.

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Conservation Measure 5: Compensate for Direct and Indirect Effects on Valley Elderberry Longhorn Beetle Habitat

Project impacts to VELB habitat are discussed in Section 2.3 and compensation ratios are discussed below in Section 3.4.

Giant Garter Snake

Conservation measures for giant garter snake were developed using portions of the *Programmatic Formal Consultation for U.S. Army Corps of Engineers 404 Permitted Projects with Relatively Small Effects on the Giant Garter Snake within Butte, Colusa, Glenn, Fresno, Merced, Sacramento, San Joaquin, Solano, Stanislaus, Sutter, and Yolo Counties, California* (U.S. Fish and Wildlife Service 1997).

Conservation Measure 6: Conduct Construction Activities during the Active Period for Giant Garter Snake

To the maximum extent possible, all construction activity within giant garter snake aquatic and upland habitat within 200 feet of aquatic habitat will be conducted during the snake's active period (May 1–October 1). During this timeframe, potential for injury and mortality are lessened because snakes are actively moving and avoiding danger. Canal relocation at Reaches 22 and 28 to 29 and pipe reconstruction at Reaches 26–28 must be conducted when the canal is dry (February–March). Additional protective measures will be implemented at these locations (see Conservation Measure 14 below).

Conservation Measure 7: Install and Maintain Exclusion and Construction Barrier Fencing around Suitable Giant Garter Snake Habitat

To reduce the likelihood of giant garter snakes entering the construction area, the implementing agency will install exclusion fencing and orange construction barrier fencing along the portions of the construction area that are within 200 feet of suitable aquatic and upland habitat. The exclusion and construction barrier fencing will be installed during the active period for giant garter snakes (May 1–October 1) to reduce the potential for injury and mortality during this activity.

The construction specifications will require that the implementing agency or its contractor retain a qualified biologist to identify the areas that are to be avoided during construction. Areas adjacent to the directly affected area required for construction, including staging and access, will be fenced off to avoid disturbance in these areas. Before construction, the contractor will work with the qualified biologist to identify the locations for the barrier fencing and will place flags or flagging around the areas to be protected to indicate the locations of the barrier fences. The protected area will be clearly identified on the construction specifications. The fencing will be installed the maximum distance practicable from the aquatic habitat areas and will be in place before construction activities are initiated.

The exclusion fencing will consist of 3 foot-tall silt fencing buried at least 4–6 inches below ground level. The exclusion fencing will ensure that giant garter snakes are excluded from the construction area and that suitable upland and aquatic habitat is protected throughout construction. The construction barrier fencing will be commercial-quality, woven polypropylene, orange in color, and 4 feet high (Tensor Polygrid or equivalent). The fencing will be tightly strung on posts with a maximum of 10-foot spacing.

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Barrier and exclusion fences will be inspected daily by a qualified biological monitor during ground-disturbing activities and weekly after ground-disturbing activities until project construction is complete or until the fences are removed, as approved by the biological monitor and the resident engineer. The biological monitor will be responsible for ensuring that the contractor maintains the buffer area fences around giant garter snake habitat throughout construction. Biological inspection reports will be provided to the project lead and USFWS.

Conservation Measure 8: Minimize Potential Impacts on Giant Garter Snake Habitat

The implementing agency will implement the following measures to minimize potential impacts on giant garter snake habitat.

- Staging areas will be located at least 200 feet from suitable giant garter snake habitat.
- Any dewatered habitat will remain dry for at least 15 consecutive days after April 15 and prior to excavating or filling of the dewatered habitat.
- Vegetation clearing within 200 feet of the banks of suitable giant garter snake aquatic habitat will be limited to the minimum area necessary. Avoided giant garter snake habitat within or adjacent to the project area will be flagged and designated as an environmentally sensitive area, to be avoided by all construction personnel.
- The movement of heavy equipment within 200 feet of the banks of suitable giant garter snake aquatic habitat will be confined to designated haul routes to minimize habitat disturbance.

Conservation Measure 9: Prepare and Implement a Stormwater Pollution Prevention Plan

Because ground disturbance for the project would be greater than 1 acre, the implementing agency would obtain coverage under the U.S. Environmental Protection Agency's (EPA's) National Pollutant Discharge Elimination System (NPDES) general construction activity stormwater permit. The Central Valley Regional Water Quality Control Board (RWQCB) administers the NPDES stormwater permit program in Sutter and Butte Counties. Obtaining coverage under the NPDES general construction activity permit generally requires that the project applicant prepare a stormwater pollution prevention plan (SWPPP) that describes the BMPs that would be implemented to control accelerated erosion, sedimentation, and other pollutants during and after project construction. The SWPPP would be prepared prior to commencing earth-moving construction activities.

The specific BMPs that would be incorporated into the erosion and sediment control plan and SWPPP would be site-specific and would be prepared by the construction contractor in accordance with the California RWQCB Field Manual. However, the plan likely would include, but not be limited to, one or more of the following standard erosion and sediment control BMPs.

- **Timing of construction.** The construction contractor will conduct all construction activities during the typical construction season to avoid ground disturbance during the rainy season.
- **Staging of construction equipment and materials.** To the extent possible, equipment and materials will be staged in areas that have already been disturbed.
- **Minimize soil and vegetation disturbance.** The construction contractor will minimize ground disturbance and the disturbance/destruction of existing vegetation. This will be accomplished in part through the establishment of designated equipment staging areas, ingress and egress

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corridors, and equipment exclusion zones prior to the commencement of any grading operations.

- **Stabilize grading spoils.** Grading spoils generated during the construction will be temporarily stockpiled in staging areas. Silt fences, fiber rolls, or similar devices will be installed around the base of the temporary stockpiles to intercept runoff and sediment during storm events. If necessary, temporary stockpiles may be covered with an appropriate geotextile to increase protection from wind and water erosion.
- **Install sediment barriers.** The construction contractor may install silt fences, fiber rolls, or similar devices to prevent sediment-laden runoff from leaving the construction area. Natural/biodegradable erosion control measures (i.e., coir rolls, straw wattles or hay bales) will be used. Plastic monofilament netting (erosion control matting) will not be allowed because animals can become caught in this type of erosion control material.
- **Stormwater drain inlet protection**. The construction contractor may install silt fences, drop inlet sediment traps, sandbag barriers, and/or other similar devices.
- **Permanent site stabilization**. The construction contractor will install structural and vegetative methods to permanently stabilize all graded or otherwise disturbed areas once construction is complete. Structural methods may include the installation of biodegradable fiber rolls and erosion control blankets. Vegetative methods may involve the application of organic mulch and tackifier and/or the application of an erosion control seed mix. Implementation of a SWPPP will substantially minimize the potential for project-related erosion and associated adverse effects on water quality.

Conservation Measure 10: Prepare and Implement a Bentonite Slurry Spill Contingency Plan (Frac-Out Plan)

Before excavation begins, the implementing agency would ensure the contractor would prepare and implement a bentonite slurry spill contingency plan (BSSCP) for any excavation activities that use pressurized fluids (other than water). If the contactor prepares the plan, it would be subject to approval by USACE, NMFS, and SBFCA before excavation can begin. The BSSCP would include measures intended to minimize the potential for a frac-out (short for "fracture-out event") associated with excavation and tunneling activities; provide for the timely detection of frac-outs; and ensure an organized, timely, and "minimum-effect" response in the event of a frac-out and release of excavation fluid (i.e., bentonite). The BSSCP would require, at a minimum, the following measures.

- If a frac-out is identified, all work will stop, including the recycling of the bentonite fluid. In the event of a frac-out into water, the location and extent of the frac-out will be determined, and the frac-out will be monitored for 4 hours to determine whether the fluid congeals (bentonite will usually harden, effectively sealing the frac-out location).
- NMFS, CDFW, and the RWQCB will be notified immediately of any spills and will be consulted regarding clean-up procedures. A Brady barrel will be onsite and used if a frac-out occurs. Containment materials, such as straw bales, also will be onsite prior to and during all operations, and a vacuum truck will be on retainer and available to be operational onsite within notice of 2 hours. The site supervisor will take any necessary follow-up response actions in coordination with agency representatives. The site supervisor will coordinate the mobilization of equipment stored at staging areas (e.g., vacuum trucks) as needed.

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- If the frac-out has reached the surface, any material contaminated with bentonite will be removed by hand to a depth of 1-foot, contained, and properly disposed of, as required by law. The drilling contractor will be responsible for ensuring that the bentonite is either properly disposed of at an approved Class II disposal facility or properly recycled in an approved manner.
- If the bentonite fluid congeals, no other actions, such as disturbance of the streambed, will be taken that will potentially suspend sediments in the water column.
- The site supervisor has overall responsibility for implementing this BSSCP. The site supervisor will be notified immediately when a frac-out is detected. The site supervisor will be responsible for ensuring that the biological monitor is aware of the frac-out, coordinating personnel, response, cleanup, regulatory agency notification and coordination to ensure proper clean-up, disposal of recovered material, and timely reporting of the incident. The site supervisor will ensure all waste materials are properly containerized, labeled, and removed from the site to an approved Class II disposal facility by personnel experienced in the removal, transport, and disposal of drilling mud.
- The site supervisor will be familiar with the contents of this BSSCP and the conditions of approval under which the activity is permitted to take place. The site supervisor will have the authority to stop work and commit the resources (personnel and equipment) necessary to implement this plan. The site supervisor will ensure that a copy of this plan is available (onsite) and accessible to all construction personnel. The site supervisor will ensure that all workers are properly trained and familiar with the necessary procedures for response to a frac-out, prior to commencement of excavation operations.

Conservation Measure 11: Prepare and Implement a Spill Prevention, Control, and Counter-Measure Plan

A spill prevention, control, and counter-measure plan (SPCCP) is intended to prevent any discharge of oil into navigable water or adjoining shorelines. the implementing agency or its contractor would develop and implement an SPCCP to minimize the potential for and effects from spills of hazardous, toxic, or petroleum substances during construction and operation activities. The SPCCP would be completed before any construction activities begin. Implementation of this measure would comply with State and Federal water quality regulations. The SPCCP would describe spill sources and spill pathways in addition to the actions that would be taken in the event of a spill (e.g., an oil spill from engine refueling would be immediately cleaned up with oil absorbents). The SPCCP would outline descriptions of containments facilities and practices such as doubled-walled tanks, containment berms, emergency shut-offs, drip pans, fueling procedures and spill response kits. It would also describe how and when employees are trained in proper handling procedure and spill prevention and response procedures.

The implementing agency would review and approve the SPCCP before onset of construction activities and routinely inspect the construction area to verify that the measures specified in the SPCCP are properly implemented and maintained. The implementing agency would notify its contractors immediately if there is a non-compliance issue and would require compliance.

The Federal reportable spill quantity for petroleum products, as defined in 40 CFR 110, is any oil spill that results in one or more of the following.

- Violates applicable water quality standards.

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- Causes a film or sheen on or discoloration of the water surface or adjoining shoreline.
- Causes a sludge or emulsion to be deposited beneath the surface of the water or adjoining shorelines.

If a spill is reportable, the contractor's superintendent would notify the implementing agency, and the implementing agency would take action to contact the appropriate safety and cleanup crews to ensure that the SPCCP is followed. A written description of reportable releases must be submitted to the Central Valley RWQCB. This submittal must contain a description of the release, including the type of material and an estimate of the amount spilled, the date of the release, an explanation of why the spill occurred, and a description of the steps taken to prevent and control future releases. The releases would be documented on a spill report form.

Conservation Measure 12: Conduct Preconstruction Surveys and Monitoring for Giant Garter Snake

Prior to ground-disturbing activities within 200 feet of suitable habitat, a USFWS-approved biological monitor will conduct a preconstruction survey of suitable aquatic and upland habitat and inspect exclusion and orange barrier fencing to ensure they are both in good working order each morning. If any snakes are observed within the construction area at any other time during construction the USFWS-approved biological monitor will be contacted to survey the site for giant garter snakes. The biological monitor will have the authority to stop construction activities until appropriate corrective measures have been completed or it is determined that the snake will not be harmed. Giant garter snakes encountered during construction activities will be allowed to move away from construction activities on their own. If unable to move away on their own, trapped or injured giant garter snakes will be only be removed by the USFWS-approved biological monitor and will be placed in the nearest suitable habitat that is outside of the construction area. The biological monitor will immediately report these activities to USFWS by phone and will provide a written account of the details of the incident within 24 hours.

Once all initial ground-disturbing activities are completed, the biological monitor will perform weekly checks of the site for the duration of construction in order to ensure that construction barrier fences and exclusion fences are in good order, trenches are being covered, project personnel are conducting checks beneath parked vehicles prior to their movement, and that all other required biological protection measures are being complied with. The biological monitor will document the results of monitoring on construction monitoring log sheets, which will be provided to USFWS within 1 week of each monitoring visit.

Conservation Measure 13: Provide Escape Ramps or Cover Open Trenches at the End of Each Day

To avoid entrapment of giant garter snake, thereby preventing injury or mortality resulting from falling into trenches, all excavated areas more than 1 foot deep will be provided with one or more escape ramps constructed of earth fill or wooden planks at the end of each workday. If escape ramps cannot be provided, then holes or trenches will be covered with plywood or other hard material. The biological monitor or construction personnel designated by the contractor will be responsible for thoroughly inspecting trenches for the presence of giant garter snakes at the beginning of each workday. If any individuals have become trapped, the USFWS-approved biological monitor will be contacted to relocate the snake and no work will occur in that area until approved by the biologist.

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Conservation Measure 14: Implement Additional Protective Measures during Work in Suitable Habitat during the Giant Garter Snake Dormant Period

USACE will implement additional protective measures during time periods when work must occur during the giant garter snake dormant period (October 2–April 30), when snakes are more vulnerable to injury and mortality. It is expected that these additional measures will be implemented during canal relocation at Reaches 22 and 28 to 29 and pipe reconstruction at Reaches 26–28 and during February–March, and if construction activities extend to the period between October 2 and November 1. A full-time USFWS-approved biological monitor will be onsite for the duration of construction activities.

- All emergent vegetation within the Sutter-Butte Canal on the levee side, and vegetation within 200 feet of the canal will be cleared prior to the giant garter snake hibernation period (i.e., vegetation clearing must be completed by October 1 for following winter work).
- Exclusion fencing will be installed around the perimeter of the work area and across the Sutter-Butte Canal where construction activities associated with levee slope flattening and pipe reconstruction activities would occur. The fencing should enclose the work area to the maximum extent possible to prevent giant garter snakes from entering the work area. Fencing will be installed during the active period for giant garter snakes (May 1–October 1) to reduce the potential for injury and mortality during fence installation. The USFWS-approved biological monitor will work with the contractor to determine where fencing should be placed and will monitor fence installation. The exclusion fencing will consist of 3 foot-tall erosion fencing buried 4-6 inches below ground level. The exclusion fencing will minimize opportunities for giant garter snake hibernation in the adjacent upland area (between canal and existing levee).

  Portions of the Sutter-Butte Canal that are temporarily disturbed during construction will be revegetated with emergent vegetation and adjacent disturbed upland habitat will be revegetated with native grasses and forbs after construction is complete.

Conservation Measure 16: Restore Temporarily Disturbed Aquatic and Upland Habitat to Pre-Project Conditions

To avoid permanent impacts, Upon completion of the construction, USACE will restore temporarily affected suitable and upland habitat for giant garter snake to pre-project conditions within a maximum of one season (a season is defined as the calendar year between May 1 and October 1 [U.S. Fish and Wildlife Service 1997]).

Conservation Measure 17: Compensate for Permanent Loss of Suitable Habitat for Giant Garter Snake

Compensation for permanent effects on giant garter snake aquatic and upland habitat will follow the guidance in the Programmatic Consultation. USACE will compensate for the permanent loss of suitable aquatic habitat and upland habitat for giant garter snake by purchasing preservation credits at a USFWS and CDFW approved conservation bank. Project impacts to GGS are discussed in Section 2.3 and compensation ratios are discussed below in Section 3.4.

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2.2 Site Characteristics

2.2.1 Biological Resources in the Project Area

This section identifies the field surveys conducted to identify biological resources known to occur or having the potential to occur in the project area, special-status wildlife and fish species with potential to occur in the project area, and the effects of the project on sensitive biological resources.

Field Surveys

The field surveys conducted to identify biological resources in the project area consisted of habitat mapping, a delineation of wetlands and other waters of the U.S., special-status wildlife surveys, and a tree survey.

Land Cover Mapping

The information pertaining to land cover types in the project area was derived primarily from the collaborative mapping done in November 2010 by ICF International GIS staff and Galloway Consulting and updated as needed based on the results of the 2011 reconnaissance-level biological assessment conducted by ICF International biologists. These 2010 and 2011 field surveys were conducted by combination of aerial photograph interpretation and walking and driving through the project area.

Land cover types in the project area fall into four broad categories: wildlands, potential wetlands and other waters of the U.S., agricultural lands, and developed/disturbed areas.

Delineation of Wetlands and Other Waters of the U.S.

In June, July, and August 2012, HDR conducted a formal delineation of wetlands and other waters for all areas that may potentially be directly affected by construction of the project. Potential borrow site locations were surveyed for wetlands in winter 2012. An approved Preliminary Jurisdictional Delineation for the project area was received on May 1, 2013.

Special-Status Wildlife Surveys

Field surveys to identify habitats for special-status wildlife and elderberry shrub (*Sambucus* spp.) habitat for VELB in the project area were conducted by ICF biologists on July 20–22, July 27, and August 31, 2011. Additional mapping of the elderberry shrubs was conducted by ICF concurrently with arborist surveys in summer 2012. During the 2011 surveys, biologists located elderberry shrubs by driving and walking along the levee in the project area and mapped elderberry shrubs (and shrub clusters) with a sub-meter accuracy global positioning system (GPS). When the bases of shrubs were accessible, stem counts, heights, and widths of shrubs were recorded, and shrubs were surveyed for VELB exit holes. Where dense poison oak (*Toxicodendron diversilobum*), Himalayan blackberry (*Rubus armeniacus*), and/or other vegetation surrounds elderberry shrubs, stem counts and exit hole surveys could not be conducted. Final stem counts will be conducted on all elderberry shrubs prior to removal for transplanting.

An assessment of habitat for giant garter snake was conducted by ICF and HDR biologists on July 12, 2012, and October 25, 2012. During the assessment, biologists evaluated aquatic and upland habitat

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for giant garter snake, took representative photographs of habitat present, and recorded all wildlife species observed.

Borrow sites recently have been identified and have not been surveyed yet. Surveys of these sites are planned to occur prior to construction. Any borrow site that contains habitat for listed species will not be utilized.

Tree Survey

ICF arborists assessed trees within the project footprint from July 17 to October 11, 2012. The arborist survey methods followed standard professional practices. Tree location data were collected with a GPS unit. Trees within the defined project footprint, overhanging the project footprint, and greater than 4 inches in DBH were surveyed. Trees were labeled with an aluminum tree tag with unique numbers inscribed on the tags.

The assessment criteria and recorded data from the arborist survey included:

- Identification of the species
- Status of the species
- Number of trunks
- Diameter of trunk 4.5 feet above the ground surface (DBH)
- Tree height
- Canopy dripline radius
- Health, vigor, and structure
- Remarks

For trees with relatively symmetrical canopies, the measurement from the trunk to the end of the longest lateral limb was measured and doubled to determine the diameter of the canopy. For trees with asymmetrical canopies, the diameter of the canopy was determined by adding the distance as measured from the longest lateral limb to the trunk to the distance measured from the trunk to the longest lateral limb on the opposite side of the tree (greater than 90 degrees either side from the first measurement).

Tree health and structure were rated as *good*, *fair*, or *poor*. Table 2-3 provides a general definition of these ratings. Where conditions were between ratings of good and fair or fair and poor, intermediate ratings of fair-good and fair-poor were given.

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Table 2-3. Criteria Used to Rate the Health, Vigor, Structure and Form of Surveyed Trees

Rating	Tree Health and Vigor
Good	Overall appearance of the tree is exemplary of the species. No visible wounds or defects, or completely healed. Crown root area displays no signs of wood deterioration. Bark missing from less than 10% of trunk circumference. Trunk does not show any signs of wood decay, cracking, or deterioration. Foliage is exemplary of the species, no sprout growth observed, evenly distributed, and free of pests. No signs of disease symptoms or pests observed. Current annual twig growth is greater than expected for the species. Buds are normal size, viable, abundant, and uniform throughout canopy. Little to no evidence of stress or nutrient deficiency.
Fair	Overall appearance of the tree is representative of the species. Wounds actively healing, but not completely healed. Crown root area displays minor signs of wood deterioration. Bark missing from more than 10% but less than 30% of trunk circumference. Trunk does not show any signs of wood decay, cracking, or deterioration. Foliage is representative of the species, some sprout growth observed, foliage is unevenly distributed yet balanced across whole tree, or only a minor pest problem observed. Disease symptoms or pests observed create an intermittent or temporary nuisance. Current annual twig growth is as expected for the species. Buds are of normal size and viable, but are somewhat sparse or irregular throughout the canopy. Some evidence of minor stress or nutrient deficiency observed.
Poor	Overall appearance of the tree deviates from species representative. Wounds not healing vigorously or are showing signs of decay. Crown root area decayed over more than 30% of tree's cross section. Bark missing from more than 30% of trunk circumference. Trunk shows signs of wood decay, cracking, or deterioration. Foliage deviates from species representative, sprout growth observed, foliage is unevenly distributed, or pest infestation observed. Disease symptoms or pests observed threaten the health and well-being of host and/or adjacent trees. Current annual twig growth is less than expected for the species. Buds are few, or not viable, or sparse, or irregular throughout the canopy. Evidence of stress or nutrient deficiency observed.

Rating	Tree Structure and Form
Good	Tree structure has a low potential for failure. Ample space for tree to grow to mature size characteristic of the species. No visible root defects or damage from roots to infrastructure observed. No anchor roots exposed. Trunk appears solid and free of cavities, decay, or hollowness. No bark inclusion observed. Canopy is full and balanced. Single leader, branch attachment solid, and angle of branch attachment exemplary. No dead limbs observed, all limbs free of defects, and limbs are not overburdened.
Fair	Tree structure has a moderate potential for failure. Adequate space available for tree to grow to a size representative of the species. Roots abutting infrastructure, displacing built objects from normal alignment. Some anchor root exposure. Trunk displays some signs of minor deterioration, but structurally still solid and in process of healing. Bark inclusion observed only on minor branches and away from posing threats to health, safety, and welfare of the public. Canopy is slightly lacking or unbalanced. Leader not clearly defined, but not missing; branch attachment characteristic of species. One minor dead limb observed, but solidly attached, other limbs free of defects, limbs only slightly overburdened.
Poor	Tree structure has a high potential for failure. Inadequate space available for tree to grow to a size representative of the species. Roots lifting sidewalks or built objects from normal grade, extensive portions of root system cut, decay of root crown in excess of 30%, or root zone subject to overwatering. Anchor roots exposed. Trunk decay is affecting 30% or more of the trunk cross section, healing process slow or not evident, or crack observed. Unequal weight distribution within tree structure due to trunk lean. Bark inclusion at branches, involving main trunk, or posing a threat to health, safety, or welfare of the public. Canopy is lacking or unbalanced, or concentrated in the upper 1/3 of tree. Double leader or no leader observed, a branch observed nearly as large as trunk, narrow angles of branch attachment, multiple limb attachments or attachments of limbs not characteristic of species, or decay observed at branch attachment. More than one dead limb observed, a wound in limb observed greater than 30% of cross section, limbs overburdened, or multiple branches sprouting from cuts.

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2.2.2 Special-Status Plants

Special-status plant species are plants that are legally protected under CESA, ESA, or other regulations, and species considered sufficiently rare by the scientific community to qualify for such listing.

Nine special-status plant species have been reported in the seven USGS quadrangles that overlap the project area (California Department of Fish and Game 2010; California Native Plant Society 2012; California Department of Fish and Game 2012; U.S. Fish and Wildlife Service 2012). Two species, slender Orcutt grass (*Orcuttia tenuis*) and Greene's tuctoria (*Tuctoria greenei*) are vernal pool species that lack potential habitat in the project area. No vernal pools were observed in the area during the 2010 and 2011 field surveys. Six species were determined to have low potential for occurrence because the potential habitat (i.e., oak woodland, ruderal areas outside the toe of the levee) constitutes a relatively small portion of the biological study area and has been lowered in quality by past and ongoing disturbance (agricultural activities, dredging). Additionally, suitable microhabitat requirements (subalkaline flats, heavy clay soils, acidic clay soils) for these species may not be met.

Sanford's arrowhead is the only special status species that could occur in jurisdictional habitat, including freshwater marshes, sloughs, canals, and other slow moving habitats. It is neither federally or state listed, but is classified as fairly endangered in California according to the California Rare Plant Rank. For the project area, it was determined to have low potential to occur along the edges of irrigation canals, inundated areas of the river's floodplain within riparian forest, and ponds on the land side of the levee that support a fringe of riparian forest.

2.2.3 Special-Status Wildlife Species

Special-status wildlife species are defined as animals that are legally protected under the ESA, CESA, or other regulations and species that are considered sufficiently rare by the scientific community to qualify for such listing. Special-status wildlife species are defined as follows.

- Species that are listed or proposed for listing as threatened or endangered under the ESA (50 CFR 17.11 for listed animals and various notices in the Federal Register (FR) for proposed species).
- Species that are candidates for possible future listing as threatened or endangered under the ESA (77 FR 69993, November 21, 2012).
- Species listed or proposed for listing by the State of California as threatened or endangered under the CESA (14 CCR 670.5).
- Species that meet the definitions of rare or endangered under CEQA (State CEQA Guidelines Section 15380).
- Animals listed as California species of special concern on CDFW's Special Animals List (California Department of Fish and Game 2011).
- Animals that are fully protected in California under the California Fish and Game Code (Sections 3511 [birds], 4700 [mammals], and 5050 [reptiles and amphibians]).

Based on the USFWS (2012) species list and CNDDB (California Department of Fish and Game 2012) records search for the quadrangles overlapping the affected area, 23 special-status wildlife species

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were identified as having potential to occur in the affected area. Of these 23 species, four are known to occur in the affected area (western pond turtle, Swainson's hawk, western yellow-billed cuckoo, and bank swallow). Swainson's hawk was observed in the affected area during 2011 field surveys. Though not reported to occur in the affected area, 10 other special-status wildlife species have a moderate or high potential to occur in the affected area given their known range, reports of occurrence, and/or the presence of suitable habitat. These species include Antioch Dunes anthicid beetle (*Anthicus antiochensis*), Sacramento anthicid beetle (*A. sacramento*), Sacramento Valley tiger beetle (*Cicindela hirticollis abrupta*), VELB, giant garter snake, northern harrier, bald eagle, western burrowing owl, tricolored blackbird, and silver-haired bat. The remaining nine species have low or no potential to occur. Seven additional species were added as having at least a moderate potential to occur in the affected area based on species habitat requirements and professional judgment (white-tailed kite, loggerhead shrike, purple martin, yellow warbler, pallid bat, hoary bat, and western red bat).

ESA Consultation to Date

Of the 10 federally listed species considered for inclusion, only VELB and the giant garter snake have the potential to be affected by the project.

USACE, pursuant to ESA, must consult with USFWS with regard to any proposed actions that may affect the continued existence of a federally listed species. Following is a summary of communications with USFWS for the project.

The Corps has determined that the proposed project may affect, and is likely to adversely affect the federally-listed as threatened valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*)(beetle) and the giant garter snake (*Thamnophis gigas*)snake. A Biological Opinion (08ESMF00-2013-F-0342-1) was received from USFWS on May 2, 2013 concurring with the Corps determination and that critical habitat will not be affected concluding ESA section 7 consultation for the proposed project.

Project impacts to VELB and GGS habitat are discussed below.

Valley Elderberry Longhorn Beetle

Status and Distribution

VELB was listed by USFWS as a threatened species on August 8, 1980 (45 FR 52803–52807), due to loss of habitat and inadequate regulatory protection. The current known range of VELB extends from southern Shasta County, south to Fresno County, and from the east side of the Coast Range to the Sierra Nevada foothills (Barr 1991; U.S. Fish and Wildlife Service 2006). The USFWS promulgated the final ruling designating critical habitat for VELB on August 8, 1980 (45 Federal Register [FR] 52804). Two critical habitat areas were designated along portions of the American River in Sacramento County (the Sacramento Zone and the American River Parkway Zone). The Proposed Action addressed in this BA is not located within designated critical habitat for VELB. Critical habitat has not been designated for giant garter snake. Accordingly, critical habitat is not discussed further in this BA.

In 2006, USFWS released a 5-year review for VELB that recommended delisting the species due to reduction of its primary threats (loss of riparian and inadequacy of regulatory mechanisms) and the increased number of occurrences in the Central Valley (U.S. Fish and Wildlife Service 2006). The

report recommended a post-delisting monitoring plan that includes monitoring of the 195 known VELB locations. The purpose of the plan would be to ensure that VELB remains stable after ESA protections are removed.

On August 19, 2011, USFWS announced a 90-day finding on a petition to delist VELB (76 FR 51929–51931). USFWS found that the petition presented substantial scientific or commercial information indicating that delisting may be warranted and requested further scientific and commercial data and other information regarding VELB. Following the review of additional information, USFWS will issue a 12-month finding on the petition, which will address whether the petitioned action is warranted.

Habitat and Biology

VELB is dependent on its host plant, elderberry, which is a common component of riparian corridors and adjacent upland areas in the Central Valley. VELB has four stages of life: egg, larva, pupa, and adult. Females deposit eggs on or adjacent to the host elderberry. Egg production varies and females have been observed to lay between 16 and 180 eggs (U.S. Fish and Wildlife Service 2007). Eggs hatch within a few days of being deposited and larvae emerge. The larvae bore into the wood of the host plant and create a long feeding gallery in the pith of the elderberry stem. The larvae feed on the pith of the plant for 1–2 years. When a larva is ready to pupate, it chews an exit hole to the outside of the stem and then plugs it with frass. The larva then retreats into the feeding gallery and constructs a pupal chamber from wood and frass. The larvae metamorphose between December and April; the pupal stage lasts about a month. The adult remains in the chamber for several weeks after metamorphosis and then emerges from the chamber through the exit hole. Most records for adults show occurrence from late-April to mid-May (U.S. Fish and Wildlife Service 2007). Adults feed on elderberry leaves and mate within the elderberry canopy.

Studies conducted in the American River basin demonstrate that VELB occurs most frequently and is most abundant in significant riparian zones that are well developed. Within significant riparian zones, VELB primarily occurs within the riparian corridor but can occur infrequently in non-riparian scrub habitats adjacent to the riparian corridor. Along the American River, the beetle tends to occupy woodlands dominated by exotic trees (black locust [*Robinia psuedoacacia*]) and black walnut [*Juglans californica*]), and in mixed riparian forests. The beetle less commonly occupies annual grasslands and live oak woodlands. One study showed that the beetle preferentially occupies elderberry shrubs in wooded areas with a relatively dense canopy cover over elderberry shrubs located in open and sparsely wooded areas. Of the occupied shrubs found in wooded areas, about 50% were under a canopy cover of 25–50%, while 25% were under canopies with 50–75% cover and 25% were under canopies with 75–100% cover. The study also demonstrated that VELB appears to be capable of limited dispersal and prefers to remain within contiguous patches of high quality riparian habitat. Clusters of local aggregations of VELB along the American River Parkway were approximately 600–800 meters in diameter (Talley 2005 in Talley et al. 2006).

A variety of branch sizes are utilized for larval development and pupation, although most of those measured in Barr's study (1991) were 2–4 inches (5–10 centimeters) in diameter at the exit hole. Infrequently, smaller branches (less than 1.5 inches [3.8 centimeters] in diameter) that contained exit holes were encountered. Lang et al. (1989) found no current-year exit holes on stems smaller than 1 inch (2.5 centimeters) in diameter. Talley et al. (2007) found that exit holes most frequently occurred in stems that were 0.8–2.8 inches (2–7 centimeters) in diameter and below 3.2 feet (1 meter) (79%). Holes were also found in larger diameter stems (2.8–4.7 inches [7–12 centimeters]) (36% of occurrences) and at heights of 3.2–6.4 feet (1–2 meters) above the ground (19%).

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Reasons for Decline

The primary threat to VELB has been attributed to habitat loss and degradation of the riparian forest ecosystem as a result of agricultural and urban development (Barr 1991; Barbour et al. 1993; Eng 1984; Kucera and Barrett 1995; Katibah 1984). Colonization by the Argentine ant (*Linepithema humile*) may also pose a biological threat to VELB through egg predation (Huxel 2000).

Occurrence in the Project Area

The closest VELB occurrence in the CNDDB (California Department of Fish and Game 2012) is approximately 0.5 mile from the project area. Numerous other occurrences are located within 10 miles of the project area.

Suitable habitat for VELB is located at numerous places in the project area along the levee construction footprint. There were no elderberry shrubs observed at the five borrow site locations during the wetlands delineation effort at these sites. A total of 267 shrubs/shrub clusters were mapped in the project area. Because of property inaccessibility and the high density of California grape and Himalayan blackberry along portions of the Feather River riparian corridor, stem counts and examination of shrubs for VELB exit holes could only be conducted for 73 shrubs/shrub clusters in the project area.

Effects of the Project on Valley Elderberry Longhorn Beetle

Direct effects are defined as the direct or immediate effects of a proposed action on a species or its habitat. Direct effects may result from the action and may include the effects of interrelated and interdependent actions. An *interrelated action* is an activity that is part of the proposed action and depends on the proposed action for its justification. An *interdependent action* is an activity that has no independent utility apart from the action under consultation (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998).

Indirect effects are caused by or result from the proposed action, are later in time, and are reasonably certain to occur. Indirect effects may occur outside the area directly affected by the action (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998).

Direct Effects

Permanent Loss of Elderberry Shrubs and Potential Loss of Individual VELB from Shrub Removal

Removal of habitat (elderberry) and potential injury or mortality of VELB associated with construction of the project would be considered direct effects on VELB. Trimming of elderberry branches that are 1 inch or greater in diameter could also result in injury or mortality of VELB. Because VELB larvae may feed on the roots of elderberries, disturbance of elderberry roots within the shrub dripline could also result in injury or mortality of individuals. Where root damage is expected to be extensive, elderberry shrubs would be removed. Where damage is limited (few roots affected) and roots are expected to grow back, impacts would be considered temporary. Because incidental take of VELB would be difficult to detect or quantify, effects on elderberry shrubs will be used as a proxy for measuring take.

Elderberry shrubs within the construction area that cannot be protected will be removed in accordance with to USFWS-approved procedures outlined in the Conservation Guidelines (U.S. Fish and Wildlife Service 1999a). Shrubs will be transplanted to the Star Bend Conservation Area.

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Transplanted shrubs will be moved prior to construction when the plants are dormant, approximately November through the first 2 weeks in February, after they lose their leaves. Transplanting during the dormant period will reduce shock to the plant and increase transplantation success. However, transplanted elderberry shrubs may experience stress, a decline in health, or death due to changes in soil, hydrology, microclimate, or associated vegetation.

Elderberry shrubs that can be avoided at the dripline of the shrub or greater distance will be protected with fencing and/or k-rail as described in Conservation Measure 2. Based on the location of shrubs in the project footprint, there is anticipated to be 162 elderberry shrubs that will require transplantation during construction of the project.

As described in Conservation Measure 3, surveys of elderberry shrubs to be transplanted will be conducted by a qualified biologist prior to transplantation. The data collected during the surveys prior to transplantation will be used to determine if compensation requirements are being met, or if additional plantings are necessary. Because the project would be constructed in six separate contracts, elderberry survey data for each contract will be used to rectify any discrepancies in compensation for the previous contract, and ensure that impacts are being fully mitigated. Compensation ratios for VELB habitat is discussed below in Section 3.4.

Indirect Effects

As discussed above, *indirect effects* are caused by or result from the project, are later in time, and are reasonably certain to occur. Indirect effects may occur outside the area directly affected by the action.

Loss of Connectivity to Adjacent Habitat

Loss of connectivity between elderberry shrubs may result when elderberries or associated vegetation is removed. Removal of such vegetation could result in gaps in vegetation that are too wide for VELB to travel across due to their fairly limited movement distances (Talley et al. 2006a), resulting in separation of individuals or reducing the possibility of colonization of adjacent areas. Removal of associated vegetation may result in an altered habitat structure or microclimate that could affect behaviors of VELB in response to these changes in unforeseen ways (U.S. Fish and Wildlife Service 2003).

Although more research is needed, VELB has been observed to fly a mile or more in contiguous or fairly contiguous habitat, and exit holes have been observed on isolated shrubs that are a minimum of 0.25 mile (0.4 kilometer) from the next nearest elderberry (Arnold pers. comm. 2011). Within the American River Basin, evidence suggests that local beetle movements are farther within the riparian corridor (141±144 feet [43±44 meters]) than in the adjacent non-riparian scrub (82±52 feet [25±16 meters]) (average±1 standard deviation nearest neighbor distances between recent exit holes) illustrating that VELB population extents may also be habitat-specific (Talley et al. 2006a).

Soil Disturbance Adjacent to Roots

Ground disturbance within 20 feet (6.1 meters) of an elderberry shrub's dripline could result in disturbance of roots. Root damage could result in stress or reduced vigor of elderberry shrubs. Because construction of the project may result in disturbance within 20 feet (6.1 meters) of the dripline of elderberry shrubs, indirect effects on these shrubs may result. Elderberry shrubs will be fenced and/or protected with k-rail, as described in Conservation Measure 2, to minimize soil disturbance adjacent to roots. With this measure in place, and because elderberry shrubs are hearty

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and frequently re-sprout after damage, this indirect effect is not expected to substantially affect VELB.

Dust

Vehicle travel on the levee road adjacent to elderberry shrubs during construction of the project could result in dust becoming airborne and settling on elderberries. The levee road is graveled, and existing shrubs are and have been exposed to dust from vehicles associated with farming and levee maintenance. Construction of the project would increase the amount of dust in the project area as a result of ground-disturbing activities and an increase in the frequency of vehicles driving on the levee road. The amount of dust in the project area would be minimized through dust control measures, as described in Conservation Measure 4. Additionally, according to Talley et al. (2006b), in an experiment along the American River Parkway (Sacramento County) conditions of elderberry shrubs related to dust from nearby trails and roads (paved and dirt) did not affect the presence of VELB. Additional work by Talley and Holyoak (2009) found no effect on elderberries from dust accumulations. Because dust has not been found to greatly affect elderberry shrubs and because dust control measures would be implemented during construction, this indirect effect is not expected to substantially affect VELB.

Altered Hydrology

Reduction of water to elderberry shrubs as a result of altered hydrology from changes in topography or compaction of soil could result in reduced shrub vigor/vitality and an associated decrease in shoot, leaf, and flower production and ultimately reduce the suitability of the shrubs to provide habitat for VELB. In most portions of the project area, the levee will be degraded and re-built within the same footprint, and would not modify the hydrology of the surrounding area where elderberries may be present. There may be a few instances where the slope is modified or there are other changes that may affect the hydrology in the project area. These situations are expected to be rare. Additionally, a substantial portion of the elderberries are located within riparian woodland along the Feather River and obtain water from within the river channel, which will not be hydrologically changed as a result of the project. Therefore, altered hydrology as a result of the project is not expected to substantially affect VELB.

Existing Elderberry Shrubs in the Conservation Area

As described in Conservation Measure 5, elderberry shrubs to be removed will be transplanted to the Star Bend Conservation Area, which contains existing elderberry shrubs. Although transplantation activities may occur within 100 feet of existing elderberry shrubs, it is unlikely that they would be indirectly affected by transplantation activities, as the transplantations would be conducted by qualified individuals who would be knowledgeable about elderberry shrubs and the existing conditions within the conservation area.

Temporal Loss of Habitat

It generally takes 5 or more years for newly planted elderberry cuttings/seedlings to become large enough to support beetles, and it generally takes 25 years or longer for riparian habitats to reach their full value (U.S. Fish and Wildlife Service 1994). Because elderberry shrubs within the project area will be transplanted to the Star Bend Conservation Area, which is immediately adjacent to the project area, no temporal loss of habitat for VELB is expected. Additional elderberry plantings in the conservation area will provide additional and/or replacement habitat for VELB in future years.

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Giant Garter Snake

Status and Distribution

Giant garter snake was listed as a threatened species by USFWS on October 20, 1993 (58 FR 54033). The species is also State-listed as threatened. Giant garter snake is endemic to the Sacramento and San Joaquin Valleys where it is found in lowland areas (U.S. Fish and Wildlife Service 1999b). Historically, this species was found throughout the Central Valley from Butte County in the north to Kern County in the south. Currently, giant garter snake is only known to occur in 13 discrete populations in the Sacramento and San Joaquin Valleys in Butte, Colusa, Fresno, Glenn, Merced, Sacramento, San Joaquin, Solano, Stanislaus, Sutter, and Yolo Counties (U.S. Fish and Wildlife Service 1999b:9, 11–12).

Habitat and Ecology

Giant garter snakes inhabit agricultural wetlands and other waterways including irrigation and drainage canals, ricelands, marshes, sloughs, ponds, small lakes, and low gradient streams, as well as adjacent upland areas in the Central Valley. Because of the direct loss of natural habitat, giant garter snake relies heavily on rice fields in the Sacramento Valley, but it also uses managed marsh areas in national wildlife refuges and State wildlife areas.

Habitat requirements for giant garter snake consist of the following.

- Adequate water during the snake's active season (early spring through mid-fall) to provide food and cover.
- Emergent, herbaceous wetland vegetation, such as cattails and bulrushes, for escape cover and foraging habitat during the active season.
- Grassy banks and openings in waterside vegetation for basking.
- Higher elevation uplands for cover and refuge from flood waters during the snake's dormant season in the winter.

Giant garter snake can persist in waterbodies that contain predatory fish if sufficient cover is present. It is typically absent from larger rivers because of lack of suitable habitat and emergent vegetative cover; it is also typically absent from wetlands with sand, gravel, or rock substrates. Riparian woodlands typically do not provide suitable habitat because of excessive shade, lack of basking sites, and absence of prey populations.

Giant garter snake inhabits small mammal burrows and other soil crevices above prevailing flood elevations throughout its winter dormancy period (November through mid-March), where it typically selects burrows with sunny exposure along south and west facing slopes. The breeding season extends from March through May and resumes briefly in September. Females give birth to live young from late July through early September. Giant garter snake feeds primarily on small fishes, tadpoles, and frogs (U.S. Fish and Wildlife Service 1999b:12, 13, 22, 24).

Reasons for Decline

Giant garter snake has been extirpated from the southern third of its range as a result of agricultural and flood control activities, which have eliminated the snake's freshwater marsh habitat in the historical Buena Vista, Tulare, and Kern lakebeds. Much of the habitat on the floor of the Central

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Valley has been lost or degraded by upstream watershed modifications, water storage and diversion projects, and urban and agricultural development. Other negative factors that may be contributing to the decline of giant garter snakes include interrupted water supply, poor water quality, and contaminants (U.S. Fish and Wildlife Service 1999b:25.)

Occurrence in the Project Area

There are no CNDDB records of occurrences of giant garter snake in the project area; however, there are 20 records of occurrences within 5 miles of the project area (California Department of Fish and Game 2012). The information for some of these records is suppressed, but the closest available occurrence is approximately 2 miles from the project area (California Department of Fish and Game 2012).

Within the project area, suitable aquatic habitat for giant garter snake is present within rice fields, irrigation canals, drainage canals, and ponds. Some of the drainage canals and ponds in the project area provide suitable aquatic habitat but do not have connectivity to other water features except the Feather River (which is not considered suitable habitat).

Canals

Canals in the project area consist of the Sutter-Butte Canal and other linear, concrete-lined features that convey water across multiple parcels. Many of these features have no vegetation present, while some have herbaceous emergent (rooted) vegetation and shrubs present in the margins. These canals generally convey water only during the active agricultural periods, which take place between April 15 and February 15.

Suitable upland habitat in the project area is limited to the levee banks and adjacent ruderal areas. Giant garter snakes (if present) are expected primarily to be associated with aquatic habitat in the project area. Table 2-5 provides a summary of the suitability of potential aquatic habitat in the levee construction portion of the project area. Table 2-6 provides a summary of the suitability of potential borrow sites to provide habitat for giant garter snake.

Table 2-5. Suitability of Aquatic Habitat for Giant Garter Snake in the Levee Construction Portion of the Project Area

Approximate Stationing	Aquatic Habitat	Suitability for Giant Garter Snake
208	Perennial ponded area, ditch along levee toe	Suitable aquatic—limited upland, no connectivity to other aquatic.
233	Ditch on land side of levee	Suitable aquatic.
254–258	Pond	Suitable aquatic—limited upland, no connectivity to other aquatic.
280	Canal	Suitable aquatic (low quality) —limited upland, has connectivity to other canals/ditches.
292	Concrete lined canal	Suitable—isolated segment but near other canals.
310	Perennial pond	Suitable aquatic—burrows in grassy hillside and levee side, channel from pond continues north along base of levee and also provides habitat.
336	Perennial pond	Dense willow ring, limited basking areas and upland, limited suitability/low potential for species.

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Approximate Stationing	Aquatic Habitat	Suitability for Giant Garter Snake
373	Open channel on water side of levee	Suitable aquatic.
396	Canal	Suitable aquatic.
409–410	Cement-lined storage pond	Not suitable—concrete-lined and fenced.
409–410	River backwater, freshwater emergent, and seasonal wetland	Marginal aquatic—area connected to river with marsh.
426	Channel with marsh (seasonal wetlands)	Suitable aquatic—open areas for basking, side of levee may provide upland.
434	Perennial pond	Suitable aquatic—open areas for basking, side of levee provides upland habitat.
512	Canal	Not suitable—canal is concrete-lined, used for drainage, and not connected to other canals/ditches and water not maintained.
544–577	Abbott Lake	Suitable aquatic—open areas for basking, limited upland habitat, connected "channel" along base of levee to the north also provides suitable aquatic.
647–649	Cement-lined storage pond	Not suitable.
689	Canal	Assumed suitable—appears to connect to other canals/ditches, limited suitable upland.
872–880	Seasonal wetland	Wetland feature observed dry during October 25, 2012 site visit. Not suitable—likely does not stay inundated through summer, may not have open water.
1043–1052	Detention pond	Not suitable—unvegetated and unlikely to sustain water through summer.
1043	Stream	Not suitable—stream isolated by river and development.
1060	Stream	Not suitable—stream isolated by river and development.
1375	Unlined canal	Suitable habitat—water present throughout the summer.
1428	Start of Sutter-Butte Canal	Suitable throughout the project area—water year-round, some patches of suitable emergent vegetation, connectivity to other canals/ditches.
1707	Canal	Similar to the Sutter-Butte Canal, suitable aquatic—connectivity to other canals/ditches.
1761–1766	Ditch	Not suitable—ditch is not very defined and is isolated.
1902	Ditch	Suitable aquatic—ditch had water on October 25, 2012 site visit, ditch is small and isolated but is in close proximity to the Sutter-Butte Canal.
1958	Canal/ditch	Assumed suitable—connected to Sutter-Butte Canal.
2076, 2122, 2217, 2262	Ponds in tailings area	Marginal suitability—aquatic areas appear suitable at base, but are often surrounded by steep mounds of tailings; availability of food is questionable; upland areas are rocky and are unlikely to provide burrows.
2359	Canal	Assumed suitable—it connects to other canals and ditches, although canal has stagnant water and really steep sides.

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Table 2-6. Habitat Suitability of Potential Borrow Sites for Giant Garter Snake

Potential Borrow Site	Habitat Present	Habitat Suitability
Oroville Wildlife Area Dredge Tailings Area	Tailings with emergent vegetation	Not considered suitable—aquatic areas appear suitable at base, but are often surrounded by steep mounds of tailings; availability of food is questionable; upland areas are rocky and are unlikely to provide burrows.
City of Live Oak Detention Basin	Irrigation ditch and grassland	Suitable—irrigation ditch along the edge of the property extends beyond the potential borrow site and provides suitable aquatic habitat; adjacent grassland provides suitable upland habitat.
South Ella Detention Pond	Ruderal grassland	Not suitable—no reported aquatic habitat within 200 feet of potential detention pond borrow site.
Lanza 40-acre property	Agricultural/ row crops	Suitable—irrigation ditch along the edge of the property provides suitable aquatic habitat but adjacent area where borrow would be removed is not suitable (i.e., no impacts to irrigation ditch).
Marler property	Agricultural/ row crops	Not suitable—no aquatic or upland habitat present.

Effects of the Project on Giant Garter Snake

Suitable aquatic habitat for giant garter snake in the project area consists of rice fields, irrigation canals, drainage canals, and ponds. Suitable upland habitat consists of ruderal grassland on the levee banks and adjacent to the levee banks. For the effects discussion below, impacts on ruderal grassland areas were calculated if they occur within 200 feet of suitable aquatic habitat.

Permanent and Temporary Disturbance of Suitable Aquatic and Upland Habitat for Giant Garter Snake

Permanent and temporary losses of suitable aquatic and upland habitat for giant garter snake within the project area are summarized in Table 2-7. Construction of SB-8 would result in the permanent loss of 3.54 acres of suitable upland habitat for giant garter snake. The permanent loss results from the installation of 3,700 linear feet of landside levee slope erosion protection (anchored high performance turf reinforced mat). Construction of SB-8 would also result in the temporary loss or disturbance of 118.80 acres of suitable upland habitat for giant garter snake. Temporary impacts to suitable upland habitat would mostly occur along the levee and at the City of Live Oak Detention Basin borrow site.

Permanently impacted suitable upland and aquatic habitat for giant garter snake would be compensated for through purchasing preservation credits equal to 22.5 acres of giant garter snake habitat at Westervelt Ecological Services' Sutter Basin Conservation Bank in Sutter County, as described in Conservation Measure 17.

Temporarily affected aquatic and upland habitat would be restored to pre-project conditions within a maximum of one season (a season is defined as the calendar year between May 1 and October 1 [U.S. Fish and Wildlife Service 1997]), as described in Conservation Measure 16.

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If additional impacts to giant garter snake habitat are expected to occur within or outside of the project area, USACE will consult with USFWS to determine whether reinitiation of Section 7 consultation is necessary to address these additional effects.

Disturbance or degradation of suitable aquatic habitat for giant garter snake in the project area could occur if soil or other materials are sidecast or fall into the habitat. Fuel or oil leaks or spills adjacent to aquatic habitat could also cause degradation of habitat. These potential effects would be avoided by installing sediment and construction barrier fencing (Conservation Measure 7), locating staging areas away from aquatic habitat (Conservation Measure 8), implementing sediment and contaminant BMPs as required by the NPDES permit (SWPPP) (Conservation Measure 9), and preparing a frac-out plan and SPCCP (Conservation Measures 10 and 11).

Table 2-7. Effects on Giant Garter Snake Habitat in the project area

Habitat	SB8 Levee Construction Area	Borrow Sites in Acres	SB8 Total Acreage
Temporary Effects			
Aquatic habitat	11.9	127.72	139.62
Upland habitat (ruderal within 200 feet of aquatic habitat)	96.79	175.47	272.26
Permanent Effects			
Aquatic habitat	0	0	0
Upland habitat (ruderal within 200 feet of aquatic habitat)	3.54	0	3.54

Potential Injury or Mortality of Giant Garter Snake

Construction activities in suitable habitat could result in the injury, mortality, or disturbance of giant garter snakes. Giant garter snakes could be injured or crushed by construction equipment working in suitable aquatic and upland habitat, or if soil or other materials are side-cast or fall into suitable aquatic habitat. Snakes could also be killed by construction vehicles traveling though the project area. Fuel or oil spills from construction equipment into aquatic habitat could also cause illness or mortality of giant garter snakes. Trenches left open overnight could trap snakes moving through the construction area during the early morning hours. Noise and vibrations from construction equipment, and presence of human activity during construction activities may also disturb giant garter snakes within the project area.

Most construction activities will be limited to the snake's active period (May 1–October 1) when the potential for direct mortality is reduced because snakes can actively move and avoid danger. However, realignment work for the Sutter-Butte Canal (Reaches 22, 28-29) requires construction during February and March when the irrigation canal is dry. Giant garter snakes, if present, in the upland ruderal grassland adjacent to the canal could be injured or killed during work within the snake's dormant period. Conservation Measure 14 would be implemented to reduce the potential for mortality.

Potential effects on giant garter snake would be minimized or avoided by conducting biological resources awareness training (Conservation Measure 1), conducting work during the active period (May 1–October 1) (Conservation Measure 6), installing exclusion fencing around suitable habitat (Conservation Measure 7), conducting preconstruction surveys and monitoring (Conservation

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Measure 12), and providing escape routes or covering open trenches (Conservation Measure 13). If work continues past October 1, additional preconstruction surveys and monitoring will be required (Conservation Measure 14).

Indirect Effects

Construction of the project is not expected to have any indirect effects on giant garter snake. Two potential indirect effects on giant garter snake and its habitat were considered but were determined to have no potential to occur as a result of the project. Specifically, the following determinations were made.

- There would be no increase of trash, hazardous waste, or off-road vehicle use due to increased human presence. The project would not result in development or increased access to giant garter snake habitat.
- The project would not result in indirect effects on habitat suitability through changes in the length of inundation or other habitat modifications that would make the habitat less suitable for giant garter snake.

Cumulative Effects

As described above, cumulative effects are future State, local, and private actions not involving a Federal action that are reasonably certain to occur within the action area under consideration. No other actions within the action area are proposed at this time. Therefore, no cumulative effects would result from the proposed action.

Future Federal actions that are unrelated to the project are not considered in this section because they would be subject to separate consultation pursuant to Section 7 of the ESA.

2.2.4 Special-Status Fish Species

Several special-status fish species occur or have the potential to occur in or near the study area. Critical habitat for spring-run Chinook salmon and Central Valley steelhead falls within the study area in the Feather River. In addition, the Feather River is designated critical habitat for green sturgeon (74 FR 52345 October 9, 2009). While the Feather River is not designated critical habitat for winter-run Chinook salmon, effects on this species were considered as they have the potential to occur in the study area for at least part of their life-cycle.

No construction activities are proposed in-river or below ordinary high water mark (OHWM); all activities that would result in physical disturbance and removal of vegetation on the waterside slope of the levee would be limited to areas above OHWM. Therefore, no physical modification of critical habitat for ESA-listed fish species would be expected because all proposed construction activities would occur above the OHWM of the Feather River. No mitigation measures are required for special-status fish due to project impacts. Loss of waterside riparian habitat that may indirectly affect fish habitat is being compensated for as described below.

2.2.5 Riparian Forest

Riparian forest occurs along the Feather River, on the waterside and landside of the levees, and forms a fringe around ponds. Riparian forests support an overstory dominated by mature native and nonnative trees. The dominant overstory species are valley oak (*Quercus lobata*), Fremont

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cottonwood (*Populus fremontii* ssp. *fremontii*), or Goodding's black willow (*Salix gooddingii*). Other trees commonly observed in the riparian forest are box elder (*Acer negundo* var. *californicum*), arroyo willow (*S. lasiolepis*), Oregon ash (*Fraxinus latifolia*), and western sycamore (*Platanus racemosa*). The shrub layer of most of the riparian forest in the biological study area is extremely dense, and species commonly observed are Himalayan blackberry, poison oak, button bush (*Cephalanthus occidentalis*), wild rose (*Rosa* spp.) and blue elderberry (*Sambucus nigra* ssp. *caerulea*). Blue elderberry is the host plant for the valley elderberry longhorn beetle, federally listed as threatened. Many of the trees and shrubs in the riparian forest are covered in California grape (*Vitis californica*). The herbaceous understory of riparian forest contains a mixture of native and introduced species. Representative species observed were horsetails (*Equisetum* spp.), mugwort (*Artemisia douglasiania*), and curly dock (*Rumex crispus*). Several patches of the invasive giant reed (*Arundo donax*) occur along the edges of riparian areas.

Effects of the Project on Riparian Forest

An arborist survey of the project area was conducted during the summer of 2012 to identify riparian trees that would be affected by the project. Cutoff wall and seepage berm construction would require removal of vegetation within the construction footprint. An additional amount of riparian habitat located in the ETL vegetation-free zone could require removal to comply with USACE levee vegetation policy. A variance under the policy would reduce this loss.

Construction of the project is estimated to impact 42.50 acres of riparian forest and scrub shrub riparian habitat (USFWS Draft Coordination Act Report). Tree survey dripline canopy data indicates that this impact acreage provides in total 2.88 acres of riparian tree canopy. Impacts to riparian trees were generated from data collected during the arborist survey described above in Section 2.3.1.

Vegetation removed would not be restored onsite because riparian restoration would not be permitted on the levees or seepage berms as it would conflict with USACE levee vegetation policy. The policy requires that the crown, slopes, and areas within 15 feet of the waterside and landside levee toes be maintained free of all woody vegetation.

Riparian communities, including cottonwood riparian woodland and valley oak riparian woodland, are considered sensitive natural communities by the CNDDB (California Department of Fish and Game 2012). These woodlands would be regulated by CDFW and USFWS (46 FR 7644) under no-net-loss policies for existing riparian habitat values.

2.2.6 Oak Woodland

The biological study area contains several small patches of oak woodland. The overstory of oak woodlands is predominantly valley oak but some ornamental tree species are also present. The understory of oak woodland contains annual grasses mixed with native and nonnative forbs. Representative understory species are wild oat (*Avena* spp.), soft chess (*Bromus hordeaceus*), ripgut brome (*B. diandrus*), field hedge parsley (*Torilis arvensis*), and the invasive yellow starthistle (*Centaurea solstitialis*).

Construction of the project is estimated to impact 1.30 acres of oak woodland (USFWS Draft Coordination Act Report). Tree survey dripline canopy data indicates a loss of oak trees totaling 10.12 acres of non-riparian native tree canopy. Impacts to non-riparian native trees were generated from data collected during the arborist survey described above in Section 2.3.1.

2.2.7 USACE Section 404 Jurisdictional Areas

The project area contains numerous features that are potential wetlands and other (i.e., non-wetland) waters of the United States that may be subject to USACE jurisdiction under Section 404 of the Clean Water Act (CWA). An approved Preliminary Jurisdictional Delineation for project site was received on May 1, 2013 from the USACE Sacramento District.

Affected Wetland and Other Water Types

The types and acreages of wetlands and other waters that would be affected by the proposed project are listed below in Table 2-8. A description of each type of affected wetland and other water is provided below.

Table 2-8. Acreages of Affected Wetlands and Other Waters

Land Cover Types	SB8 Alternative - Permanent	SB8 Alternative - Temporary
Irrigation/canal ditch	4.19	3.08
Riparian forest wetland	0.005	0.324
Forested Wetland	0.002	0
Drainage Fixture	0.006	0.008
Tailings wetland	0.911	0.11
Seasonal wetlands	0.026	0
Open water	0.038	0
Subtotal	***5.178***	***3.099***

Irrigation Ditches/Canals

The drainage ditches and canals scattered within the biological study area are anthropogenic features that drain water from active agricultural lands during the growing season or following a rain event. They consist of the Sutter-Butte Canal, and other linear, concrete-lined features that convey water across multiple parcels. Many of these features are unvegetated; however, some support emergent vegetation or shrubs along their margins.

Open Water

In addition to providing habitat for fish, open water provides foraging, cover, and reproductive sites for a variety of wildlife species. Open water areas provide essential foraging habitat for a variety of birds, including wading birds such as great blue heron, great egret, and snowy egret (*Egretta thula*); waterfowl such as northern shoveler (*Anas clypeata*), northern pintail (*Anas acuta*), common goldeneye (*Bucephala clangula*), mallard (*Anas platyrhynchos*), common merganser (*Mergus merganser*), ruddy duck (*Oxyura jamaicensis*), gadwall (*Anas strepera*), and cinnamon teal (*Anas cyanoptera*); other water birds such as eared grebe (*Podiceps nigricollis*), double-crested cormorant (*Phalacrocorax auritus*), and American white pelicans (*Pelecanus erythrorhynchos*); and land birds such as bald eagle (*Haliaeetus leucocephalus*), bank swallow (*Riparia riparia*), and belted kingfisher (*Megaceryle alcyon*).

Reptiles and amphibians, including western pond turtle, common garter snake, western aquatic garter snakes (*Thamnophis couchii*), Pacific tree frog, western toad, and bullfrog, use open water

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areas for breeding, foraging, and cover. Canals and ditches that contain water through mid-fall, have suitable prey, and adequate cover and foraging habitat have the potential to support giant garter snake (*Thamnophis gigas*).

Mammals that use open water habitats for foraging include bats such as California myotis, Yuma myotis, hoary bat, and western red bat, which forage for insects over open water. Additionally, terrestrial mammals such as black-tailed deer, raccoon, striped skunk, and Virginia opossum use open water habitats as water sources. Aquatic and semi-aquatic mammals that occur in open water habitats include beaver, river otter (*Lutra canadensis*), mink (*Mustela vison*), and muskrat.

Riparian Forest Wetlands

Forested/shrub wetlands occur on the waterside of the levee along the margins of the Feather River (but are outside the OHWM of the river) and are concentrated in the southern half of the biological study area. The vegetation in riparian forest wetlands is comparable to that of non-wetland riparian forest and non-wetland riparian scrub-shrub (described above); however, the forested/shrub wetlands exhibit positive indicators of all three Federal wetland criteria.

Tailing Ponds

Tailing ponds are concentrated in the northern portion of the project area. As indicated, these waterbodies formed in the tailings from dredge mining and are ringed by trees and shrubs. Similar to freshwater emergent wetlands, tailing ponds with standing water typically contain a mixture of floating and emergent wetland vegetation such as common rush, tall flatsedge, lady's thumb, spikerush (*Eleocharis* spp.) floating primrose willow, and common duckweed. The adjacent trees and shrubs are Pacific willow (*Salix lasiandra*), Goodding's black willow, and valley oak.

Seasonal Wetlands

Seasonal wetlands are scattered throughout the southern half of the project area. The vegetation in seasonal wetlands is dominated by herbaceous species such as tall flatsedge, ripgut brome, Hooker's evening primrose (*Oenothera elata*), horseweed (*Conyza canadensis*), common rush (*Juncus effusus*), seashore vervain (*Verbena litoralis*), and Bermuda grass (*Cynodon dactylon*). Based on the lack of a restrictive layer and absence of a plant community with species that are typically found only in vernal pools (e.g., coyote thistle [*Eryngium* sp.]), the seasonal wetlands in the project area were determined to not be vernal pools.

Soils and Substrate

The Natural Resources Conservation Service (NRCS) Soil Survey shows the permanent impacts to jurisdictional waters are mapped within 10 different soil types. Descriptions of the soil types are listed in Table 2-9. Most of the soils have loamy alluvium parent materials, except for the 118 Xerorthents, which are dredge spoils. The soils are found on low slope floodplain and terrace landorms and range from somewhat poorly drained to somewhat excessively drained.

Hydric soils are formed under saturated conditions (due to flooding or ponding) for sufficiently long enough duration during the growing season to form anaerobic conditions in the upper soil layer. The soils support growth of hydrophytic vegetation. The 7 soils with a hydric rating and criteria are also indicated in Table 2-. Five of 7 hydric soils listed are described by the NRCS as only containing minor hydric soil components located in only 3–5% of the soil mapping unit, which means that the soils in the impacted areas themselves may not contain any hydric soil layers.

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The predominant soil types of the permanently impacted jurisdictional areas (excluding canals) are 118 Xerorthents, tailings, 0 to 50 percent slopes (45% of area) and 124 Conejo loam, 0 to 2 percent slopes (29% of area). Soil type 118 Xerorthents, tailings is derived from dredged spoil piles from gravelly alluvium derived from igneous, metamorphic and sedimentary rock. The texture of the surface layer is very gravelly sandy loam. It is rated as a hydric soil across 80% of its mapping unit with a hydric rating of 4, which refers to soils that are frequently flooded for long or very long duration during the growing season. Soil type 124 Conejo loam, 0 to 2 percent slopes is derived from loamy alluvium derived from mixed sources. Typically, the surface layer is an approximate 7 inch brown loam and the subsoil is brown loam about 23 inches thick. It is not rated as a hydric soil. The third soil type comprising a substantial portion (17%) of the total impacted area is 121 Boga-Loemstone complex, 0 to 1 percent slopes. It's derived from loamy alluvium over dense silty alluvium derived from igneous and metamorphic rock. The surface layer texture is loam and it is not rated as a hydric soil.

Vegetation

The dominant plant communities in the impacted areas are described above in Section 2.3.3.

Threatened and Endangered Species

Discussion of federally–listed and other special status species is described in detail above in Section 2.3.2 and 2.3.3.

VELB was listed by USFWS as a threatened species on August 8, 1980 (45 FR 52803–52807), due to loss of habitat and inadequate regulatory protection (U.S. Fish and Wildlife Service 2011). The current known range of VELB extends from southern Shasta County, south to Fresno County, and from the east side of the Coast Range to the Sierra Nevada foothills (Barr 1991; U.S. Fish and Wildlife Service 2006). Two critical habitat areas have been designated along portions of the American River in Sacramento County (U.S. Fish and Wildlife Service 1984).

The giant garter snake is the only federally listed species occurring in jurisdictional waters requiring ESA consultation. Critical habitat has not been designated for the giant garter snake.

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Table 2-9. Characteristics of Soils in the Impacted Areas

Soil Unit	Parent Material	Slope	Drainage Class	Capacity of Limiting Layer to Transmit Water	Landform	Hydric Rating	Hydric Criteria
Sutter County							
124 Conejo loam, 0 to 2 percent slopes	Loamy alluvium derived from mixed sources	0–2%	Well drained	Moderately high or high (0.57–1.98 in/hr)	Terraces		
126 Conejo-Tisdale complex, 0 to 2 percent slopes	Loamy alluvium derived from mixed sources	0–2%	Well Drained	Moderately High (0.2–0.57 in/hr)	Terraces	Yes [a]	2B3, 4
138 Liveoak sandy clay loam, 0 to 2 percent slopes	Loamy alluvium derived from igneous and metamorphic rock	0–2%	Moderately well drained	Moderately high or high (0.57–1.98 in/hr)	Terraces		
143 Marcum-Gridley clay loams, 0 to 1 percent slopes	Loamy alluvium derived from mixed sources	0–1%	Moderately well drained	Very low (0.00–0.00 in/hr)	Terraces	Yes [b]	2B3, 4
165 Shanghai silt loam, frequently flooded, 0 to 2 percent slopes	Alluvium derived from mixed sources	0–2%	Somewhat poorly drained	Moderately high or high (0.57–1.98 in/hr)	Floodplains	Yes	4
Butte County							
118 Xerorthents, tailings, 0 to 50 percent slopes	Dredged spoil piles from gravelly alluvium derived from igneous, metamorphic and sedimentary rock	0–50%	Somewhat Excessively Drained	High (1.98–4.25 in/hr)	Floodplains	Yes	4
121 Boga-Loemstone complex, 0 to 1 percent slopes	Loamy alluvium over dense silty alluvium derived from igneous and metamorphic rock	0–1%	Moderately well drained	Low to moderately low (0.00–0.06 in/hr)	Terraces		
152 Gianella fine sandy loam, 0 to 1 percent slopes, frequently flooded	Stratified coarse-loamy alluvium derived from igneous, metamorphic and sedimentary rock	0–1%	Moderately well drained	Moderately high or high (1.13–5.38 in/hr)	Floodplains	Yes [c]	4
161 Gianella fine sandy loam, 0 to 1 percent slopes, rarely flooded	Stratified coarse-loamy alluvium derived from igneous, metamorphic and sedimentary rock	0–1%	Moderately well drained	Moderately high or high (1.13–5.95 in/hr)	Floodplains	Yes [d]	2B2
162 Gianella loam, 0 to 1 percent slopes, rarely flooded	Stratified coarse-loamy alluvium derived from igneous, metamorphic and sedimentary rock	0–1%	Moderately well drained	Moderately high or high (0.85–1.98 in/hr)	Floodplains	Yes [e]	2B2

[a] Only for the Oswald component, which comprises 3% of the soil mapping unit.
[b] Only for the Oswald and Capay components, which comprise a combined 4% of the soil mapping unit.
[c] Only for the Columbia, frequently flooded component, which comprises 3% of the soil mapping unit.
[d] Only for the Columbia taxadjunct, very fine sandy loam component, which comprises 3% of the soil mapping unit.
[e] Only for the Columbia taxadjunct, very fine sandy loam component, which comprises 5% of the soil mapping unit.
2B2 - A water table at a depth of 0.5 foot or less during the growing season if permeability is equal to or greater than 6.0 in/hr in all layers within a depth of 20 inches
2B3 - A water table at a depth of 1.0 foot or less during the growing season if permeability is less than 6.0 in/hr in any layer within a depth of 20 inches.
4 - Soils that are frequently flooded for long or very long duration during the growing season.

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Chapter 3
Mitigation Design

3.1 Basis for Design

On-site replacement habitat involves replacement of affected habitat with new habitat of the same type and at the same location as the loss. Because much of the affected habitat (specifically, woody vegetation) is not compliant in its location with USACE levee vegetation policy, this option is not considered feasible. Further, the highly dispersed nature of the impact locations makes efficient replacement infeasible. Therefore, on-site replacement was not considered further as a viable option for this project and off-site, in-kind habitat replacement was selected as the best option for mitigation. It involves replacement of affected habitat with the same type of habitat at a different location off-site. This often allows for consolidation of mitigation at a single or small number of sites, allowing for economy of scale and higher quality habitat due to large patch size.

The project will utilize two sub-types of off-site, in-kind replacement:

- **Permittee-responsible mitigation.** This option involves replacement of in-kind habitat on habitat lands operated by the permittee. Two separate sites are proposed for this mitigation option. The first site is the Star Bend Conservation Area (SBCA) on the west levee of the Feather River near river mile 18 is an existing floodplain habitat restoration site that was created as part of the Star Bend setback levee project. The second site is the proposed 500-acre Three Rivers Levee Improvement Authority (TRLIA) Feather River Floodway Corridor Restoration Project (FRFCRP) located on the east bank of the Feather River just upstream of the Star Bend site. Together, both sites contain sufficient area to accommodate all of the project's upland compensatory mitigation and will be used for mitigating impacts to: 1) riparian forest; 2) oak woodland; and 3) VELB.
- **Purchase of credits at commercial mitigation banks.** This option involves replacement of in-kind habitat through purchase of credits issued for habitat lands operated by a commercial mitigation bank. For the aquatic habitat impacts to GGS, the project proposes to purchase credits at the Sutter Basin Conservation Bank, operated by Westervelt Ecological Services in Sutter County, which is the only bank that presently offers giant garter snake credits approved by both the USFWS and CDFW. The project proposes to purchase jurisdictional water credits at the River Ranch Wetland Mitigation Bank, owned and operated by Wildlands, Inc., and located at the confluence of the Sacramento and Feather Rivers in Yolo County. There are currently no mitigation banks that offer oak woodland (non-riparian native tree) credits.

3.2 Characteristics of Design Reference Site

Previous mitigation work was performed at the 48.5-acre SBCA starting in 2009 for the Feather River Setback Levee and Habitat Enhancement Project (Restoration Resources 2010). The work was done as part of a project to replace a portion of the Feather River west levee with a new setback levee approximately 3,400 feet long that begins near the intersection of Star Bend Road and continues southeasterly to the intersection of Tudor Road. For Phase 1A of the project, 37 existing elderberry

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shrubs were transplanted. For Phase 1B, 20 acres of elderberry and native associate plants were installed to enhance VELB habitat. For Phase 1C, approximately 2.46 acres of California blackberry (*Rubus ursinus*) and California rose (*Rosa californica*) were planted to protect an area of cultural significance (Restoration Resources 2010). Phase 2 of the Star Bend mitigation project will consist of planting the remaining approximately 24.5 acres. This acreage will be utilized for the mitigation described in this MMP.

The design characteristics used in the initial mitigation work at SBCA will serve as a reference site for the additional VELB mitigation to be performed at Star Bend for this MMP. These characteristics are described in the report *Habitat Enhancement Plan for the Feather River Setback Levee and Habitat Enhancement Project at Star Bend*, prepared by River Partners and Stillwater Sciences in 2009 for Levee District 1 (LD1)and Wood Rodgers.

Design characteristics for riparian forest and oak woodland will incorporate the species composition and plant spacing found in other natural areas in the project site that will not be disturbed. These areas were field mapped, including field inventories of species composition and size. Additional guidance will be provided by the guidelines for Phase 2 riparian habitat planting outlined in River Partners and Stillwater Sciences (2009).

Design of the FRFCRP has not begun, but the site's ecological setting is similar to that found at the SBCA, and it is likely that design principles used at that site could be applied to the FRFCRP.

As described above, mitigation for USACE jurisdictional habitat and GGS will occur off-site at commercial mitigation and conservation banks.

3.2.1 Previous Work Credit

Much of the design information presented below that is specific to the Star Bend site is taken from the report *Habitat Enhancement Plan for the Feather River Setback Levee and Habitat Enhancement Project at Star Bend*, prepared by River Partners and Stillwater Sciences in 2009 for Levee District 1 and Wood Rodgers.

3.3 Proposed Mitigation Site

3.3.1 Location

The SBCA mitigation site is located on the water side (east) of the new setback levee that was constructed in 2009 on the Feather River, approximately six miles south of Yuba City, Sutter County, California (Figures 1 and 2). The 48.5-acre site is just upstream of the Star Bend boat ramp (near River Mile 18) and is bounded on the north and east by a sharp bend in the river. Access by road is from the west via Star Bend Road off of Garden Highway (River Partners and Stillwater Sciences 2009). The property to the east is part of the O'Connor Lakes unit of CDFW's Feather River Wildlife Area. The unit is managed by CDFW and DWR to provide wildlife habitat, restore native plant communities, and convey Feather River flood events. The land to the west of the levee is primarily orchards.

In 2009, LD 1 of Sutter County constructed the Feather River Setback Levee and Habitat Enhancement Project at Star Bend to replace a portion of existing levee that poses a high risk of

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failure in order to decrease the flood stage, velocity, and scour potential; increase and improve floodplain habitat; and improve habitat connectivity between the Abbot Lake and O'Connor Lakes Units of CDFW's Feather River Wildlife Area. The SBCA project created approximately 48.5 acres of floodplain habitat, which included habitat enhancement and onsite mitigation for impacted elderberry.

Approximately 20 acres have been used for elderberry transplants and associated native plants. In early 2012, a fire at the SBCA damaged portions of the site; however, VELB planting losses were minimal. The remaining approximately 24.5 acres are available at the conservation area for compensating for impacts on elderberry shrubs, riparian forest, and non-riparian, native trees from construction of the FRWLP.

The FRFCRP site is located on the east side of the Feather River in the levee setback area created by the TRLIA EIP Feather River Setback Levee project (Figure 1). The FRFCRP is located along a section of the Feather River which currently provides over 3,000 acres of wildlife habitat. Restoration on this site is important because it would add another large block of contiguous habitat (approximately 500 acres) along the lower Feather River; thereby reducing habitat fragmentation.

3.3.2 Ownership Status

The SBCA is under joint control by one of SBFCA's member agencies (Levee District 1) and CDFW. The FRFCRP site is entirely owned by TRLIA.

3.3.3 Jurisdictional Areas

There are no known jurisdictional areas in or near the mitigation activities.

3.3.4 Aquatic Functions

The Feather River Setback Levee and Habitat Enhancement Project at Star Bend constructed in 2009, along with the TRLIA EIP Feather River Setback Levee project, increased the amount of floodplain potentially exposed to inundating flows by approximately 1649 acres. The floodplain restoration allows for higher quality floodplain habitat (better water quality, food inputs, and shelter) for juvenile salmonids and other native species such as Sacramento splittail and steelhead. Organic material produced by native deciduous species restored within the floodplain provides an increased nutrient load for the aquatic environment. This influx of nutrients provides for a greater invertebrate population, thereby creating an abundant food source for fish.

3.3.5 Hydrology and Topography

Both the SBCA and the FRFCRP site were once part of a dynamic system of meandering channels and oxbow lakes that covered an area much wider than the levees of the Feather River Flood Control Project. Levee construction, beginning in the 1860's, confined the channel to its present location, and dams on the Feather and Yuba rivers regulate flows (River Partners and Stillwater Sciences 2009).

To the north of the SBCA, overbank flow from the Feather River periodically (i.e., modeled stage of the 2.5- to 3-year recurrence interval flow [approximately 60,000 cfs]) fills the drainage feature and depressions left by dredger mining (Wood Rodgers, Inc. 2007). In the O'Connor Lakes unit, scour channels, debris accumulations in trees and shrubs, and deposits of sand are evidence of periodic

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overbank flow. Periodic maintenance on the O'Connor Lakes Unit is conducted by DWR to increase the conveyance of flood flows and transport sediment (River Partners and Stillwater Sciences 2009).

On the land-side of the existing levee system, rain, flood irrigation and seepage under the levee are the primary sources of surface water. Flooding is used to irrigate the orchard crops, occasionally leaving standing water behind for short periods of time following irrigation. The levee ditch was constructed to contain any water seeping under the toe of the levee, but was only inundated in 1986 and 1997, years in which extremely large flood events occurred (B. Hampton, Manager, LD1, pers. comm., 2007). During those events, water remained for a couple of weeks, generally percolating into soil after flood flows had receded (B. Hampton, Manager, LD1, pers. comm., 2007). In 2006, which had a relatively large flood event, there was no water in the levee ditch (B. Hampton, Manager, LD1, pers. comm., 2007) (River Partners and Stillwater Sciences 2009).

The 2010 initial monitoring report for the Star Bend site (Restoration Resources 2010) stated that surface water was present within the 20 acre habitat area in March 2010 due to low depressions that do not provide sufficient drainage, but began to dry out into April. These areas may have stayed inundated due to the more than average rain received in the regional area during the winter and early spring season.

Elevations of the project area average 45 feet above sea level. Topography is generally flat, with steeper gradients at the river's edge. Several small hills and depressions occur in the O'Connor Lakes Unit as a result of overbank flood scour and deposition, and previous soil excavation and habitat enhancement projects (River Partners and Stillwater Sciences 2009).

Hydrologic function and existing topography of the FRFCRP is likely similar to that found at the SBCA.

3.3.6 Soils and Substrate

The Sutter County Soil Survey (Lytle 1988, NRCS 2008) identifies two soil series within the SBCA. The majority of the site consists of mapping unit 124 Conejo loam, 0 to 2 percent slopes. Conejo soils are very deep, well drained soils formed in alluvium and are observed on alluvial fans and stream terraces. Conejo soils contain about 39.2% sand, 37.3% silt and 23.5% clay. They are classified in hydrologic group B, which have moderately low runoff potential when thoroughly wet and water transmission through the soils is unimpeded.

Mapping unit 134 Holillipah loamy sand, 0 to 2 percent slopes occupies the northern boundary of the site along the Feather River. The Holillipah soils, which contain deep sand to loamy sand derived from mixed alluvium, are frequently flooded, and somewhat excessively well drained (River Partners and Stillwater Sciences 2009).

Detailed soil information for the FRFCRP has not been collected.

3.3.7 Vegetation

Vegetation types at the SBCA were assessed during a September 13, 2006 field survey by EIP Associates (EIP Associates 2007) and were mapped and described during wetland delineation surveys conducted in September 2007 and January 2008 by Stillwater Sciences (Stillwater Sciences 2008b) (River Partners and Stillwater Sciences 2009).

Plant species observed during a September 13, 2006 field survey by EIP Associates included wild oats (*Avena fatua*), ripgut brome (*Bromus diandrus*), soft brome (*Bromus hordeaceus*), turkey mullein

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(*Eremocarpus setigerus*), wild mustard (*Brassica* sp.), and prickly lettuce (*Lactuca serriola*) (EIP Associates 2007) (River Partners and Stillwater Sciences 2009).

Riparian forest habitat occurs north of the SBCA, throughout much of the levee ditch, and across much of the O'Connor Lakes unit to the southeast. The area north of the existing levee has a dense canopy of native riparian tree species (approximately one acre), including Fremont cottonwood (*Populus fremontii*), Goodding's black willow (*Salix gooddingii*), northern California black walnut (*Juglans californica* var. *hindsii*), Oregon ash (*Fraxinus latifolia*), and valley oak (*Quercus lobata*). There is a sparse to moderately dense shrub layer with arroyo willow (*Salix lasiolepis*), box elder (*Acer negundo*), California button willow (*Cephalanthus occidentalis*), California rose, and narrowleaf willow (*Salix exigua*). The vine layer is thin, containing predominantly California wild grape (*Vitis californica*) and poison oak (*Toxicodendron diversilobum*). The herbaceous layer is generally absent, with small clearings containing black mustard (*Brassica nigra*), oat (*Avena* sp.), perennial pepperweed (*Lepidium latifolium*), seashore vervain (*Verbena littoralis*), and soft brome (River Partners and Stillwater Sciences 2009).

Portions of the Star Bend setback levee ditch (approximately three acres) are predominantly comprised of a mature canopy of valley oak, occasionally shared with blue elderberry (*Sambucus mexicana*). The understory is fairly sparse, with blue wildrye (*Elymus glaucus*), California blackberry, California rose, California wild grape, Goodding's black willow, narrowleaf willow, and poison oak (River Partners and Stillwater Sciences 2009).

The northwest corner of the SBCA includes the recent mitigation work previously described. For Phase 1A of the project, 37 existing elderberry shrubs were transplanted. For Phase 1B, 20 acres of elderberry and native associate plants were installed to enhance VELB habitat. For Phase 1C, approximately 2.46 acres of California blackberry (*Rubus ursinus*) and California rose (*Rosa californica*) were planted to protect an area of cultural significance (Restoration Resources 2010).

The majority of the land west of the SBCA is a plum orchard that is flood irrigated. Annual grass and weedy forb species occur between the rows of trees, but the sparse distribution and short stature of the forbs indicate they are sprayed with herbicides or otherwise controlled on a regular basis (River Partners and Stillwater Sciences 2009).

The FRFCRP is vegetated with non-native annual grasses and forbs and is devoid of any woody vegetation. The site is mostly surrounded by orchards or other agriculture, but there an area of existing riparian vegetation adjacent to the southwest corner.

3.3.8 Present and Historical Uses of the Mitigation Area

Prior to the arrival of Europeans, Native Americans of the Valley Nisenan populations established villages along the Feather River and its tributaries in the vicinity of the site. The northwest corner of the site is a historic low rise along the river and contains an historic record of an indigenous village site (Bayham 2004) (River Partners and Stillwater Sciences 2009).

John Sutter laid claim to the region when he secured the New Helvetia Land Grant in the 1840s. He promptly built Hock Farm, a rancho in the vicinity of the site, which provided cattle stock that ranged freely along Feather River. W. H. Ashford owned and farmed a section of the west bank as early as 1880, which includes most of the site. In 1880, the O'Connor family owned the parcel to the south of the site where the lakes are located (Sutter County 1880). The 1912 (U.S. Army Corps of Engineers 1912) geologic survey shows dredging activities to the north and south of the site, but not within the

site. The 1912 survey also shows that the site had not been cleared for agriculture (River Partners and Stillwater Sciences 2009).

The SBCA is presently being used for the Phase I and Phase II mitigation work previously described. The SBCA converted 55 acres of former orchard and levee into floodplain habitat. Twenty acres of elderberry shrubs and native associate plants for VELB habitat were planted as part of the initial mitigation. The remaining 35 acres were not planted.

The FRFCRP is currently being managed as open floodplain habitat. Prior to inclusion in the setback area created by the TRLIA EIP Feather River Setback Levee project, the site was largely planted in orchard trees.

3.3.9 Present and Proposed Uses of All Adjacent Areas

The Feather River and three other properties surround the SBCA (i.e., Churkin, Singh, and CDFW properties). The majority of the area west of the site on the land side of the levee is a plum (*Prunus* sp.) orchard that is flood irrigated. The existing levee, operated by LD1, and the Star Bend pumping plant also are located along the site's western boundary. The pumping plant includes pump station discharge lines and irrigation pipelines that bisect the northern portion of the site and continue to adjacent properties. All the property to the east of the SBCA is part of the O'Connor Lakes unit of CDFW's Feather River Wildlife Area. The unit is managed by CDFW and DWR to provide wildlife habitat, restore native plant communities, and convey Feather River flood events.

The FRFCRP is surrounded by orchards or other agricultural land uses to the north, south, and east. To the west is an area of riparian vegetation.

3.4 Created/Restored Habitats

3.4.1 Compensation Ratios

The amount of proposed compensation is based on the significance of the habitats affected to fish and wildlife resources, USFWS general fish and wildlife mitigation recommendations (Fish and Wildlife Coordination Act Report), USFWS GGS programmatic biological opinion and VELB Conservation Guidelines. Compensation ratios may be adjusted at the project preconstruction engineering and design stage as a result of further assessments of habitat values and functions in consultation with the USFWS and other resource agencies.

VELB Habitat

Before construction begins, USACE will compensate for direct effects on elderberry shrubs by transplanting shrubs that cannot be avoided to the SBCA. Elderberry seedlings or cuttings and associated native species will also be planted in the conservation area. Each elderberry stem measuring 1 inch or greater in diameter at ground level that is adversely affected (i.e., transplanted) would be replaced, in the Star Bend area, with elderberry seedlings or cuttings at a ratio ranging from 1:1 to 8:1 (new plantings to affected stems). The numbers of elderberry seedlings/cuttings and associated riparian native trees/shrubs to be planted as replacement habitat are determined by stem size class of affected elderberry shrubs, presence or absence of exit holes, and whether the shrub lies

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in a riparian or non-riparian area. Stock of either seedlings or cuttings would be obtained from local sources (including the project area if acceptable to USFWS).

At the discretion of USFWS, shrubs that are unlikely to survive transplantation because of poor condition or location, or a plant that would be extremely difficult to move because of access problems, may be exempted from transplantation. In cases where transplantation is not possible, minimization ratios would be increased to offset the additional habitat loss.

The relocation of the elderberry shrubs will be conducted according to USFWS-approved procedures outlined in the Conservation Guidelines (U.S. Fish and Wildlife Service 1999a). Elderberry shrubs within the project construction area that cannot be avoided will be transplanted during the plant's dormant phase (November through the first 2 weeks of February). A qualified biological monitor will remain onsite while the shrubs are being transplanted.

Property inaccessibility and the high density of vegetation along portions of the Feather River riparian corridor limited the number of elderberry shrubs that could be surveyed (73 shrubs were surveyed). For this reason, compensation for the removal of approximately 162 shrubs was estimated based on the average number of stems in each stem diameter range for the 73 shrubs that could be surveyed (see Table 3-1). Those averages are as follows.

- Number of stems ≥1 inch and ≤3 inches = 4.
- Number of stems >3 inches and <5 inches = 1.
- Number of stems ≥5 inches = 1.

Because most of the shrubs are located in riparian habitat and did not have exit holes, the compensation ratios for these conditions were used.

Table 3-1. Estimated Compensation for Elderberry Shrubs Removed

Stem Diameter	Number of Stems[1]	Seedling Ratio[2]	Native Plant Ratio[2]	Total Seedlings	Total Native Plants
Stems ≥1" to ≤3"	648	2:1	1:1	1,296	1,296
Stems >3" to <5"	162	3:1	1:1	486	486
Stems ≥5"	162	4:1	1:1	648	648
Total	972			2,466	2,466

N/A = not applicable.

1 The number of stems per shrub was based on the average number of stems in each stem diameter range for the 72 shrubs that could be surveyed. Those averages are as follows: number of stems ≥1" and ≤3" = 4; number of stems >3" and <5" = 1; and number of stems ≥5" = 1.

2 Ratios are based on shrubs within riparian habitat with no VELB exit holes.

Based on the information in Table 3-1, 493 elderberry units, or 20.38 acres, will be required to fully mitigate for project impacts per USFWS VELB Conservation Guidelines. All of this mitigation will occur at the SBCA.

Riparian Habitat and Oak Woodland

Project impacts would be mitigate at a 2:1 compensation ratio as listed in Table 3-2. The USFWS Draft Fish and Wildlife Coordination Act Report (FWCA report) recommended at least a 2:1 replacement ratio to compensate for loss in functions and values.

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USACE Section 404 Jurisdictional Areas

Project impacts would be mitigated at a 2:1 compensation ratio per the USFWS FWCA report. Of the 5.178 acres of impact (Table 2-8), approximately 4.10 acres would be compensated onsite in conjunction with relocation of the Sutter Butte canal.

Table 3-2. Anticipated Project Impacts to Sensitive Resources and Proposed Compensatory Mitigation

Impact Type	Impact Unit	Impact Quantity	Mitigation Need	Mitigation Area
Riparian Forest and Riparian Scrub Shrub	acres of cover type	42.50 acres	85.00 acres (2:1 replacement ratio[1])	85.00 acres at 10' o.c. plant spacing
Oak Woodland	acres of cover type	1.30 acres	2.60 (2:1 replacement ratio1[1])	2.60 acres at 10' o.c. plant spacing
Elderberry	individual shrubs and total stem count within each shrub	162 shrubs with 972 total stems	162 transplants, 2,466 elderberry seedlings, and 2,466 native associates	20.38 acres [2] (493 elderberry units)
Giant Garter Snake	acres of permanent impact	0.00 aquatic 3.54 acres upland	3.54 acres (3:1 replacement ratio[3])	10.62 acres
Jurisdictional Waters	acres of permanent impact	1.71 acres	3.42 acres (2:1 replacement ratio1[1])	3.42 acres

Notes:

1 Compensation ratio from USFWS Draft Fish and Wildlife Coordination Act Report .

2 Compensation acreage determined based on USFWS VELB Compensation Guidelines.

3 Compensation ratio from USFWS Programmatic Biological Opinion (U.S. Fish and Wildlife Service 1997)

To fully mitigate for project impacts, approximately 87.60 acres of land will be required (elderberry transplantation/compensation (20.38 acres) met through riparian forest compensation). If all of the 24.5 acre SBCA Phase 2 land is used for mitigation purposes, approximately 63.10 acres of land would be required at the FRFCRP site to accommodate the remaining mitigation.

Compensation for GGS and Section 404 wetland impacts would be met by purchase of 14.04 acres of equivalent credit through mitigation or conservation banks (i.e., Sutter Basin Conservation Bank and River Ranch Wetland Mitigation Bank).

3.4.2 Long-Term Goal(s)

The long-term ownership goal is to merge the SBCA with CDFW's adjoining O'Conner Lakes and Abbott Lakes Wildlife Units. A similar goal with an appropriate public agency is also envisioned for the FRFCRP.

Given the presence of good soils and potential exposure to frequent flooding, both project areas should sustain rapid growth of restored riparian species throughout the life of the project implementation (approximately 3 years). An "over-planting" approach is used to rapidly establish native riparian species. Over-planting the project site will eliminate the need for any additional replanting efforts. The ultimate ecological objective for over-planting is that in time the area will thin

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out and create a complex of open canopy, dense forest, and dead snags, all of which provide benefits to wildlife (River Partners and Stillwater Sciences 2009).

It is anticipated that at the end of the 3-year establishment period, 70% survivorship of woody species will be attained. Over time, mortality based on differences of soil textures and water table depths will create areas of complex, open canopy, dense forest, and dead snags, all of which create habitat for wildlife (River Partners and Stillwater Sciences 2009).

3.4.3 Aquatic Functions

No jurisdictional open water habitat will be created at the either site. The Feather River Setback Levee and Habitat Enhancement Project at Star Bend, together with the TRLIA EIP Feather River Setback Levee project, increased the amount of floodplain potentially exposed to inundating flows by approximately 1649 acres. The floodplain restoration allows for higher quality floodplain habitat (better water quality, food inputs, and shelter) for juvenile salmonids and other native species such as Sacramento splittail and steelhead. Organic material produced by native deciduous species restored within the floodplain provides an increased nutrient load for the aquatic environment. This influx of nutrients also provides for a greater invertebrate population, thereby creating an abundant food source for fish. The additional mitigation plantings for VELB habitat and plantings for riparian forest and non-riparian, native trees proposed for this MMP will further increase the food inputs and shelter for aquatic species by expanding the acreage of floodplain forest and upland habitat at the site (River Partners and Stillwater Sciences 2009).

3.4.4 Hydrology and Topography

The long-term source of water for the new SBCA and FRFCRP mitigation plantings will be groundwater and Feather River flood flows. After the plants have become established enough to discontinue irrigation, groundwater will be the primary source of water. Additional surface water flooding will be provided during when the Feather River flows, most often high during spring and early summer snowmelt. Hydraulic modeling shows that the Feather River overbanks at locations north of the Star Bend site approximately once every 2.5 to 3 years (Wood Rodgers, Inc. 2007, as cited in River Partners and Stillwater Sciences 2009). It is anticipated that flooding will occur at the proposed mitigation site on a similar recurrence interval frequency. The duration of flooding will depend upon water year type. In some years, the river will not overtop its banks and inundate the site. In other years, flooding may occur over a period of several days, while in the wetter years the site could be flooded for several weeks. Flood water that overbanks into the site will generally flow downgradient from the north to south and eventually infiltrate into the ground or recede back into the river when the river's flood stage decreases.

3.4.5 Soils and Substrate

The majority of the SBCA consists of 124 Conejo loam soils, which are very deep, well drained soils formed in alluvium and are observed on alluvial fans and stream terraces. They are classified in hydrologic group B, which have moderately low runoff potential when thoroughly wet and water transmission through the soils is unimpeded. These soils are highly suitable for supporting elderberry shrubs and associated plans for VELB habitat, and for supporting riparian and non-riparian tree species. The same species that will be planted in the soils at the SBCA are currently growing in the same soils in lands in the site's vicinity.

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Detailed soil information has not been collected at the FRFCRP site.

3.4.6 Vegetation

The target plant communities and species at the SBCA and FRFCRP site will include riparian forest, non-riparian native trees, and elderberry shrubs and associated plants for VELB habitat (Table 3-3).

Table 3-3. Woody Planting Species for Star Bend Conservation Area

Common Name	Scientific Name
Coyote brush	*Baccharis pilularis*
Mule fat	*Baccharis salicifolia*
Buttonbush	*Cephalnathus occidentalis*
California Rose	*Rosa californica*
California Blackberry	*Rubus ursinus*
Sandbar willow	*Salix exigua*
Arroyo willow	*Salix lasiolepis*
Blue elderberry	*Sambucus mexicana*
Valley oak	*Quercus lobata*
Interior live oak	*Quercus wislizeni*
Oregon ash	*Fraxinus latifolia*
Fremont cottonwood	*Populus fremontii*
Box elder	*Acer negundo*

The detailed planting plan is described below in Section 5.2.

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Chapter 4
Success Criteria and Monitoring

4.1 Success Criteria

For this MMP, a "success criterion" is a measure that indicates whether the mitigation goals have been achieved at the end of the monitoring period. The mitigation will be evaluated annually using the annual performance standards. Table 4-1 summarizes the monitoring success criteria for restored and enhanced wetlands, drainages, and upland and riparian areas.

Table 4-1. Monitoring Success Criteria for Planted Areas at the SBCA and FRFCRP site

Monitored Characteristic	Monitoring Year	Success Criteria Standards
Riparian Vegetation		
Plant survival	1–5	Demonstrate at least 60% survival of all riparian vegetation plantings after 5 years.
Oak Woodland		
Plant survival	1-5	Demonstrate at least 60% survival of all non-riparian native plant plantings after 5 years.
Valley Elderberry Longhorn Beetle		
Plant survival	1-10 or 1,2,3,5 7,10 and 15	Demonstrate at least 60% survival of all elderberry and native associate plantings

A minimum survival rate of at least 60% must be maintained throughout the monitoring period. Within one year of discovery that survival has dropped below 60 percent, failed plantings will be replaced to bring survival above this level. USACE in consultation with the resource agencies will make any determination as to replacement responsibilities arising from circumstances beyond its control, such as plants damaged or killed as a result of severe flooding or vandalism.

4.2 Monitoring

4.2.1 Methods

Monitoring will be quantitative and qualitative. The monitoring methods that will be used during the annual performance monitoring are described below by habitat and restoration/mitigation category.

Annual Surveys

At the end of the first growing season, the restoration contractor will conduct a complete census of all woody species planted. The data are best analyzed using a database to calculate survivorship, and to determine any changes to or omissions from the original planting design. During years two and three, woody species plantings will be sampled to determine survivorship, growth, and coverage.

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Sampling of native grass and herbaceous understory plantings will also be conducted (River Partners and Stillwater Sciences 2009).

Census

At the end of the first growing season, a census noting survivorship for each location (alive, dead, or missing/not planted) will be conducted. The census allows for pattern analysis to examine the effects of soil, hydrology, or other factors affecting survivorship. During implementation, changes in the planting design are possible (or even desirable) and should be noted. Deviations in planting can also be recorded during the census. Results of the census will be used to determine progress towards performance criteria and replanting, if necessary (River Partners and Stillwater Sciences 2009).

Permanent Plot Sampling

After the initial census, subsequent monitoring (years 2 and 3) utilizes permanent plots to collect data on overall survivorship, height, and cover. The sampling procedure is modified for a restoration setting from protocol developed by Dr. Dave Wood (CSU, Chico) to establish permanent plots in riparian forests (personal communication). Some of the methods have been adapted from Elzinga et al. 1998. Comparison of survivorship between the sampling procedure and census indicates that sampling estimates are within 2% and provide additional information on cover and recruitment (results based on data from field 4 of the Ord Bend Unit, Sacramento River National Wildlife Refuge (River Partners 2003)). The sampling procedure may also be used to compare pre- and post-restoration vegetation, if the permanent plots are installed beforehand (River Partners and Stillwater Sciences 2009).

Plot location and Size

All samples are based on 20 m x 50 m (1,000 m^2) plots (quadrats) placed with the long axis oriented in a north-south direction. Permanent plot locations will be selected by stratifying the field and using the grid cell method (overlaying each field with a 20 m x 50 m grid) to select sampled plots. Plots that extend past the plantable area are generally rejected. In addition, we exclude locations that are not characteristic of that particular area. In general, a plot should be established every 5-20 acres. The plots serve as areas to collect information on woody, shrub, and herbaceous species (if desired) (River Partners and Stillwater Sciences 2009).

Once each specific plot location is randomly selected, its field location will be permanently recorded at the upstream, inland corner of the plot. The position will be recorded with a GPS unit, and, in subsequent monitoring years, will be reestablished in the same position (River Partners and Stillwater Sciences 2009).

Measurements

At each plot, cover and height measurements of all shrubs and trees inside the 20 m x 50 m plot will be recorded. To assess the survivorship of planted species, we will note their status: alive, dead, or missing (not planted). Because restoration activities often create conditions that favor the survivorship and natural recruitment of native plants, newly recruited native riparian woody species will also be recorded. The estimate of aerial cover of both trees and shrubs will be based on the longest diameter through the horizontal plane of the plant's drip line, a thin line at which a drop

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of water would fall from the outward most oriented leaf (River Partners and Stillwater Sciences 2009).

4.2.2 Monitoring Schedule

The riparian forest and oak woodland non-riparian native tree restoration areas will be monitored annually during Years 1 through 5 following completion of mitigation project implementation. First year monitoring will not be completed until after one full growing season for vegetation has passed since completion of construction. The implementing agency will submit an annual report at the end of each monitoring year and a final report to USFWS and other resource agencies for review and approval. These areas will be monitored annually during May or June.

The population of valley elderberry longhorn beetles, the general condition of the conservation area, and the condition of the elderberry and associated native plantings in the conservation area must be monitored over a period of either ten (10) consecutive years or for seven (7) years over a 15-year period. The applicant may elect either 10 years of monitoring, with surveys and reports every year; or 15 years of monitoring, with surveys and reports on years 1, 2, 3, 5, 7, 10, and 15. The conservation plan provided by the applicant must state which monitoring schedule will be followed. No change in monitoring schedule will be accepted after the project is initiated. If conservation planting is done in stages (i.e., not all planting is implemented in the same time period), each stage of conservation planting will have a different start date for the required monitoring time. In any survey year, a minimum of two site visits between February 14 and June 30 of each year must be made by a qualified biologist (River Partners and Stillwater Sciences 2009).

4.2.3 Photo-Documentation

The progress of the restoration areas will be documented photographically. Permanent photo-documentation stations will be established at several points throughout both sites. The locations of photo-documentation stations will be determined during the first year of the monitoring period, and the locations will be identified in the field and mapped, either on a map or by using a GPS receiver.

The number of photographs taken at a given photo-documentation station will vary, depending on the area and habitat. Photos will include panoramic views taken from a high point at the site that will not be obscured in future years by growing vegetation. A sufficient number of stations will be established to ensure that the photographs provide a visual record of the sites. Photographs will be taken during June of each monitoring year. Additional representative photographs may be taken at other times of the year at the implementing agency's discretion.

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Chapter 5
Implementation Plan

5.1 Site Preparation

5.1.1 Avoidance Measures

Site preparation during the first phase of work will involve implementing the following avoidance measure actions related to preconstruction surveys and construction staking.

- Stake the limits of the work area, including construction, staging, and access areas.
- Perform pre-construction surveys for giant garter snake, western pond turtle, nesting birds/raptors, native bats and valley elderberry longhorn beetle.
- Stake the limits of Environmentally Sensitive Areas (ESAs).
- Place protection fencing around the perimeter of ESAs.
- Place silt fencing, when appropriate, around the perimeter of ESAs.
- Perform preconstruction surveys of affected drainages.

Prior to construction, the construction contractor, under the supervision of SBFCA, will survey and stake the location of the work area and ESAs. These locations will be based on the project construction documents prepared by SBFCA and will be in accordance with this MMP.

The construction contractor will install protective fencing and/or silt fencing according to the specifications in the project construction documents around ESAs to be preserved. Protective fencing will consist of orange plastic-mesh fencing that is secured to metal T-posts. To prevent soil or sediment from entering sensitive areas, silt fencing may be installed around areas to be preserved. Silt fencing may be used in combination with protective fencing and will be installed in accordance with the Stormwater Pollution Prevention Plan that will be prepared by the contractor and the best management practices identified in the project construction documents. This silt fence will also serve as exclusion fencing to aid in preventing wildlife from entering active construction areas.

Prior to initial ground disturbance, preconstruction surveys for giant garter snake, western pond turtle, nesting migratory birds/raptors, and roosting bats will be conducted to ensure that these sensitive species are not directly or indirectly affected by restoration activities. Nesting bird and raptor surveys will be conducted no more than 14 days prior to the start of construction to ensure that no active bird nests are present within 50 feet and no raptor nests are present within 300 feet of restoration activities. A bat emergence survey will also be conducted within 14 days prior to construction to ensure that no trees supporting maternal roosts are present within or adjacent to restoration activities.

If a special-status species is identified within or adjacent to restoration activities, appropriate no-disturbance buffers will be established for breeding sites or the individual(s) will be allowed to passively move out of the construction area. Buffers will be determined by a qualified biologist, coordinating with the appropriate regulatory agency, and will depend on the species identified and

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one or more of the following factors: season of activity, level of noise or construction activity, level of ambient noise in the vicinity, and line-of-sight.

5.1.2 Pest Plant Removal

Weed control is necessary for the successful establishment of native plants and improvement of habitat. The weeds of greatest concern at the site are black mustard, yellow starthistle and pepperweed (River Partners and Stillwater Sciences 2009).

In areas to be planted with herbaceous species, spraying and mowing for an entire season before planting is recommended. Once the herbaceous species are planted, weed control methods will be mowing, possibly applying 2,4-D to control broad leaf pressure. The restoration contractor will abide by county and state herbicide permitting and reporting requirements. Roundup® (glyphosate) and 2,4-D (for broad-leaf control in native grass planting) are likely to be the most commonly used herbicides on the project. Rodeo® (for areas adjacent to water bodies), Telar® (for pepperweed control), Poast® (for post-emergence control of annual grasses in herbaceous understory planting) and Garlon™ (for woody species control) may also be used (River Partners and Stillwater Sciences 2009). No herbicide will be applied on days when wind speed is high enough to cause drift onto adjacent natural or planting areas.

Phase 2 planting areas that are within 200' of any elderberry plantings or transplants in the Phase 1 planting area will not be sprayed with any herbicide during site preparation activities. Only hand or mechanical weed removal methods will be employed in these areas.

5.1.3 Construction Monitor

An individual familiar with this mitigation and monitoring plan will supervise all phases of construction of the project. These phases may include:

- Layout of proposed other waters of the United States boundaries prior to construction.
- Placement and installation of ESA fencing.
- Site preparation/vegetation clearing operations.
- Planting and seeding operations.

The construction monitor will have authority to direct equipment operators and will submit a summary report to USACE documenting construction observations and any problems that arise.

5.2 Planting/Seeding

5.2.1 Planting Plan

A conceptual planting plan and plant palette for the SBCA is shown in Figures 3 and 4. Planting of the SBCA and FRFCRP site will consist of the following species for Elderberry mitigation, riparian mitigation, oak woodland (non-riparian native tree mitigation) and upland seed mix (Tables 5-1 through 5-4):

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Table 5-1. Plant Palette for Elderberry Mitigation Areas

Scientific Name	Common Name	Percent of Planting Mix	Plant Spacing (feet on-center)	Container Size
Sambucus mexicana	Blue elderberry	50	10' O.C.	1-gallon
Baccharis pilularis	Coyote brush	10		1-gallon
Populus fremontii	Fremont cottonwood	10		1-gallon
Rosa californica	California rose	10		1-gallon
Quercus lobata	Valley oak	10		1-gallon
Salix lasiolepis	Arroyo willow	5		1-gallon
Salix exigua	Sandbar willow	5		1-gallon

Table 5-2. Plant Palette for Riparian Mitigation Areas

Scientific Name	Common Name	Percent of Planting Mix	Plant Spacing (feet on-center)	Container Size
Populus fremontii	Fremont cottonwood	25	10' O.C.	1-gallon
Box elder	Acer negundo	12.5		1-gallon
Oregon ash	Fraxinus latifolia	12.5		1-gallon
Rosa californica	California rose	10		1-gallon
Quercus lobata	Valley oak	10		1-gallon
Salix lasiolepis	Arroyo willow	10		1-gallon
Salix exigua	Sandbar willow	10		1-gallon
Rubus ursinus	California blackberry	5		1-gallon
Cephalanthus occidental	Buttonbush	5		1-gallon

Table 5-3. Plant Palette for Oak Woodland (Non-Riparian Native Tree Mitigation Areas)

Scientific Name	Common Name	Percent of Planting Mix	Plant Spacing (feet on-center)	Container Size
Quercus lobata	Valley oak	75	10' O.C.	1-gallon
Baccharis pilularis	Coyote brush	15		1-gallon
Quercus wislizeni	Interior live oak	10		1-gallon

Table 5-4. Upland Seed Mix

Botanical Name	Common Name	Pounds Pure Live Seed Per Acre (Slope Measurement)
In-Stream Bench Seeding (Type 1)		
Leymus triticoides	Creeping wild rye	10
Hordeum brachyantherum ssp californicum	Meadow barley	12
Elymus glaucus	Blue wild rye	12
Eschscholizia californica	California poppy	2
Lupinus succulentus	Arroyo lupine	4
Triticum x Elymus	Regreen	25

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5.2.2 Nature and Source of Propagules

Container plants will be purchased from a commercial nursery located within two hours of the project site. If possible, container plants will be grown from seeds or cuttings collected at or near the project site in order to populate the site with species ecotypes that are adapted to local ecological conditions.

5.3 Irrigation

Because of the dry summers typical of the climate in the area, irrigation will be required for plant establishment and survival. Irrigation should be applied with the goal that plants will become self-sufficient by the end of the third growing season (River Partners and Stillwater Sciences 2009).

In the first growing season, the rapidly growing seedlings have roots only in the surface (the top 1–2 feet) of the soil profile. The rooting zone must be kept moist through the season to ensure optimum growth and survival. Because of the sandy soils at the site and water table depths of over 20 feet, the soil moisture of the fields planted with woody species will need to be closely monitored. The intervals between irrigations are dependent upon soil texture, depth to water table, the weather conditions, and plant water stress. Because a mixture of species with different water demands is proposed, the plants must be carefully observed to maintain a balance of soil moisture that is acceptable for xeric species like valley oak and elderberry as well as more mesic species like cottonwood and willow (River Partners and Stillwater Sciences 2009).

Prior to project implementation, a more detailed irrigation design will be developed. All irrigation water at the SBCA will be provided by an existing well located in the O'Connor Lakes Unit, near the midpoint of the eastern edge of the project area. The mainline will run west from the well (River Partners and Stillwater Sciences 2009). Irrigation water at the FRFCRP site will be supplied from existing wells on-site.

Based on knowledge of the site and plant design, the following are expected to be the requirements for the system:

- The plant spacing throughout most of the restoration and mitigation areas will be 10-foot-wide rows with a 10-foot distance down the planting rows, and rows planted in an approximate east-west direction.
- Planting rows will curve and run parallel to flood flows. The irrigation system will utilize existing wells as water sources.
- The drip-line emitters will be spaced, with three emitters per plant 12 inches apart. The design flow will be 0.6 gallons per hour per emitter (1.8 gallons per plant per hour).

Within selected areas, soil-moisture sensors will be placed throughout both planting areas. Sensors will be installed at depths of 12 and 36 inches (River Partners and Stillwater Sciences 2009).

In conjunction with these measurements, plant stress observations before and after irrigation periods will be necessary to critically judge the timeliness and effectiveness of irrigation. Measurements provide the most direct assessment of soil moisture. Table 5-5 provides the irrigation goals of the project (River Partners and Stillwater Sciences 2009).

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Table 5-5. Irrigation Goals for the Star Bend Conservation Area

Year	Goal	Frequency
1	Keep the shallow roots (1–2 feet) of young plants moist to ensure optimum growth and survival.	Utilize soil moisture probes to monitor and maintain moisture throughout the soil column.
2	Encourage deep rooting and enhance field access to facilitate weed control.	Deliver less frequent but longer irrigations.
3	Encourage deep rooting and enhance field.	Continue with long irrigations and extend the access to facilitate weed control period between irrigations.

Source: River Partners and Stillwater Sciences 2009

The strategy for the second and third year is to train the roots to grow deep. Roots at depth (5–15 feet) will need less water and may be able to tap into the water table on the site and outcompete more shallow-rooted weeds. Less frequent, deep watering will encourage roots to grow deeper, well below the roots of the weeds, allowing the tree exclusive use of this deep moisture. As the tree's roots grow deeper, the times between irrigations become longer; this allows the soil surface layers to dry, thereby reducing weed vigor (River Partners and Stillwater Sciences 2009).

We anticipate that the well-drained, sandy soils, and relatively deep groundwater present on the site, will require frequent irrigations and careful observation of water stress. These areas may dictate the frequency of watering on the site. Field managers should use a combination of methods including evapotranspiration estimates, soil probes, gypsum blocks, and plant water stress signs to assess soil moisture and alter the irrigation regime (River Partners and Stillwater Sciences 2009).

5.4 Implementation Schedule

The mitigation project would be implemented concurrent with project construction. Elderberry shrub transplant activities would take place during the dormant period. Mitigation maintenance will begin immediately following completion of the mitigation activities.

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Chapter 6
Maintenance during Monitoring Period

6.1 Maintenance Activities

6.1.1 Overall

Mitigation and riparian vegetation enhancement activities at the SBCA and FRFCRP site will be monitored by SBFCA and/or CDFW (or their designee) to determine if mitigation requirements and habitat enhancement goals and performance standards are being met. Annual monitoring of riparian vegetation establishment, including natural native plant recruitment, nonnative plant recruitment, and plant development, will determine if remedial actions are needed. Annual monitoring reports will be submitted by December 31 of each year. If monitoring reveals that performance standards are not being met, remedial activities may be implemented (River Partners and Stillwater Sciences 2009).

6.1.2 Irrigation

All planted areas within the mitigation site will be irrigated during the establishment period. Soil moisture should be checked at least twice weekly and plantings should be qualitatively assessed for signs of drought stress. All planting areas will be irrigated at least twice weekly from May through October. Irrigation event duration should be adjusted depending on soil moisture and prevailing weather conditions but should be of sufficient length to maintain vigorous plant growth and encourage deep root growth.

Between November and April soil moisture at the mitigation site will be checked twice a month, and, if necessary, the irrigation system will be run for approximately ½ hour or long enough to replenish soil moisture around the plantings in the mitigation area.

6.1.3 Invasive Plant Control

Weeding efforts will occur on a monthly basis from April to October of each year for 5 years. Weed control will consist of controlling populations of invasive weeds when they occur in the planting areas. Weed control will consist of mechanical or manual removal only. At no time will herbicides be used in the planted areas. Plant Replacement

Dead of diseased plants will be replaced immediately upon their discovery with new plants of the same size and species. Plant species substitutions will only be permitted with the prior approval of the resource manager.

6.1.4 Plant Replacement

Dead of diseased plants will be replaced immediately upon their discovery with new plants of the same size and species. Plant species substitutions will only be permitted with the prior approval of the resource manager.

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6.1.5 Irrigation System Maintenance

The resource manager will maintain the irrigation system during the plant establishment maintenance period. Maintenance will include the repair and replacement of parts, ensuring the system is delivering the required amount of water, and ensuring the system is fully operational at all times. The resource manager will regularly inspect the irrigation system, adjust and replace parts as necessary.

6.1.6 Reporting and Record Keeping

The resource manager will prepare and keep current a record of monthly maintenance performed on the project. The record will identify, at a minimum, project name, mitigation planting zones, current date and establishment period. The record will also identify and discuss weed control performed, irrigation activity and maintenance, plant health, vandalism, site feature conditions, general observations, total precipitation for the month, personnel onsite and any other pertinent information describing site conditions and activities performed during the month.

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Chapter 7
Proposed Monitoring Reports

7.1 Due Dates

USACE will notify resource agencies of the due date (month and day) for the annual monitoring report.

7.2 As-Builts

As-built planting and irrigation drawings of the mitigation areas will be prepared by the implementing agency following completion of the project. The as-built drawings will be prepared on 40-scale or larger-scale maps and will indicate the following features.

- Extent of planting areas (in plan view).
- Location of any permanent markers (e.g., identification stakes, photo documentation stations).
- Seeded areas.
- Other pertinent features.

Any changes from the original mitigation construction plans will be indicated in indelible red ink. The as-built drawings will be submitted to USACE and other resource agencies within 6 weeks of construction completion.

7.3 Annual Reports

7.3.1 File Number

Any appropriate USACE permit/file numbers will be included on correspondence, including the cover and title page of all reports.

7.3.2 Contents

The following text describes the content that will be included in the mitigation monitoring reports.

Years of Full Monitoring

Annual monitoring report will be prepared by SBFCA in accordance with USACE guidance (U.S. Army Corps of Engineers 2004 and 2006) by December 31 of each monitoring year. Each full-year monitoring report will include the following information.

- Project Information
    - Project name and a summary of the project location and description including date of project commencement and completion.

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  - Contact information for the applicant.
  - A list of the names, titles, and companies of the people who prepared the content of the annual report or participated in monitoring activities that year.
  - USACE permit file number.
  - Type and acres of impacted habitat.
  - The monitoring year.
  - Information on any required performance bonds or surety, if applicable.
- Compensatory Mitigation Site Information
  - Location of the mitigation site.
  - Purpose and goals of the mitigation.
  - Dates of mitigation site construction and completion.
  - Dates and summary of maintenance and performance monitoring visits.
  - Contact information for the responsible party for the mitigation site.
  - Summary of remedial actions, if applicable.
- Figures and Graphics
  - Location map.
  - Mitigation site map indicating restored habitats, monitoring locations, photo documentation stations, and any other pertinent site features.
- List of USACE-approved success criteria
- Monitoring Results
  - A summary and analysis of the monitoring results, including an evaluation of site conditions in the context of the performance standards and success criteria, including a comparison with previous monitoring years.
  - Summary of field data taken to determine compliance.
- Problems noted and proposed remedial measures
  - Problems noted during the course of the monitoring surveys or other site visits.
  - Management recommendations, including discussion of areas with inadequate performance and recommendations for remedial action.
- Appendices
  - Original data sheets and technical appendices, as required by USACE and other resource agencies.
  - Photo-documentation of the planting areas using photographs taken during the monitoring surveys.

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Final Monitoring Report

A final monitoring report will be submitted by SBFCA after all performance monitoring at the mitigation site is complete. The final report will be prepared by a qualified biologist and will evaluate whether the mitigation has achieved the goals and success criteria set forth in the approved MMP. The final report will be submitted within 90 days of the end of the monitoring period to USFWS and other resource agencies for review and approval.

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Chapter 8
Potential Contingency Measures

8.1 Initiating Procedures

If the final report indicates that the mitigation project has been unsuccessful, in part or in whole, based on the approved success criteria for physical and ecological functions, the implementing agency will evaluate the causes for not meeting the criteria and submit a revised or supplemental mitigation plan within 90 days of the end of the monitoring period for the review and approval of USFWS to compensate for those portions of the original program that did not meet the approved success criteria. The approved remedial measures will be developed based on the qualitative and quantitative monitoring results to determine the most effective remedy. The revised mitigation plan containing the remedial measures will be processed as an amendment to the original permit unless USFWS determines that no permit amendment is required.

If, after all remedial measures have been implemented, it becomes evident that the permit requirements cannot be satisfied according to the proposed mitigation plan, the implementing agency will coordinate with the permitting agencies to develop a contingency plan to be approved by all parties.

8.2 Contingency Funding Mechanism

USACE and SBFCA will fund any necessary contingency mitigation efforts, including additional planning, implementation, and monitoring.

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Chapter 9

Completion of Mitigation Responsibilities

9.1 Notification

USACE will notify USFWS of completion of mitigation responsibilities in conjunction with the final annual report. A minimum of 2 years will be required after the completion of all maintenance activities (e.g., irrigation, replanting, rodent control, fertilization) before final success criteria will be considered met.

9.2 USFWS Confirmation

After receiving the final monitoring report, USFWS will conduct a site visit and confirm in writing to the implementing agency that the mitigation obligations and responsibilities have been met, or if not met, describe additional actions required.

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Chapter 10
Long-Term Management

10.1 Property Ownership

The SBCA is owned in part by LD 1 and in part by CDFW. The FRFCRP site is entirely owned by TRLIA.

10.2 Management Plan

10.2.1 Purpose

This section only addresses permittee-responsible mitigation, as compensatory mitigation not addressed below will be deemed satisfied and complete through purchase of credits from a commercial mitigation bank approved by the appropriate resource agencies.

The purpose of this long-term management plan is to ensure the mitigation site is monitored and maintained in perpetuity. This management plan provides management objectives and tasks to monitor, manage, maintain and report on the mitigated natural resources. Routine monitoring and minor maintenance tasks are intended to assure the viability of the mitigation site's functions and values. This long-term management plan will take effect after the completion of the monitoring period, once it has been determined by the appropriate resource agencies that the mitigation project has achieved its project objectives and outlined performance standards for each habitat type have been reached. During the long-term management period the gradual withdrawal of the required support systems (e.g., irrigation and frequency of maintenance) for mitigation resources will begin. The goal for each mitigation site is to become fully self-sustaining. The designated resource manager(s) will oversee all long-term management activities.

10.2.2 Resource Manager

The resources managers are LD1 and DFW. The resource managers, and subsequent resource managers, upon transfer, shall implement this long-term management plan. Long-term management tasks shall be funded through the mitigation site's endowment fund. The resource manager(s) shall be responsible for providing an annual report, consisting of a description of the management tasks and total funds expended, to the appropriate resource agencies. Any subsequent modification to the mitigation sites by the resource manager(s) or their representatives must be approved by the appropriate resources agencies and the necessary permits obtained.

10.2.3 Management Approach

The general management approach to the long-term maintenance of the mitigation site will be to maintain quality habitat functions and values for each mitigated resource and on-going monitoring and maintenance of the mitigation site. When necessary, adaptive management will be used to adjust management practices, including corrective actions as determined to be appropriate by the

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appropriate resources agencies in discussion with the resource manager(s). Adaptive management includes those activities necessary to address the effects of climate change, fire, flood, or other natural events, force majeure, etc. Before considering any adaptive management changes to the long-term management plan, the appropriate resource agencies will consider whether such actions will help ensure the continued viability of the mitigation site's biological resources.

10.2.4 Long-Term Management Needs

The expected long-term management needs and activities necessary to maintain the mitigation site will be resource specific long-term maintenance activities as described below and other general maintenance activities such as exotic species elimination, clean-up and trash removal, infrastructure management such as gate, fence, road, culvert, signage and drainage-feature repair, and other maintenance activities necessary to maintain the functions and values of the mitigation site.

Biological Monitoring

Annual field surveys will be conducted to qualitatively assess and record the general conditions of the riparian, non-riparian native trees, and elderberry planting areas. General hydrology, general vegetative cover, structure and native plant diversity, invasive species, and erosion sites will be recorded, evaluated and mapped during site examinations in the spring. Notes to be made will include observations of species encountered, general condition of the planting areas, occurrences of erosion, and presence of significant populations of non-native invasive plants.

Diversity of native plant species will be maintained by replanting native species as specified in the original planting plan, or when appropriate, introduction of additional native species. Native species from various plant communities should be selected to complement natural seral processes that may take place as the mitigation site ages and matures.

Other Site Management Activities

Other site management and maintenance activities are those that may be required on an as-needed basis. Items listed below may be observed, implemented, and/or recorded during annual site observation and included in annual report to the appropriate resource agencies. Funding for these management and maintenance activities will be covered by the mitigation site's endowment fund.

General Inspections: The resource manager(s) will conduct two general site inspections each year. These inspections may take place while conducting other routine site maintenance visits. Photo documentation will be collected. Permanent photo points for taking photographs will be established, and a site map showing the photo point will be prepared for the mitigation project file. Representative photographs will be taken once per year during the same season.

Mosquito Abatement: Potential mosquito abatement issues will be addressed through the development of a plan by the resource manager(s) and the mosquito and vector control district in coordination with and approved by the appropriate resource agencies.

Trash and Trespass: At least once yearly trash will be collected and disposed within the mitigation site. Vandalism and trespass impacts will be repaired and rectified. Sources of trash and trespass will be monitored.

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Non-native Invasive Species: The resource manager(s) will monitor and maintain control over non-native invasive species, including but not limited to noxious weeds, that diminish site quality for which the mitigation project was established. The mitigation site currently functions with a number of nonnative species, some of which have become naturalized. They are predominantly annual species that occur in grasslands. It is unreasonable to require or expect eradication of established nonnative species at the site. The required management of nonnative plants therefore will be limited to the management of newly introduced invasive species and controlling the spread of existing invasive species. Methods of removing or controlling these species are outlined below.

Hand/mechanical: Hand removal or use of small hand-powered or handheld equipment (such as a Weed Wrench or a chainsaw) always should be the preferred method of removing invasive species from the mitigation properties. If hand-removal methods are found ineffective, or the problem is too widespread for hand removal to be practical, mechanical methods (use of larger equipment with motors such as mowers) or biological controls as described below can be used.

Biological controls: The county agricultural commissioner would be the point of contact for use of biological controls in the mitigation properties.

At no time will herbicides be utilized at the mitigation site.

Weeding will be done on an as-needed basis starting in March and ending in October.

Each year's annual walk-through survey (or a supplemental survey) will include a qualitative assessment (e.g., visual estimate of cover) of potential or observed noxious weeds or other non-native species invasions, primarily in or around the wetlands. Additional actions to control invasive species will be evaluated and prioritized.

Fire Hazard Reduction: Potential wildfire fuels will be reduced as needed by mowing in areas where approved by the resource agencies. The site will be maintained as required for fire control while limiting impacts to biological values. Vegetation will be mowed in areas required by authority agency(ies), and as approved by the appropriate resource agencies, for fire control.

Reporting and Administration

The resource manager(s) will provide an annual report on all management tasks conducted and general site conditions to appropriate resource agencies and any other appropriate parties. The annual report will be completed and circulated to the appropriate resource agencies and other parties by August 15 of each year. The report will make recommendations with regard to any habitat enhancement measures deemed to be necessary, any problems that need near short and long-term attention (e.g., weed removal, erosion control), and any changes in the monitoring or management program that appear to be warranted based on monitoring results to date.

10.2.5 Management Responsibilities and Plan Modification

Transfer of Management Responsibilities

Any subsequent transfer of management responsibilities under this long-term management plan to a different resource manager shall be requested in writing by the existing resource manager(s). The request shall be made to the appropriate resource agencies, which will issue written approval that shall be incorporated as an amendment into this long-term management plan. Any subsequent

property owner assumes resource manager responsibilities described in this long-term management plan and as required in the conservation easement, unless otherwise amended in writing by the appropriate resource agencies.

Amendment to Management Plan

The resource manager(s), property owner, and the resource agencies may meet and confer from time to time, upon the request of any one of them, to revise the long-term management plan to better meet management objectives and preserve the habitat functions and values of the mitigation site. Any proposed changes to the long-term management plan shall be discussed with the appropriate resource agencies and the resource manager(s). Any proposed changes will be designed with input from all parties. Amendments to the long-term management plan shall be approved by the appropriate resource agencies in writing and implemented by the resource manager(s).

10.2.6 Funding

Long-Term Funding Mechanism

An endowment will be provided by the implementing agency to CDFW who will hold the principal and interest monies as required by law in a deposit fund, or subsequent state authorized trustee fund which consists of monies that are paid into it in trust pursuant to law, and will be appropriated to fulfill purposes for which payments into it are made. These interest monies will fund the long-term management, enhancement and monitoring activities set forth by the conservation easement and consistent with this long term management plan.

The resource manager(s) shall consult with CDFW as required to determine the amount of funding available for management and monitoring activities.

10.2.7 Long-Term Conservation Mechanism

Conservation Easement

Conservation easements will be created for the portion of the SBCA owned by LD, and the entire FRFCRP site. They will act as a legal binding agreement to restrict the use of the parcel for the purpose of conserving in perpetuity the mitigated natural resources. The conservation easement will be attached to the property's fee title and apply to present and all future owners and resources managers of the mitigation site should LD1 relinquish or transfer land management responsibilities.

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Chapter 11
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Figures

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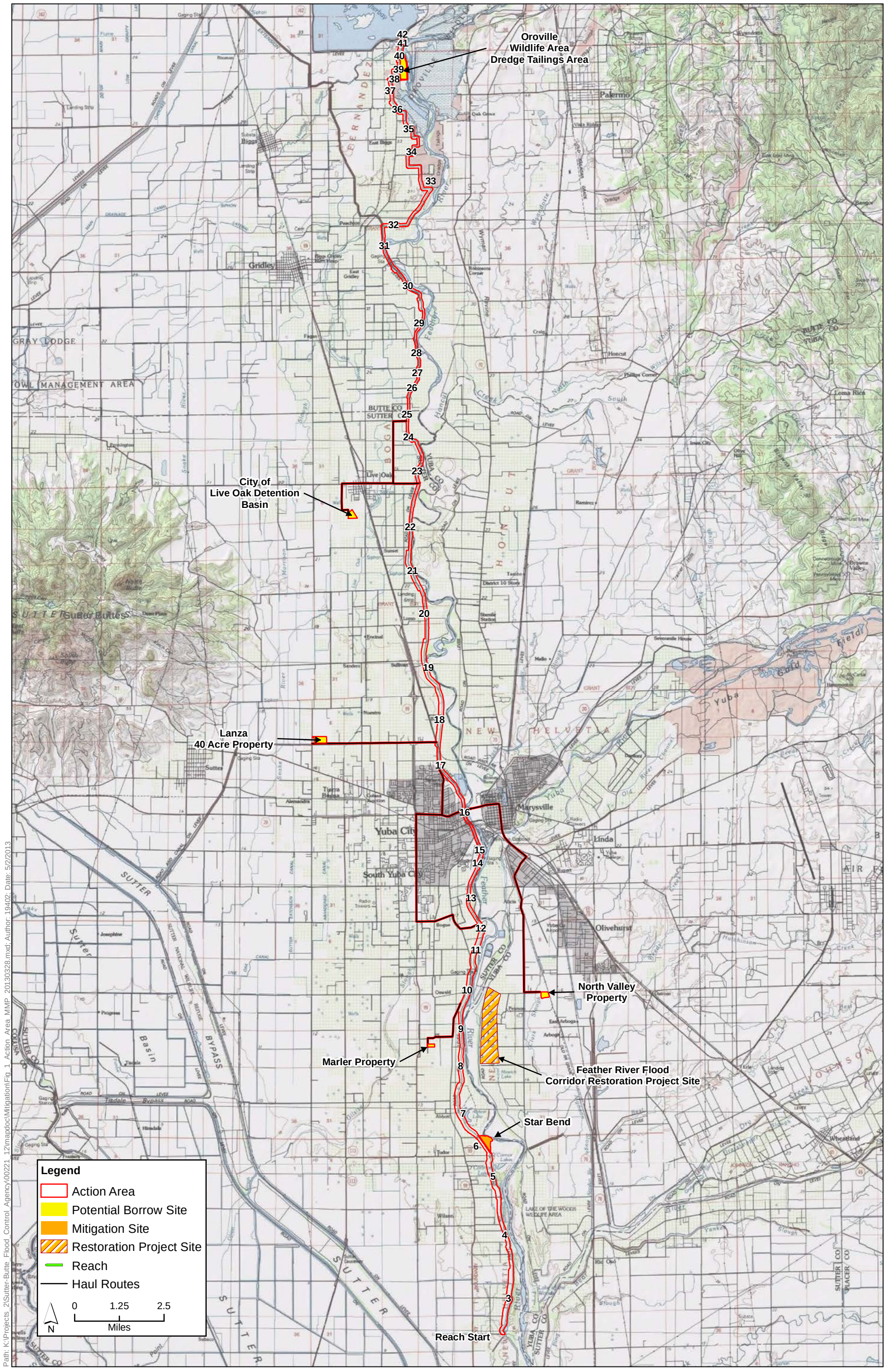

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Figure 1
Feather River West Levee Project Action Area

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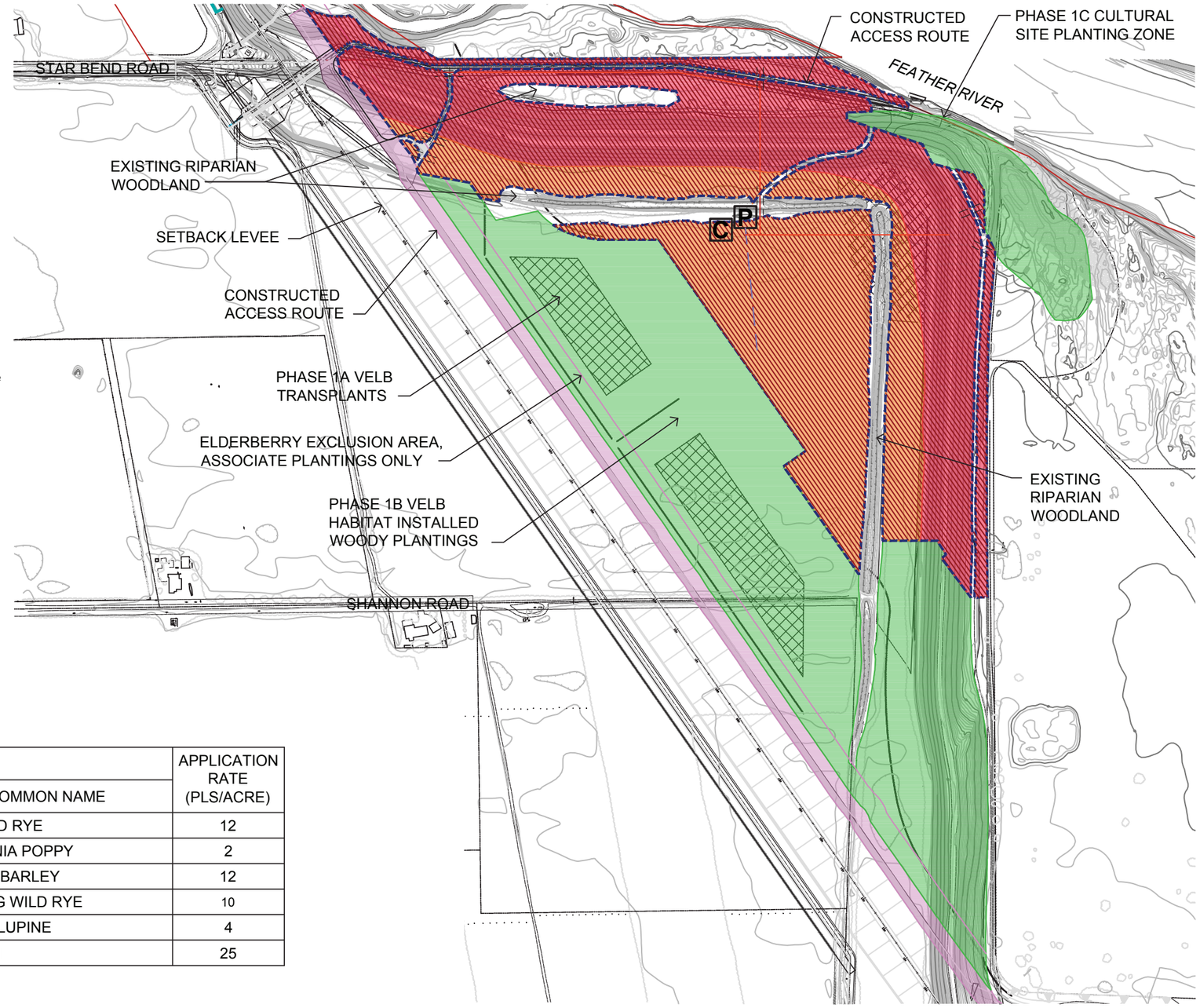
Figure 2
Star Bend Conservation Area

Legend:

- Protection Fencing
- Area of Levee Grading Disturbance
- Area of Mitigation Disturbance
- 50' Vegetation Planting Exclusion Area
- Star Bend Mitigation and Enhancement Habitat Phase 1
- Star Bend Elderberry Mitigation and Enhancement Habitat Phase 2 (11.40 acres) (Planting rows 10' apart, plants spaced per Restoration Planting Program)
- Star Bend Riparian and Non-Riparian Native Trees Mitigation and Enhancement Habitat Phase 2 (13.15 acres) (Planting rows 10' apart, plants spaced per Restoration Planting Program)
- P — Existing Well Pump with Filter, 6CLC 2 Stage Goulds Pump 7.5HP 230 Volt 3 Phase Motor Smartflow 7.5 HP VFD with 900 Series Tornado Filter
- C — Existing Irrigation Controller, Hunter ACC-1200 Controller, Mounted in lockable box adjacent to electric sub-panel
- Existing Mainline Pipe, 4" SCH 40 PVC, On-Grade
- New Mainline Pipe, 4" SCH 40 PVC, On-Grade
- New Mainline Pipe, 4" SCH 40 PVC, Below-Grade
- Sleeve, SCH 40 PVC, Below-Grade



RESTORATION SEED MIX

PLANTING ZONE	SPECIES NAME		APPLICATION RATE (PLS/ACRE)
	BOTANICAL NAME	COMMON NAME	
UPLAND SEED MIX	ELYMUS GLAUCUS	BLUE WILD RYE	12
	ESCHSCHOLIZIA CALIFORNICA	CALIFORNIA POPPY	2
	HORDEUM BRACHYANTHERUM	MEADOW BARLEY	12
	LEYMUS TRITICOIDES	CREEPING WILD RYE	10
	LUPINUS SUCCULENTUS	ARROYO LUPINE	4
	TRITICUM X ELYMUS	REGREEN	25

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Figure 3
Star Bend Conservation Area
Conceptual Planting Plan

RESTORATION PLANTING PROGRAM

PLANTING ZONE	SPECIES NAME		AVERAGE PLANT SPACING (FEET ON CENTER)	PERCENTAGE OF PLANT PALETTE	CONTAINER SIZE
	BOTANICAL NAME	COMMON NAME			
ELDERBERRY MITIGATION AREA	BACCHARIS PILULARIS	COYOTE BUSH	10' O.C.	10	1 GALLON
	POPULUS FREMONTII	FREMONT COTTONWOOD	10' O.C.	10	1 GALLON
	ROSA CALIFORNICA	CALIFORNIA WILD ROSE	10' O.C.	10	1 GALLON
	QUERCUS LOBATA	VALLEY OAK	10' O.C.	10	1 GALLON
	SALIX EXIGUA	SANDBAR WILLOW	10' O.C.	5	1 GALLON
	SALIX LASIOLEPIS	ARROYO WILLOW	10' O.C.	5	1 GALLON
	SAMBUCUS MEXICANA	MEXICAN BLUE ELDERBERRY	10' O.C.	50	1 GALLON
	TOTAL PLANT PALETTE FOR ELDERBERRY MITIGATION AREA =			100	
RIPARIAN MITIGATION AREA	ACER NEGUNDO	BOX ELDER	10' O.C.	15	1 GALLON
	CEPHALANTHUS OCCIDENTALIS	BUTTONWILLOW	10' O.C.	15	1 GALLON
	FRAXINUS LATIFOLIA	OREGON ASH	10' O.C.	10	1 GALLON
	PLATANUS RACEMOSA	CALIFORNIA SYCAMORE	12' O.C.	10	1 GALLON
	POPULUS FREMONTII	FREMONT COTTONWOOD	12' O.C.	10	1 GALLON
	QUERCUS LOBATA	VALLEY OAK	12' O.C.	5	1 GALLON
	ROSA CALIFORNICA	CALIFORNIA WILD ROSE	2' O.C. WITHIN CLUSTERS OF 5, 15' O.C. BETWEEN CLUSTERS	10	1 GALLON
	RUBUS URSINUS	CALIFORNIA BLACKBERRY	2' O.C. WITHIN CLUSTERS OF 5, 15' O.C. BETWEEN CLUSTERS	10	1 GALLON
	SALIX EXIGUA	SANDBAR WILLOW	10' O.C.	5	1 GALLON
	SALIX LASIOLEPIS	ARROYO WILLOW	10' O.C.	10	1 GALLON
	VITIS CALIFORNICA	CALIFORNIA WILD GRAPE	2' O.C. WITHIN CLUSTERS OF 5, 15' O.C. BETWEEN CLUSTERS	5	1 GALLON
	TOTAL PLANT PALETTE FOR RIPARIAN MITIGATION AREA =			100	
NON-RIPARIAN NATIVE TREE MITIGATION AREA	BACCHARIS PILULARIS	COYOTE BUSH	10' O.C.	15	1 GALLON
	QUERCUS LOBATA	VALLEY OAK	10' O.C.	75	1 GALLON
	QUERCUS WISLIZENII	INTERIOR LIVE OAK	10' O.C.	10	1 GALLON
	TOTAL PLANT PALETTE FOR NON-RIPARIAN NATIVE TREE MITIGATION AREA =			100	

NOTES:

1. IRRIGATION IS NECESSARY FOR PLANT SURVIVAL AND ESTABLISHMENT. IRRIGATION WILL BE APPLIED TO ACHIEVE SELF-SUFFICIENT PLANTS BY THE END OF THE THIRD DRY SEASON.
2. THE IRRIGATION SYSTEM WILL UTILIZE WELLS AND INFRASTRUCTURE ESTABLISHED IN PHASE 1.
3. SOIL MOISTURE PROBES WILL BE USED TO MONITOR AND MAINTAIN MOISTURE THROUGHOUT THE SOIL COLUMN. DEEP ROOTING WILL BE ENCOURAGED THROUGH DEEP WATERING WITH DIMINISHING FREQUENCY.
4. STAR BEND MITIGATION AND ENHANCEMENT HABITAT PHASE 2 IS COMPRISED OF 11.40 ACRES OF ELDERBERRY MITIGATION AND 13.15 ACRES OF RIPARIAN AND NON-RIPARIAN NATIVE TREE MITIGATION FOR A TOTAL OF 24.55 ACRES OF MITIGATION. AN ADDITIONAL 11.86 ACRES OF RIPARIAN AND NON-RIPARIAN NATIVE TREE MITIGATION WILL BE REQUIRED AT ANOTHER MITIGATION SITE TO BE DETERMINED.

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Figure 4
Star Bend Conservation Area
Conceptual Planting Plan

SUTTER BASIN PILOT FEASIBILITY STUDY DRAFT COST EFFECTIVENESS INCREMENTAL COST ANALYSIS REPORT

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March 2013

ICF International. 2013. Sutter Basin Pilot Feasibility Study Draft Cost Effectiveness and Incremental Cost Analysis Report. (ICF 00165.12) Sacramento, CA. Prepared for U.S. Army Corps of Engineers, Sacramento, CA.

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List of Acronyms and Abbreviations

CE/ICA	cost-effectiveness/incremental cost analysis
DFW	California Department of Fish and Wildlife
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
MMP	Mitigation and Monitoring Plan
Project	Feather River West Levee Project applicant-preferred alternative
SBFCA	Sutter Butte Flood Control Agency

Draft Sutter Basin Pilot Feasibility Study
Cost Effectiveness and Incremental Cost Analysis

Analysis Scope and Objective

This document is a cost effectiveness incremental analysis of the options for mitigating habitat and jurisdictional waters impacts associated with the SB 8 alternative and Sutter Butte Flood Control Agency's (SBFCA's) Feather River West Levee Project applicant-preferred alternative (Project).

For the purpose of this analysis, the two alternatives are treated the same because they are nearly perfectly congruent in construction footprint and activity, with the exceptions that SB 8 extends slightly farther to the south and has minor variations in staging and borrow areas. The difference in the southern limit is considered scalable between the two alternatives and would not represent different effect types, relative effect magnitude, or mitigation options. The differences in the staging and borrow areas is considered insignificant to this analysis because resultant habitat effects would be predominantly temporary and would not require habitat mitigation. Therefore, these differences are not discussed further in this analysis.

This analysis in presented in compliance with ER 1105-2-100 (April 22, 2000) and its included guidance on cost-effectiveness/incremental cost analysis (CE/ICA). It is intended to determine the least-cost solution for habitat mitigation for the project.

Project Description, Impacts, and Mitigation Needs

The project consists of levee improvements in a 41-mile corridor along the west levee of the Feather River from the Thermalito Afterbay downstream to approximately 3 miles north of the confluence with the Sutter Bypass. The levee improvements include mostly slurry cutoff walls with short segments of seepage berms and other location-specific measures like removal or treatment of encroachments.

Potential borrow sites that could supply the soil borrow material necessary for levee construction and upgrades, and routes from the project construction area to the borrow sites, are also included as part of the work. It is not anticipated that all sites would be used over the multi-year phased construction period but would be available for use if the need arises.

Existing Ecological Resources

Table 1 provides a summary of all existing land cover types within the Project area.

Table 1. Acreages of Existing Land Cover Types in the Project Area

Land Cover Type	Permanent Impacts for Which Mitigation Is Required?	Unit	Levee Construction Footprint [a]	Borrow Sites[a]	Total
Terrestrial					
Riparian Forest	Y	acre	252.71	9.97	262.68
Oak woodland	Y	acre	0.35	0	0.35
Orchard	N	acre	1212.89	0	1212.89
Field and row crops	N	acre	147.65	50.59	198.24
Wet agriculture (rice)	N	acre	0	348.08	348.08
Developed	N	acre	404.68	20.94	425.62
Ruderal	N	acre	903.24	82.96	986.20
Aquatic					
Freshwater emergent wetland	N	acre	0.57	0	0.57
Seasonal wetland	Y	acre	12.23	0	12.23
Open water	Y	acre	59.32	4.7	64.02
Tailing ponds	Y	acre	6.44	3.59	10.03
Stream	N	acre	0.17	0	0.17
Canal/ditch	Y	acre	22.51	0.64	23.15
Wet agriculture (rice)	N	acre	0	35.74	35.74

[a] Accuracy to 0.01 acre is subject to ±5% accuracy depending upon the accuracy of aerial imagery and topographic maps.

Significant Losses to Ecological Resources, Impact Units and Proposed Mitigation

Detailed discussion of the project impacts may be found in the Project's Environmental Impact Report/Supplemental Environmental Impact Statement (EIR/SEIS). Table 2 summarizes the project's impacts to sensitive ecological resources, impact unit of measure, and the proposed compensatory mitigation ratios and quantities.

Table 2. Anticipated Project Impacts to Sensitive Resources and Proposed Compensatory Mitigation

Impact Type	Impact Unit	Impact Quantity	Mitigation Need	Mitigation Area
Riparian Forest and Riparian Scrub Shrub	acres of cover type	42.50 acres	85.00 acres (2:1 replacement ratio[1])	85.00 acres at 10' o.c. plant spacing
Oak Woodland	acres of cover type	1.30 acres	2.60 (2:1 replacement ratio1[1])	2.60 acres at 10' o.c. plant spacing
Elderberry	individual shrubs and total stem count within each shrub	162 shrubs with 972 total stems	162 transplants, 2,466 elderberry seedlings, and 2,466 native associates	20.38 acres [2] (493 elderberry units)
Giant Garter Snake	acres of permanent impact	0.00 aquatic 3.54 acres upland	3.54 acres (3:1 replacement ratio[3])	10.62 acres
Jurisdictional Waters	acres of permanent impact	1.71 acres	3.42 acres (2:1 replacement ratio1[1])	3.42 acres

Notes:

1 Compensation ratio from USFWS Draft Fish and Wildlife Coordination Act Report.

2 Compensation acreage determined based on USFWS VELB Compensation Guidelines.

3 Compensation ratio from USFWS Programmatic Biological Opinion (U.S. Fish and Wildlife Service 1997)

Mitigation Planning Objectives and Potential Mitigation Strategies

The mitigation planning objective for this project is to provide compensatory mitigation at resource agency approved ratios for all permanent impacts to sensitive ecological resources.

There were four primary habitat mitigation solutions considered, listed below with a statement of applicability.

- **In-lieu fee program.** This option, wherein a permittee/applicant pays the permitting agency to implement mitigation at its discretion, generally has low favorability with the agencies requiring mitigation because it shifts the burden of responsibility for providing replacement habitat from the applicant/permittee to the permitting agency. It is often regarded as a "last resort" and typically applies only to very small projects and impacts where other mitigation options may not be feasible, upon negotiation with the permitting agency. Approved in-lieu fee programs may not exist for all mitigation needs in the project area. For this combination of reasons, in-lieu fee programs were not considered further as a viable solution for this project.
- **Out-of-kind replacement habitat.** This option involves replacement of habitat with a different type than that which was impacted, either on-site or off-site. Because in-kind replacement habitat is not feasible, this option was not considered further as a viable solution for this project.

- **On-site replacement habitat.** This option involves replacement of affected habitat with new habitat of the same type and at the same location as the loss. Because much of the affected habitat (specifically, woody vegetation) is not compliant in its location with USACE levee vegetation policy, this option is not considered feasible. Further, the highly dispersed nature of the impact locations makes efficient replacement infeasible. On-site replacement was not considered further as a viable option for this project.
- **Off-site, in-kind replacement habitat.** This option involves replacement of affected habitat with new habitat of the same type but at a different location than the loss. This often allows for consolidation of mitigation at a single or small number of sites, allowing for economy of scale and higher quality habitat due to large patch size. There are two sub-types:
    - **Permittee-responsible mitigation.** This option involves replacement of in-kind habitat on habitat lands operated by the permittee. Permittee-responsible mitigation is considered viable and is addressed in the Mitigation and Monitoring Plan (MMP) developed for the project.
    - **Purchase of credits at commercial mitigation banks.** This option involves replacement of in-kind habitat through purchase of credits issued for habitat lands operated by a commercial mitigation bank. Purchase of credits is considered viable and is addressed in the MMP developed for the project.

Permittee-Responsible Mitigation. Permittee-responsible offsite mitigation involves securing an appropriate mitigation site, implementing the mitigation plan, monitoring its performance, maintaining the site during the establishment period, developing a conservation mechanism, and arranging a source of funding for long-term protection of the site.

The Star Bend and TRLIA Feather River mitigation sites are existing floodplain habitat restoration sites that were created as part of the Star Bend setback levee and Feather River setback levee projects, respectively. Together, both sites contain sufficient area to accommodate all of the project's upland compensatory mitigation, consisting of mostly woody vegetation. Aquatic habitat mitigation, including giant garter snake habitat and jurisdictional waters, could be created through restoration of a rice field used for soil borrow for the project.

Table 3 provides a summary of the permittee-responsible mitigation and the anticipated costs. Appendix 1 contains detailed construction and establishment cost breakdowns for each category to establish a unit cost for equitable comparison between mitigation solutions (i.e., "apples-to-apples" comparison).

Table 3. Permittee-Responsible Mitigation Costs

Mitigation Type	Location	Quantity	Unit	Cost per Unit	Cost
Oak Woodland	Star Bend	1.30	Acres	$36,684	$47,689
Oak Woodland	TRLIA Feather River	1.30	Acres	$36,684	$47,689
Elderberry (New Plantings)/Riparian Forest Mitigation[1]	Star Bend	493	Units	$1,488	$733,584
Riparian Forest	Star Bend	4.12	Acres	$35,855	$147,722
Riparian Forest	TRLIA Feather River	60.50	Acres	$35,855	$2,169,228
Elderberry (Transplants)	Star Bend	162	Each	$1,200	$194,400
Giant Garter Snake	Restored rice field	10.62	Acres	$40,291	$427,890
Jurisdictional Waters	Restored rice field	3.42	Acres	$164,167	$561,452
				Total	**$4,329,654**

1 Riparian forest mitigation can be met through elderberry mitigation.

Mitigation Bank. Purchase of mitigation bank credits involves utilizing a commercial mitigation bank or banks to fulfill the project's compensatory mitigation obligation. The mitigation bank or banks would need to have been approved by the permitting agencies for the habitat types and service area that covers the impact.

Currently there is not one mitigation bank that can solely fulfill all of the credit types needed for the project's mitigation requirements. For the upland habitat impacts, the River Ranch Elderberry Conservation Bank, owned and operated by Wildlands, Inc., is located at the confluence of the Sacramento and Feather Rivers in Yolo County. This bank can fulfill the riparian and elderberry mitigation requirements of the project. There are currently no mitigation banks that offer oak woodland (non-riparian native tree) credits.

For the aquatic habitat impacts, the Sutter Basin Conservation Bank, owned and operated by Westervelt Ecological Services in Sutter County, is the only bank that presently offers giant garter snake credits approved by both the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife (DFW). Jurisdictional water credits are available at the River Ranch Wetland Mitigation Bank (discussed above).

Table 4 provides a summary of the agency-approved mitigation credits available at the banks in the service area of the impacts.

Table 4. Mitigation Bank Costs

Mitigation Type	Location	Quantity	Unit	Cost per Unit	Total
Oak Woodland	None	2.60	Acres	$50,000[1]	$130,000
Elderberry (New Plantings) and Riparian Forest Mitigation[2]	River Ranch Elderberry Conservation Bank	493	Units	$4,000	$1,972,000
Riparian Forest		64.62	Acres	$100,000	6,462,000
Elderberry (Transplants)		162	Each	$1,200	$194,400
Giant Garter Snake	Sutter Basin Conservation Bank	10.62	Acres	$40,000	$424,800
Jurisdictional Waters	River Ranch Wetlands Mitigation Bank	3.42	Acres	$100,000	$342,000
				Total	**$9,525,200**

[1]Estimate; no market credits are available at this time.

[2]Riparian forest mitigation can be fulfilled through purchase of elderberry credits

Summary of Results

The total cost for the permitted responsible mitigation option is $4,329,654. The total cost for the mitigation bank option is $9,525,200. On a cost per unit basis, the most cost-effective solution would be a blend between the two options, as shown below in Table 5.

Table 5. Unit Cost Comparison

Mitigation Type	Unit	Permittee-Responsible Mitigation Cost per Unit	Mitigation Bank Cost per Unit	Most Cost-Effective Solution
Oak Woodland	acre	$36,684	$50,000*	Permittee-responsible
Elderberry (New Plantings)/Riparian Tree Mitigation	unit	$1,488	$4,000	Permittee-responsible
Elderberry (Transplants)	each	$1,200	$1,200	Permittee-responsible/Mitigation bank
Giant Garter Snake	acre	$40,291	$40,000	Mitigation bank
Jurisdictional Waters	acre	$164,167	$100,000	Mitigation bank

*Estimate; no market credits are available at this time.

Therefore, in accordance with ER 1105-2-100 (Appendix E, page 153), the most cost-effective plan is a combination of permittee-responsible mitigation and purchase of credits at a commercial mitigation bank, as no other plan costs less, and no other plan yields more output for less money.

This blended solution is detailed in Table 6. The total compensation cost using this solution is about $4.6 million.

Table 6. Most Cost-Effective Mitigation Solution

Mitigation Type	Location	Quantity/ Unit	Cost per Unit	Total
Oak Woodland	Star Bend or TRLIA Feather River	2.6 acres	$36,684	$95,378
Elderberry (New Plantings)/Riparian Tree Mitigation	Star Bend	493 units	$1,488	$733,584
Elderberry (Transplants)		162 each	$1,200	$194,400
Riparian Forest	Star Bend or TRLIA Feather River	4.12 acres	$35,855	$147,722
Riparian Forest	TRLIA Feather River	60.50 acres	$35,855	$2,169,228
Giant Garter Snake	Sutter Basin Conservation Bank	22.5 acres	$40,000	$900,000
Jurisdictional Waters	River Ranch Wetlands Mitigation Bank	3.42 acres	$100,000	$342,000
Total				**$4,582,312**

There are other factors influencing favorability of this blended solution. One such factor is that oak woodland mitigation is not presently available at a bank, meaning a bank-only solution is not feasible. Moreover, enhancement of the Star Bend restoration area is favored by the permitting agencies to more fully realize the floodplain habitat potential for this area for fish and wildlife. Additionally, the Star Bend site is under joint control by one of SBFCA's member agencies (Levee District 1) and CDFW, easing issues with maintenance, ownership, and protective status in conservation. Conversely, these issues are not resolved for a permittee-responsible aquatic mitigation site, increasing the favorability of mitigation bank solution for these impacts.

Nearly half ($2.4 million) of the total mitigation cost of 4.6 million is endangered species compensation. The remainder is primarily compensation for loss of riparian forest. Riparian forest is a significant resource based on scarcity, institutional and public significance criteria. It is estimated that 95 percent of pre-European acres of riparian habitat in California's Central Valley have been lost to recent human activities.

An incremental cost analysis was not performed because there were no breakpoints where the incremental cost per unit changed dramatically with increasing cost and where less than full compensation for riparian forest may be justified based on incremental costs. In part, this was a result of using acres of habitat rather than habitat units as the output metric to compare measures.

More detailed analyses using habitat based modeling methods such as Habitat Evaluation Procedures may be performed during future design phases to ensure that significant habitat function and values are compensated for and the most cost effective and incrementally justified solution is identified.

Appendix A
Mitigation Cost Tables

Table A1. Elderberry Mitigation Costs at Star Bend

Habitat Feature	Task Description	Unit	Unit Cost	Quantity	Total Cost	Assumptions
Elderberry plantings at Star Bend (20.38 acres)	Mobilization	LS	$15,000	1	$15,000	
	Container plant	EA	$20	4,932	$98,640	Assumes 5 elderberry and 5 associates per unit (242 plants/acre)
	Irrigation system	AC	$8,500	20.38	$173,230	Assumes flood proof drip system
	Irrigation POC	EA	$15,000	1	$5,000	Assumes pumping ou of Feather River
	Maintenance Years 1-4	LS	$42,298	1	$107,462	Assumes 20% morality for Years 1-3 and 10% for Year 4
	Monitoring Years 1-10	LS	$92,400	1	$160,000	
	15% Contingency				$83,548	
	Total				**$642,880**	

Table A2. Non-Riparian Native Tree Mitigation Costs at Star Bend and TRLIA Feather River

Habitat Feature	Task Description	Unit	Unit Cost	Quantity	Total Cost	Assumptions
Oak plantings at Star Bend and TRLIA Feather River (20.14 acres)	Mobilization	LS	$15,000	2	$30,000	
	Container plant	EA	$20	10,180	$203,600	Assumes 10' O.C. spacing
	Acorn plantings	EA	$3	10,120	$30,360	Assumes 500 acorns/acre
	Irrigation system	AC	$8,500	20.14	$171,190	Assumes flood proof drip system
	Irrigation POC	EA	$15,000	1	$15,000	Assumes utilizing existing well
	Maintenance Years 1-4	LS	$107,462	1	$107,462	Assumes 20% morality for Years 1-3 and 10% for Year 4
	Monitoring Years 1-10	LS	$84,000	1	$84,000	
	15% Contingency				$97,203	
	Total				**$738,815**	

Table A3. Riparian Mitigation Costs at Star Bend

Habitat Feature	Task Description	Unit	Unit Cost	Quantity	Total Cost	Assumptions
Riparian plantings at Star Bend (9.51 acres)	Mobilization	LS	$15,000	1	$15,000	
	Container plant	EA	$20	4783	$95,660	Assumes 10' O.C. spacing
	Irrigation system	AC	$8,500	9.51	$80,835	Assumes flood proof drip system
	Maintenance Years 1-4	LS	$16,657	1	$67,887	Assumes 20% morality for Years 1-3 and 10% for Year 4
	Monitoring Years 1-10	LS	$13,950	1	$37,200	
	15% Contingency				$44,475	
	Total				$340,977	

Table A4. GGS Mitigation at Generic Permittee-Responsible Site

Habitat Feature	Task Description	Unit	Unit Cost	Quantity	Total Cost	Assumptions
GGS (7.5 acres aquatic and 15 acres upland)	Land cost	AC	$7,500	22.5	$168,750	
	Mobilization	LS	$15,000	1	$15,000	
	Grading	CY	$4	36,300	$145,200	Assumes 3' of cut over 7.5 acres and on-site spoils disposal
	Seeding	AC	$1,000	22.5	$22,500	Assumes seeding over all 22.5 acres
	Planting	EA	$3	15,090	$45,270	Assumes plug planting at 5' O.C. over 7.5 acres
	Erosion control	LS	$5,000	1	$5,000	
	Design and permitting	LS	$46,594	1	$46,594	Assumes 20% of construction costs
	GGS monitoring	YR	$8,000	5	$40,000	
	Endowment	LS	$300,000	1	$300,000	Assumes $6,000/year for long term maintenance and monitoring at 2% annual return on principal
	15% Contingency				$118,247	
	Total				**$906,561**	

Table A5. Jurisdictional Habitat Mitigation at Generic Permittee-Responsible Site

Habitat Feature	Task Description	Unit	Unit Cost	Quantity	Total Cost	Assumptions
Wetlands and waters (3.42 acres)	Land cost	AC	$7,500	6	$45,000	Assumes approximately 2.5 acres of upland for spoils disposal and buffer
	Mobilization	LS	$15,000	1	$15,000	
	Grading	CY	$4	16,552	$66,208	Assumes 3' of cut over 3.41 acres and on-site spoils disposal
	Seeding	AC	$1,000	6	$6,000	Assumes seeding over all 6 acres
	Planting	LS	$3	9,309	$27,927	Assumes plug planting at 5' O.C. over 3.42 acres
	Erosion control	LS	$5,000	1	$5,000	
	Design and permitting	LS	$24,027	1	$24,027	Assumes 20% of construction costs
	Wetland monitoring	YR	$12,000	5	$60,000	
	Endowment	LS	$200,000	1	$200,000	Assumes $4,000/year for long term maintenance and monitoring at 2% annual return on principal
	25% Contingency				$112,290	
	Total				**$561,452**	

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PROGRAMMATIC AGREEMENT
AMONG
THE U.S. ARMY CORPS OF ENGINEERS AND
THE CALIFORNIA STATE HISTORIC PRESERVATION OFFICER,
REGARDING
THE SUTTER BASIN FEASIBILITY STUDY

WHEREAS, the U. S. Army Corps of Engineers, Sacramento District (Corps), is proceeding with the Sutter Basin Feasibility Study, and the Corps has determined that the study and subsequent approved project alternatives (Project) constitute an Undertaking as defined in the Advisory Council on Historic Preservation Procedures 36 CFR § 800.16(y); and

WHEREAS, the purpose of the Sutter Basin Feasibility Study is to address Flood Risk Management in conjunction with Ecosystem Restoration and Recreation. The study area is located in Sutter and Butte Counties California and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The study area covers approximately 300 square miles and is approximately 43 miles long and 9 miles wide. The study area includes the communities of Yuba City, Live Oak, Gridley, Biggs, and Sutter. A map of the study area is included as Appendix 1 to this Programmatic Agreement (PA).

WHEREAS, the Undertaking is authorized under the Flood Control Act of 1962 (Public Law 87-874), that provides the Corps the authority to study flood risk management and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties; and

WHEREAS, The Corps has determined that effects on properties that are either included in, or are eligible for inclusion in the National Register of Historic Places (NRHP) cannot be fully determined prior to completion of the Sutter Basin Feasibility Study and selection of approved alternatives; this agreement addresses all phases and segments of the Project; and

WHEREAS, the Corps has consulted with the California State Historic Preservation Officer (SHPO) and offered the Advisory Council on Historic Preservation (ACHP) the opportunity to consult pursuant to Section 106 of the National Historic Preservation Act of 1966 (Section 106), and the implementing regulations described under 36 CRF Part 800; and

WHEREAS, by letter dated March 13, 2012, the ACHP declined to participate in the consultation.

WHEREAS, the Corps has consulted with the non-Federal cost-sharing agencies, the Sutter Butte Flood Control Agency and the Central Valley Flood Protection Board, and has invited them to participate as concurring parties; and

WHEREAS, the Corps has contacted the Mechoopda Indian Tribe of Chico Rancheria, the Greenville Rancheria of Maidu Indians, the Maidu Nation, the Butte Tribal Council, the Mooretown Rancheria of Maidu Indians, the United Auburn Indian Community of the Auburn Rancheria, the Maidu Cultural and Development Group, the KonKow Valley Band of Maidu, the T'Si-akim Maidu, the Strawberry Valley Rancheria, the Berry Creek Rancheria of Maidu Indians, the Enterprise Rancheria of Maidu Indians, and other Native individuals; and invited them to consult on this agreement; and

WHEREAS, the Corps has consulted with the United Auburn Indian Community of the Auburn Rancheria, the Estom Yumeka Maidu Tribe of the Enterprise Rancheria, and the Mechoopda Indian Tribe

of Chico Rancheria who have indicated their interest in participating in this agreement and are invited to participate as concurring parties; and

WHEREAS, the definitions set forth in 36 CFR § 800.16, with amendments effective August 5, 2004, are incorporated herein by reference and apply throughout this PA;

NOW, THEREFORE, the Corps and the SHPO agree that the proposed undertaking shall be implemented in accordance with the following stipulations in order to take into account the effects of the undertaking on historic properties and to satisfy the Corps' Section 106 responsibilities for all individual aspects of the undertaking.

STIPULATIONS

The Corps shall ensure that the following measures are carried out:

Stipulation I
Professional Qualification

The Corps shall ensure that historic, architectural, and archaeological work conducted pursuant to this agreement is carried out by, or under the direct supervision of, a person or persons who meet the qualifications set by the Secretary of the Interior for Archaeology and Historic Preservation under 36 CFR Part 61.

Stipulation II
Area of Potential Effects

A. Should the Corps determine that an undertaking is warranted and alternatives are defined, the Corps shall define and document the area of potential effects for all defined alternatives (APE) in consultation with SHPO. If future project design requires redefining the APE, the Corps shall consult with SHPO in a timely manner to amend the APE.

B. The APE shall include the footprint of all construction activities, staging areas, haul roads, and mitigation sites. The APE may also include sensitive structures within range of vibratory or sonic disturbances, and historic properties and districts close enough to project construction that the integrity of their setting or feeling could be affected.

C. The APE may include portions of the study area indicated on the map included as Appendix 1.

Stipulation III
Identification and Evaluation

A. The study is intended to determine the feasibility of a federal action. In the course of making that determination the Corps shall consider the probability of an action effecting historic properties by consulting with Native American groups and reviewing pertinent archaeological records and literature.

B. The Corps shall acquire a current and complete records and literature search from the Northeast Information Center at California State University, Chico prior to conducting archaeological surveys of the

APE. Records and literature searches shall be considered complete and current for a period of three years after they are conducted unless, in the professional opinion of Corps archaeologists, more frequent updates are required.

C. The Corps shall consult with Native American groups and individuals, identified as described in Stipulation V (A), to identify properties that are of religious and cultural significance to them and that may be eligible for the National Register. Traditional Cultural Properties will be evaluated following the guidance presented in National Register Bulletin 38: *Guidelines for Evaluating and Documenting Traditional Cultural Properties*.

D. The Corps shall complete and report the results of all required cultural resources inventories of the undertaking's APE in a manner consistent with the "Secretary of the Interior's Standards and Guidelines for Identification" (48 FR 44720-23) and take into account the National Park Service's publication, "The Archeological Survey: Methods and Uses" (1978: GPO stock #024-016-00091). Inventories shall include both archaeological surveys and inventories of historic buildings, structures, and districts as appropriate. The Corps shall include a geoarchaeological evaluation of the APE in its survey and shall undertake subsurface reconnaissance as appropriate. Surveys shall include areas not previously surveyed and areas where the Corps, in consultation with SHPO, deems previous surveys to be inadequate. The Corps will also include additional areas that may be affected by changes in the project design, borrow areas, haul roads, staging areas, extra work space, mitigation sites, and other ancillary areas related to the undertaking. If identified cultural resources do not need to be evaluated but can be determined eligible based on the results of the survey, context statements, and historic documentation, then the Corps may request SHPO concurrence with those determinations at that time. The Corps shall submit reports produced as a result of intensive surveys to SHPO for review. The Corps shall deliver its submissions to the SHPO in the most expeditious manner possible: by electronic means such as email or fax; or hand delivery. SHPO shall have 15 calendar days after receipt to provide comments to the Corps.

E. The Corps shall include in its site recordation documents all unrecorded archaeological sites, linear features, and isolates encountered in the course of the survey. The Corps shall prepare updated records of previously recorded sites as necessary. The Corps' survey shall record all prehistoric sites and all historical sites, structures, buildings, and engineering features greater than forty-five (45) years of age. Historic sites to be recorded shall include, but not be limited to: commercial, residential, and ecclesiastical buildings, roads, trails, bridges, levees, culverts, and agricultural features, including ditches.

F. The Corps shall use the California Department of Parks and Recreation (DPR) form 523 to record all newly discovered historic or prehistoric archaeological sites and isolates, previously recorded archaeological sites, and where necessary, shall create updated site records using the DPR 523 form. Isolates shall be numbered sequentially, plotted on a map, and recorded on a single table within the report. The Corps shall examine non-linear sites that extend outside of the APE in their entirety unless access to land is prohibited or the scale of the resource makes doing so prohibitive. In the event access cannot be gained, the Corps shall consult with SHPO regarding appropriate means of evaluating a given site. The Corps shall record linear resources (i.e., railroad, road, trail, ditch, levee, etc.) that appear on GLO plat maps or are known from other archival data to be potentially significant, or which have associated features or dateable artifacts on DPR 523 site forms. The Corps will treat linear resources not mentioned on GLO plat maps or that appear on GLO plat maps but which are not associated with features or dateable artifacts, or do not otherwise appear to be significant on the basis of known archival data as "isolated feature segments" and shall record them in tabular form and shall include at a minimum a basic GPS map of the linear feature within the APE. Historic structures and buildings shall be recorded using the State Historic Preservation Office, Historic Resources Inventory form.

G. If the selected project alternative would involve impacts to Federal levees, the levees will be treated as though they were eligible for inclusion in the National Register of Historic Places or an Evaluation Plan (EP) will be developed to provide for consistent and thorough evaluation. If the Corps elects to prepare an EP, the analysis in the EP shall consider the levees in the context of the entire Feather River levee system. Additionally, the EP shall include clear and specific criteria for determining both (1) contributing and non-contributing elements of the levee system and (2) thresholds of adverse effect. Should the Corps, in consultation with the SHPO, determine that a given levee is eligible for the NRHP; a Historic Property Treatment Plan, as described unber Stipulation VI, shall be produced for that property.

H. The Corps shall ensure that EPs prepared for previously unevaluated cultural resources identified within the APE are consistent with the "Secretary of the Interior's Standards and Guidelines for Evaluation" (48 FR 44723-26). The Corps shall develop individual EPs to address different categories of potentially eligible historic properties. The Corps shall develop a Discovery Evaluation Plan (DEP) and a Construction Monitoring Plan (CMP) as components of an EP. An EP shall be used whenever the Corps, in consultation with the SHPO, determines that a cultural resource should be evaluated and use of the EP is essential to determine the boundaries and data potential of the site. If the Corps undertakes any archaeological testing, such testing shall be sufficient to define and delineate the site clearly, and to determine the site's eligibility for inclusion in the NRHP.

I. The Corps shall submit the EP for concurrent review to the SHPO and appropriate Native American groups. The Corps shall deliver its submissions in the most expeditious manner possible: by electronic means such as email or fax; or hand delivery. The Corps shall allow reviewers 30 calendar days after receipt to comment on the draft EP. The Corps shall ensure that any comments received within that time period are taken into account and incorporated into the final EP. If the Corps cannot concur with comments made by SHPO and/or Native American groups, the Corps will resolve the dispute in accordance with Stipulation XIII. Failure of the SHPO to comment within the specified time period shall not preclude the Corps from finalizing and implementing the draft EP. The Corps shall ensure that the SHPO is expeditiously provided with copies of the final EP.

J. The Corps and the SHPO may develop standard protection plans (SPP) for classes of resources that occur commonly in the APE and that may be encountered unexpectedly during construction. SPPs shall include a clear description of the class or classes of resources covered and the specific actions that the Corps will take to mitigate or avoid adverse effects to those resources.

K. The Corps shall submit all SPPs for concurrent review to the SHPO and appropriate Native American groups. Submissions shall be delivered in the most expeditious manner possible: by electronic means such as email or fax; or hand delivery. The Corps shall allow reviewers 30 calendar days after receipt to comment on the draft SPP. The Corps shall ensure that any comments received within that time period are taken into account and incorporated into the final SPP. If the Corps cannot concur with comments made by SHPO and/or Native American groups, the Corps will resolve the dispute in accordance with Stipulation XIII. Failure of the SHPO to comment within the specified time period shall not preclude the Corps from finalizing and implementing the draft SPP. The Corps shall ensure that the SHPO is expeditiously provided with copies of the final SPP.

L. The Corps, in consultation with SHPO, shall ensure that determinations of eligibility are made in accordance with the criteria set forth in 36 CFR §60.4 for all properties not covered by an SPP, within the APE, that would be affected by the Project; including additional areas that may be affected by changes in the project design, borrow areas, haul roads, staging areas, extra work space, mitigation sites, and other ancillary areas related to the undertaking. If the Corps and the SHPO cannot agree on the eligibility of a property for the NRHP, the Corps shall obtain a determination from the Keeper of the National Register

in accordance with 36 CFR Part 63. The determination of the Keeper shall be final for purposes of this PA. Any other disputes shall be settled following the procedure set forth under Stipulation XIII

Stipulation IV
Determinations of Effect

The Corps shall apply the Criteria of Adverse Effect pursuant to 36 CFR §800.5(a) (1) to all historic properties within the APE that will be affected by the Project. The Corps shall make determinations of effect in consultation with the SHPO and other interested parties. If the Corps determines that the project will result in no adverse effects to historic properties then the Corps may issue a notice to proceed with construction. If adverse effects are unavoidable, the Corps shall develop a Historic Properties Treatment Plan following the procedure set forth under Stipulations VI and VII.

Stipulation V
Non-Federal Stakeholder Involvement

A. The Corps will identify potentially interested Native American groups in consultation with the Native American Heritage Commission (NAHC). In consultation with appropriate Indian groups and the NAHC, the Corps will identify historic properties of traditional religious and cultural importance.

B. Following the guidance provided in National Register Bulletin 38, the Corps shall seek comments from all potentially interested Native American groups when making determinations of eligibility for any Traditional Cultural Properties.

C. The Corps has consulted with the Sutter Butte Flood Control Agency and the Central Valley Flood Protection Board in the development of this agreement. Both agencies are concurring parties and will be given the opportunity to comment on the identification and treatment of historic properties.

D. The Corps shall give members of the public an opportunity to comment on the identification and treatment of historic properties.

E. The Corps shall allow all reviewers 15 calendar days after receipt to provide comments to the Corps. The Corps shall ensure that any comments received during this time period are taken into account and incorporated into the final survey and evaluation reports. Disputes shall be resolved by the Corps in accordance with Stipulation XIII.

F. Pursuant to Section 36 CFR § 800.6(c)(2-3) of the ACHP's regulations, the Corps shall consider requests by consulting parties and others to become concurring parties to this Programmatic Agreement.

Stipulation VI
Preparation of Historic Property Treatment Plans

The Corps, in consultation with SHPO shall ensure that a Historical Property Treatment Plan (HPTP) is developed for the mitigation of anticipated effects on historic properties that will result from the Project. Further, the Corps, in consultation with SHPO, will ensure the development of location and property specific Data Recovery Plans.

A. Avoidance of adverse effects on historic properties is the preferred treatment approach. The

HPTP shall discuss and justify the chosen approaches to the treatment of project historic properties and those treatment options considered, but rejected. If preservation of part or all of any historic properties is proposed, the treatment plan shall include discussion of the following:

1. Description of the area or portions of the historic properties to be preserved in-place, and an explanation of why those areas or portions of sites were chosen;
2. Explanation of how the historic properties will be preserved in-place, including both legal and physical mechanism for such preservation;
3. A plan for monitoring and assessing the effectiveness of mechanisms to preserve the historic properties; and
4. A plan for minimizing or mitigating future adverse effects on the historic properties if preservation in-place mechanisms prove to be ineffective.

B. When avoidance is not feasible, the Corps, in consultation with the SHPO, shall ensure the development of an appropriate treatment plan designed to lessen or mitigate project-related effects to historic properties. For properties eligible under criteria described in 36 CFR §60.4(a) through (c), the Corps may consider mitigation other than data recovery in the treatment plan (e.g., HABS/HAER recordation, oral history, historic markers, exhibits, interpretive brochures or publications, etc.). Where appropriate, the Corps shall include provision in the treatment plans (content and number of copies) for a publication for the general public.

C. When data recovery is proposed, the Corps in consultation with the SHPO, shall ensure the development of a data recovery plan that is consistent with the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation and the ACHP's "Recommended Approach for Consultation on Recovery of Significant Information from Archaeological Sites" (ACHP June 17, 1999). Components to be included in research designs and data recovery plans are found in Appendicies 2 and 3 to this PA.

D. Each phase or segment specific treatment plan shall relate directly to the HPTP prepared for the project, providing specific direction for the conduct of data recovery within any project segment. Appendix 3 lists components to be included in data recovery plans.

E. The Corps shall invite the interested public, including Native American groups to provide input on the identification, evaluation, and proposed treatment of historic properties. The Corps shall involve the interested public through letters of notification, public meetings, and/or site visits as the Corps deems appropriate.

Stipulation VII
Review of Treatment Plan

The Corps shall ensure that draft HPTPs are submitted concurrently to the SHPO, the ACHP, and appropriate Native American groups and individuals for review and comment. The Corps shall allows reviewers 30 calendar days after receipt of the draft HPTP to provide comments to the Corps. The Corps shall ensure that any comments received during this time period are taken into account and incorporated into the final HPTP. In the event that disputes are not easily remedied, the Corps shall resolve them in accordance with Stipulation XIII. Failure to comment within this time period shall not preclude the Corps from finalizing and implementing the HPTP. The Corps shall ensure that all reviewers are expeditiously provided copies of the final HPTP.

A. If the Corps revises the HPTP, it shall allow any party, including the SHPO, 15 calendar days to review the revised HPTP. Failure of the SHPO to comment within the specified time period shall not preclude the Corps from finalizing and implementing the revised HPTP in accordance with the terms of this stipulation.

B. Once the reviewing parties determine that the HPTP is adequate, the Corps shall issue authorization to proceed with the implementation of the plans.

C. The Corps shall provide final drafts of the HPTP to SHPO and the ACHP.

Stipulation VIII
Modifications of Project Scope

A. Identification and Evaluation

1. If modification of the project scope becomes necessary or if activities are proposed in ancillary areas (AAs) such as borrow or disposal areas that have not been previously surveyed for historic properties, the Corps shall ensure that the APE, defined as described under Stipulation II (B), of the modified project or un-surveyed AA is inventoried. Any properties located within those modified APEs that may be affected by the undertaking shall be evaluated.

2. The Corps shall identify and evaluate such properties in the manner specified in Stipulations II through IV.

3. If the Corps discovers any historic properties eligible for listing on the NRHP in the modified APE, the Corps shall develop and implement a supplemental HPTP in the manner specified in Stipulations VI and VII.

B. The Corps may authorize construction in any area subject to the provisions of this stipulation after the Corps and the SHPO have consulted and agreed in writing that such construction either will not affect historic properties, or that the area does not contain historic properties.

Stipulation IX
Notices To Proceed With Construction

A Notices to Proceed (NTP) may be issued by the Corps for individual construction segments, defined by the Corps in its construction specifications, under any of the following conditions:

1. the Corps and SHPO have determined that there are no historic properties within the APE for a particular construction segment; or

2. the Corps and SHPO have determined that there will be no adverse effects caused to historic properties within the APE for a particular construction segment; or

3. the Corps after consultation with the SHPO and interested persons has implemented an adequate treatment plan for the construction segment, and

(a) the fieldwork phase of the treatment option has been completed; and

(b) The Corps has accepted and approved a summary of the fieldwork performed and a reporting schedule for that work.

Stipulation X
Unanticipated Discovery of Historic Properties

If historic properties potentially eligible for the NRHP are discovered during construction, the Corps shall cease ground disturbing activities until it has satisfied the provisions of 36 CFR §800.13(b), "discoveries without prior planning". The Corps shall provide the SHPO and the ACHP an opportunity to review and comment on proposed treatment in accordance with Stipulation VII. The Corps shall contact the SHPO within 48 hours of the discovery. The SHPO has 48 hours to respond following initial contact by the Corps.

Stipulation XI
Curation

The Corps shall ensure that all cultural materials and associated records resulting from identification, evaluation, and treatment efforts conducted under this PA are curated in accordance with 36 CFR Part 79, except as specified in Stipulation XII. Archaeological items and materials from privately owned lands to be returned to their owners should be maintained in accordance with 36 CFR Part 79 until any specified analyses are complete.

Stipulation XII
Native American Consultation and Treatment of Human Remains

A. The Corps shall ensure that the Indian groups identified above are invited to participate in the development and implementation of the terms of this PA. The specific manner in which this Native American involvement will occur shall be set forth in the HPTPs.

B. The Corps shall ensure that Native American human remains, grave goods, items of cultural patrimony, and sacred objects encountered during the undertaking that are located on state or private land are treated in accordance with the requirements California State Health and Safety Code, Section 7050.5, NRS 383.

C. The Corps shall ensure that Native American human remains, grave goods, items of cultural patrimony, and sacred objects encountered during the undertaking that are located on federal or tribal land are treated in accordance with the requirements of the requirements California State Health and Safety Code, Section 7050.5, NRS 383, and the Native American Graves Protection and Repatriation Act of 1990, as amended.

Stipulation XIII
Dispute Resolution

A. Should any signatory to this PA object within 15 calendar days to plans provided for review pursuant to this PA or to actions proposed or carried out pursuant to this PA, not including determinations of NRHP eligibility (see Stipulation III [J]), the Corps shall notify the SHPO and consult to resolve the objection. If the Corps determines that the objection cannot be resolved, the Corps shall forward all documentation relevant to the dispute to the ACHP. Within 45 days after receipt of all pertinent documentation, the ACHP shall either:

1. Provide the Corps with recommendations that the Corps shall take into account in reaching the final decision regarding the dispute; or

2. Notify the Corps that it will comment pursuant to 36 CFR §800.7, and proceed to comment. Any ACHP comment provided in response to such a request shall be taken into account by the Corps in accordance with 36 CFR §800.7 with reference to the subject of the dispute.

B. Any recommendation or comment provided by the ACHP will be understood to pertain only to the subject of the dispute. The Corps's responsibility to carry out all actions required by this PA that are not subject of the dispute shall remain unchanged.

Stipulation XIV
Amendments, Noncompliance, and Termination

A. If any signatory believes that the terms of this PA cannot be carried out or are not being met, or that an amendment to its terms should be made, that signatory shall immediately consult with the other signatories to consider and develop amendments to this PA pursuant to 36 CFR §800.6(c)(7)

B If this PA is not amended as provided for in this stipulation, the Corps, or the SHPO may terminate it. The party terminating the PA shall in writing provide all other signatories with an explanation of the reasons for termination in accordance with §800.6(c)(8).

C. If this PA is terminated and the Corps determines that the undertaking authorizing the project will proceed, the Corps shall comply with 36 CFR §800.3-800.6.

Stipulation XV
Duration of the PA

A. Five years after the execution of the PA, the signatories shall meet to discuss project progress and efficacy of the PA. Signatories will have the option to implement modifications or revisions to the PA at this point.

B. If the project has not been implemented within ten (10) years of the date of execution of the PA and the PA has not been terminated, the signatories shall consult on a date not less than 90 days prior to the tenth anniversary of the execution of this PA to reconsider its terms. Reconsideration may include continuation of the PA as originally executed, amendment, or termination. If the PA is terminated because the undertaking no longer meets the definition of an "undertaking" set forth in 36 CFR §800.16(y), Stipulation XIV (C) shall apply.

C. This PA shall be in effect through the Corps's implementation of the undertaking, and shall terminate and have no further force or effect when the Corps, in consultation with the SHPO, determines that the terms of this PA have been fulfilled in a satisfactory manner and/or Corps involvement in the project has ended. The Corps shall provide the other signatories with written notice of its determination and of termination of this PA.

Stipulation XVI
Effective Date

This PA shall take effect on the date that it has been fully executed by the Corps and the SHPO.

EXECUTION of this PA by the Corps, the SHPO, and the ACHP, and its transmittal to the ACHP, and subsequent implementation of its terms evidence that the Corps has afforded the ACHP an opportunity to comment on the undertaking and its effects on historic properties, that the Corps shall take into account the effects of the undertaking on historic properties, and that the Corps has satisfied its responsibilities under Section 106 of the National Historic Preservation Act and applicable implementing regulations for all aspects of the undertaking.

SIGNATORIES:

U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT

BY: _____ DATE: 30 APRIL 2012

William J. Leady, P.E., Colonel, U.S. Army Corps of Engineers, District Commander

CALIFORNIA STATE HISTORIC PRESERVATION OFFICE

BY: _____ DATE: 6/8/12

for Milford Wayne Donaldson, FAIA, State Historic Preservation Officer

CONCURRING PARTIES:

SUTTER BUTTE FLOOD CONTROL AGENCY

BY: _____ DATE: _____

TITLE:

STATE OF CALIFORNIA DEPARTMENT OF WATER RESOURCES, ACTING BY AND THROUGH THE CENTRAL VALLEY FLOOD PROTECTION BOARD

BY: _____ DATE: _____

TITLE:

MECHOOPDA INDIAN TRIBE OF CHICO RANCHERIA

BY: _____ DATE: _____

TITLE:

UNITED AUBURN INDIAN COMMUNITY OF THE AUBURN RANCHERIA

BY: _____ DATE: _____

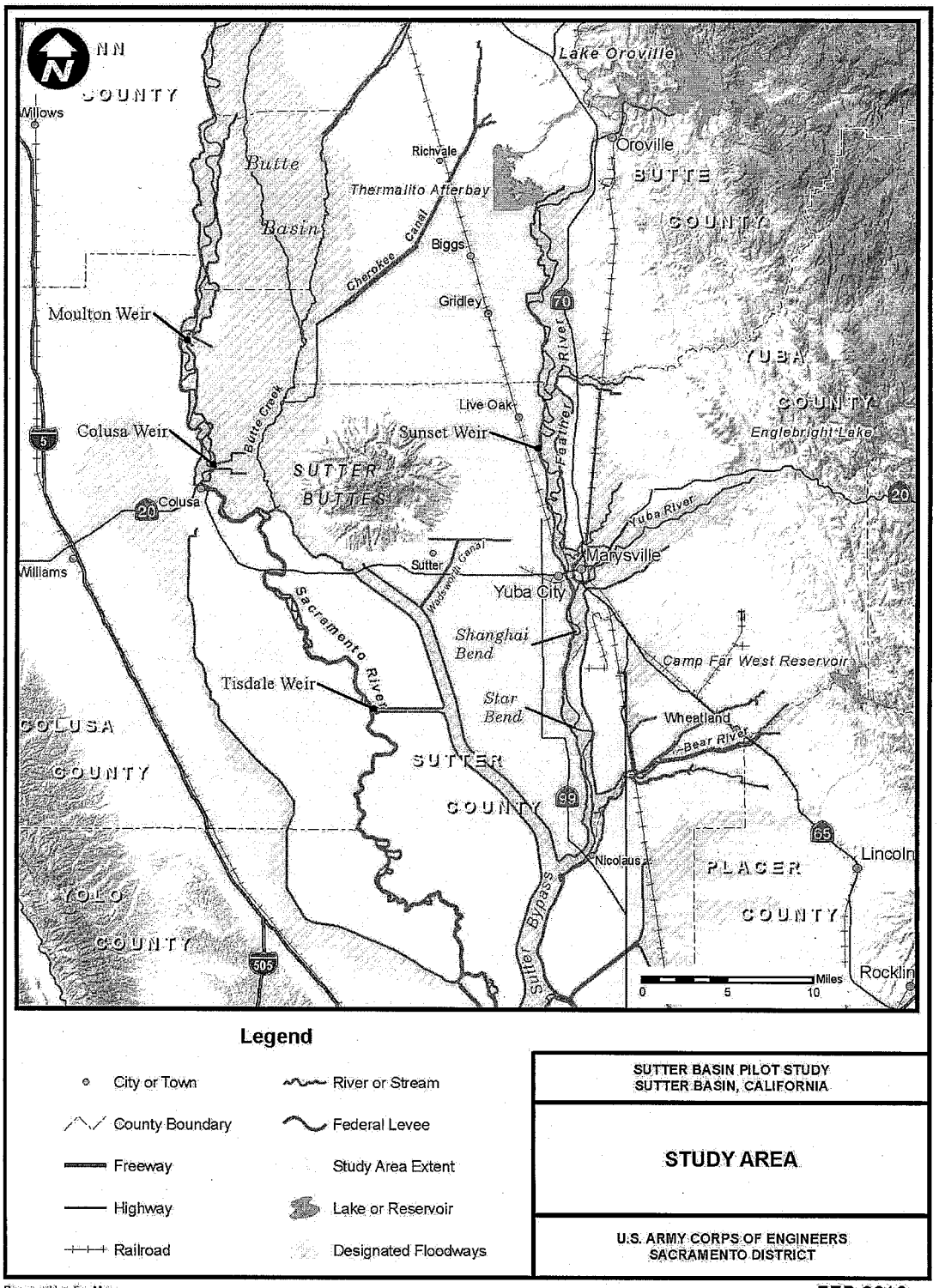
TITLE:

ESTOM YUMEKA MAIDU TRIBE OF ENTERPRISE RANCHERIA

BY: _____ DATE: _____

TITLE:

Appendix 1
Study Area Map



Prepared by Jim Mars

FEB 2012

Appendix 2
Standards and Guidelines for Research Designs

Research designs prepared for this undertaking shall specify, at a minimum:

- The property, or properties, or portions of properties where data recovery is to be carried out;
- Any property, or properties or portions of properties that will be destroyed with data recovery;
- The research questions to be addressed through the data recovery, with an explanation of their relevance and importance;
- The methods to be used, with an explanation of their relevance to the research questions;
- The methods to be used in analysis, data management, and dissemination of data, including a schedule;
- The proposed disposition of recovered materials and records;
- Proposed methods by which the parties to the Programmatic Agreement will be kept informed of the work and afforded the opportunity to participate; and
- A proposed schedule for the submission of progress reports to the California State Historic Preservation Officer.

Appendix 3
Historic Property Treatment Plans (HPTP) shall address:

- The historic properties or portions of historic properties where treatment will be implemented;

- Any historic properties or portions of historic properties that will be destroyed or altered without treatment;

- If the property or properties are eligible under criteria (a), (b), or (c), a mitigation plan other than data recovery may be considered. These may include, but are not limited to HABS/HAER recordation, oral history, historic markers, exhibits, interpretive brochures or publications.

- If the property or properties are eligible under criterion (d), a research design including the research questions and goals that the data recovery on a property could inform, an explanation of the theoretical and substantive relevance and importance of the proposed research, and specifically how the proposed actions will inform those questions and goals;

- The field and analysis methods to be used, with an explanation of their relevance to the goals of the mitigation;

- The methods to be used in data management and dissemination of data, including a schedule;

- The proposed disposition of recovered materials and records;

- Proposed methods for disseminating results of work to cultural resources professionals and separately to the interested public;

- Proposed methods by which appropriate Native American groups and individuals, local governments, and other interested persons will be kept informed about implementation of the HPTP and afforded an opportunity to comment;

- A proposed schedule for submission of progress reports to the Corps, SHPO, and the Council;

- Methods and procedures for the recovery, analysis, treatment, and disposition of human remains, associated grave goods, and objects of cultural patrimony that reflect any concerns and/or conditions identified as a result of consultations between the Corps and any affected Native American Group (see Stipulation XII);

- Qualifications of consultants employed to undertake the implementation of the STP, meeting at minimum those standards described in Stipulation I.

Avoidance of adverse effects on historic properties is the preferred treatment approach. The HPTP will discuss and justify the chosen approaches to the treatment of project historic properties and those treatment options considered, but rejected. If preservation of part or all of any historic properties is proposed, the treatment plan will include discussion of the following:

1. Description of the area or portions of the historic properties to be preserved in-place, and an explanation of why those areas or portions of sites were chosen;
2. Explanation of how the historic properties will be preserved in-place, including both legal and physical mechanism for such preservation;
3. A plan for monitoring and assessing the effectiveness of mechanisms to preserve the historic properties; and
4. A plan for minimizing or mitigating future adverse effects on the historic properties if preservation in-place mechanisms prove to be ineffective.

Appendix D
Real Estate

SUTTER FEASIBILITY REAL ESTATE PLAN
MAY 2013

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Real Estate Plan
For
Sutter Basin Pilot Feasibility Study
Sutter & Butte Counties, California

1. Statement of Purpose

This Real Estate Plan (REP) is intended to support the Sutter Basin Pilot Feasibility Study and is tentative in nature. This REP focuses on the NED and LPP alternatives, and is to be used for planning purposes only. There may be modifications to the project and its plans that occur during the Preconstruction, Engineering and Design (PED) phase, thus changing the final acquisition area(s) and/or administrative and land costs reflected in this REP.

The REP reflects an estimate of the real estate costs that will be considered in selection of the complete Federal Plan.

2. Project Authority

The authority for the USACE to study Flood Risk Management (FRM) and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, is provided in the Flood Control Act of 1962, Public Law No. 87-874, § 209, 76 Stat. 1180, 1196 (1962).

The existing project levees of the Sutter Basin provide FRM as part of the more comprehensive Sacramento River Flood Control Project (SRFCP) which was authorized by the Flood Control Act of 1917.

The purpose of the Sutter Basin Pilot Feasibility Study analyzed in the Report and this REP, is to address flood risk-related issues in the study area. The study is a General Investigations study undertaken to evaluate structural and non-structural FRM measures including re-operation of existing reservoirs, improvements to existing levees, construction of new levees, and other storage conveyance and non-structural options.

The Report presents planning, engineering, and implementation details of the recommended plan to allow final design and construction to proceed provided USACE approval of the recommended plan, and is thereafter expected to be the basis for a recommendation to Congress for authorization of a new project.

3. Project Description

Specifically, this REP identifies the real estate costs for the NED Plan (Alternative SB-7) and the Locally Preferred Plan (LPP) (Alternative SB-8). Alternative SB-7 consists of strengthening approximately 27 miles of the existing Feather River West Levee from Sunset Weir to Laurel Avenue. Alternative SB-8 consists of strengthening approximately 41 miles of the existing Feather River West Levee to Thermalito Afterbay and addresses the flooding risks in the communities of Biggs, Gridley, and Live Oak. Alternative SB-8 is supported by the local sponsors as the LPP, and can be considered in a multi-objective planning context to be a more comprehensive and complete Federal plan. Alternative SB-8 has been granted a waiver by the Assistant Secretary of the Army's office as an exception to policy to consider the LPP as the tentatively selected plan (TSP) and is discussed in more detail in the main Report.

Sutter and Butte counties lie in a portion of north-central California known as the Sacramento Valley. The project area is approximately 40 miles north of the City of Sacramento. The counties are significant components of the SRFCP. The SRFCP includes levees along the Sacramento River, the Sutter Bypass, the Feather River, Yankee Slough, Wadsworth Canal Cross Canal and Tisdale Bypass. In 1968, the Oroville Dam was completed, and over the years various improvements have been made to the original levee system to reinforce and enhance flood protection for the basin. Repairs have been made to major weaknesses in local levees since 1997. The most recent construction projects include the Wadsworth Canal slurry wall completed in 2008, and the Feather River setback levee at Star Bend was completed in 2009.

Components of the SRFCP define an area within the counties known as the Sutter-Butte basin. The basin is generally bounded by the Sutter Bypass to the west and south, the Feather River to the east and south, and the Thermalito Afterbay to the north. Urbanized areas located within the basin include Biggs, Gridley, Live Oak and Yuba City. The Feather River flows south through Butte County from the City of Oroville and enters Sutter County near the community of Live Oak. The Feather River forms the Sutter/Yuba County line before flowing into the Sacramento River in southern Sutter County. The Sutter Bypass bisects Sutter County from the Sutter Buttes in the northwest to the Sacramento River in the south. The Sutter Bypass acts as flood relief for the Sacramento River. The Sutter Bypass conveys floodwaters from Butte Basin and additional floodwaters from the Sacramento River through the Tisdale Bypass, which connects to the Sacramento River downstream from the town of Grimes.

The Sutter Butte Flood Control Agency (SBFCA) is proposing to construct the Feather River West Levee Project (FRWLP) to reduce flood risk in the Sutter Basin, which includes portions of Sutter and Butte Counties in the Sacramento Valley of California. The SBFCA was formed as a joint powers authority in 2007 through a joint exercise of powers agreement by the Counties of Sutter and Butte; the Cities of Yuba City, Gridley, Live Oak, and Biggs; and Levee Districts 1 and 9 (LD 1 and LD 9).

In partnership with the State of California (through the California Department of Water Resources (DWR) and the Central Valley Flood Protection Board (CVFPB), the SBFCA

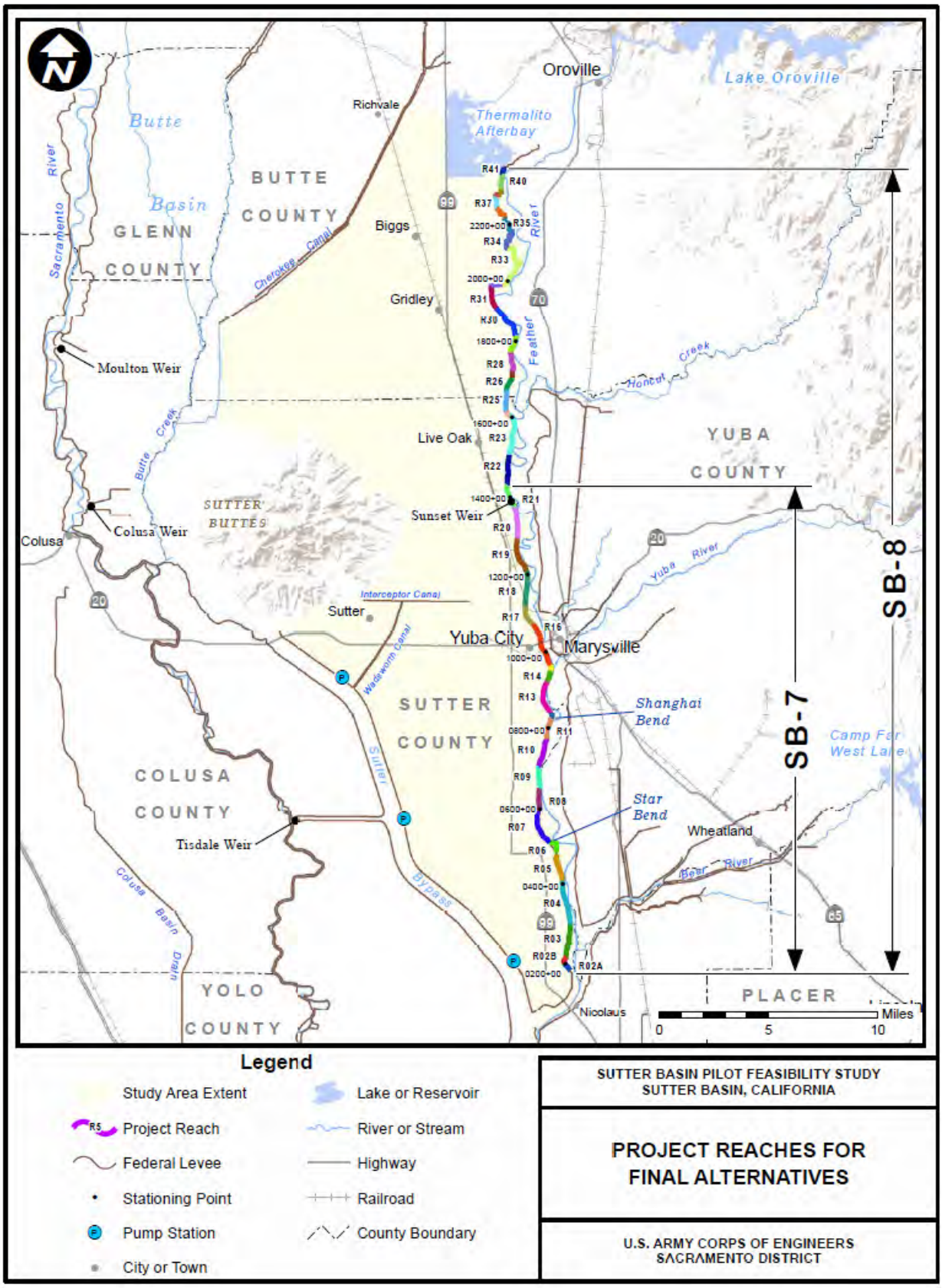
embarked on a comprehensive evaluation of the condition of the levees protecting the area in 2007, the results of which are also being used by the U.S. Army Corps of Engineers (USACE). The evaluation was necessary to identify the magnitude and severity of deficiencies and determine measures to address the deficiencies. The results of the comprehensive evaluation revealed that substantial construction is necessary to meet current flood protection standards.

The FRWLP is being advanced by SBFCA to expeditiously reduce flood risk before the Sutter Basin Pilot Feasibility Study is completed..

To construct the FRWLP, the SBFCA has requested permission from USACE pursuant to Section 14 of the Rivers and Harbors Act of 1899 (33 USC § 408) (hereinafter the "Section 408 pemit") for its proposed alteration of an existing federal levee previously constructed as part of the SRFCP. The Report and this REP does not analyze the Section 408 permit, but rather focuses only on the Federal NED Plan (Alternative SB-7) and the LPP (Alternative SB-8).

4. Description of Lands, Easements, Rights of Way, Relocations and Disposals (LERRDs)

For Alternatives SB-7 and SB-8, a reach identification system was developed as shown in the table below.



SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROJECT REACHES FOR FINAL ALTERNATIVES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

The real estate cost estimate of Alternatives SB-7 and SB-8 was developed based on the conventional approach for development of feasibility level design. During development of the REP, the real estate cost estimate was developed for alternatives SB-7 and SB-8 in accordance with ER 405-1-12 and based upon the footprints delineating project requirements developed by the Sacramento's Engineering Division. The Lands, Easements, Rights of Way, Relocations and Disposal (LERRDs) requirements for the REP include: the acquisition of flood protection levee easements, permanent road easements, utility easements, drainage easements, temporary work area easements, borrow easements, and mitigation fee title. The basess for the different types of acquisitions are as follows:

- Flood protection levee easements are required for the construction and operation and maintenance of project levee features. The easements vary in width and are delineated by the toe of existing levee and boundary of the seepage berms (within the project's limit), relocated levee segments and new seepage berms.

- 15 foot permanent road easements along the landside and waterside edge of the flood protection levee easements, at a minimum, are needed for providing maintenance access to and for flood fighting purposes along the toe of the project features.

- Flood protection levee easements and permanent road easements together will be sufficient to cover the acquisition needed for the vegetation free zone and to allow for the movement of construction equipments within the construction site.

- Additional utility easements (approximately 20ft beyond the permanent road easement for O&M roads) may also be needed for obtaining utility corridors for relocation of utilities parallel to the project's alignment outside of the proposed ROW. This additional utility easement was not specifically identified for the project and will be estimated as percentage of the total utility relocation costs.

- Drainage easements are required for the Sutter-Butte Canal relocations.

- Temporary work area easements are required for acquiring staging areas along the length of the project.

- Borrow easements are required for potential borrow sites.

- Potential on-site mitigation areas will be acquired in fee title.

Alternative SB-7 contains 21 reaches (2A north to 21) along the Feather River West Levee (FRWL) alignment, beginning at the same point south of Laurel Avenue and extending approximately 24 miles north to immediately north of Sunset Weir (station 1433+83). There are an estimated 292 parcels identified in Alternative SB-7 for project. The real estate costs for Alternative SB-7 are estimated at $47,500,000. There are 242 acres of levee easements, road easements and temporary work easements required for Alternative SB-7. There are also 1,771

acres of potential borrow sites identified and 71 acres of on- site mitigation proposed for Alternative SB-7.

The potential design features of Alternative SB-7 (Reaches 2 – 21) include the following:

Reach	Station	Length (feet)	Primary Design Measures
2A North	180+00 to 202+50	2,250	Cutoff wall with 100-foot-wide undrained seepage berm
2B	202+50 to 218+66	1,616	Cutoff wall with 100-foot-wide undrained seepage berm
3	218+66 to 300+66	8,200	Cutoff wall with 100-foot-wide undrained seepage berm (218+66 to 231+00) Cutoff wall (230+00 to 231+00)
4	300+66 to 410+67	11,001	Cutoff wall
5	410+67 to 478+68	6,801	Cutoff wall (410+67 to 478+65) Cutoff wall with 300-foot-wide undrained seepage berm (453+00 to 478+00)
6 FIP	478+68 to 512+00	3,332	Cutoff wall
6 SB	478+68 to 512+00	3,332	Remove the existing levee and construct a setback levee with 65-foot-deep (from degrade line) cutoff wall
7	512+00 to 596+00	8,563	Cutoff wall (512+00 to 596+00) Cutoff wall with relief wells (545+00 to 570+00) Erosion Protection (High-Performance Turf Reinforced Mat) (547+00 to 596+00)
8	596+00 to 654+75	5,875	Cutoff wall (596+00 to 654+75) Erosion Protection (High-Performance Turf Reinforce Mat) (596+00 to 604+60)
9	654+75 to 706+50	5,175	Cutoff wall
10	706+50 to 774+00	6750	Cutoff wall
11	774+00 to 830+00	5,600	Cutoff wall
12	830+00 to 845+00	1,500	No proposed design measure with exceptions below Cutoff wall (transition only, at both ends of this reach) Cutoff wall, transition only (830+00 to 831+50) Cutoff wall, transition only (844+50 to 845+00)
13	845+00 to 927+00	8,200	Cutoff wall Cutoff wall with full levee degrade and re-construction (844+50 to 897+50)
14	927+00 to 954+40	2,740	No proposed rehabilitation measure
15	954+40 to 968+50	1,410	No proposed rehabilitation measure
16	968+50 to 1080+00	11,150	Jet grouting cutoff wall at 5th Street bridge crossing (1006+04 to 1007+90) Toe berm, 23 feet wide, at 10th Street bridge crossing (1023+90 to 1027+50) Cutoff wall and backfill landside toe depression, transition only (1077+85 to 1080+00)

Reach	Station	Length (feet)	Primary Design Measures
17	1080+00 to 1130+86	5,086	Backfill landside toe depression (1107+00 to 1125+70) Cutoff wall (1080+00 to 1096+00) Jet grouting cutoff wall at Yuba City water treatment plant (1095+80 to 1098+30 Cutoff wall (1098+10 to 1129+50) Jet grouting cutoff wall at railroad north of Yuba City (1129+50 to 1130+67) Cutoff wall (1130+20 to 1130+86) Stop log closure structure or equivalent at 1130+00
18	1130+86 to 1213+85	8,299	Cutoff wall
19	1213+85 to 1297+83	8,398	Cutoff wall
20	1297+83 to 1374+33	7,650	Cutoff wall
21	1374+33 to 1433+83	5,950	Cutoff wall (1374+33 to 1432+50) Cutoff wall with levee relocation (20 feet riverward, transition only), (1432+50 to 1433+83) Sutter Butte Canal relocation (1429+00 to 1433+83)

Alternative SB-8 contains 41 reaches (2A north to 41) along the FRWL alignment, beginning approximately 1.7 miles north of the State Route 99 bridge over the Feather River (at station 180+00, approximately 2,250 feet south of Laurel Avenue) and extends north approximately 41 miles to the Thermalito Afterbay, downstream of Oroville Dam (at station 2368+00). There are an estimated 468 parcels identified in Alternative SB-8 for project implementation. The real estate costs for Alternative SB-8 are estimated at $63,000,000. There are 401.6 acres of levee easements, road easements and temporary work easements for Alternative SB-8. There are also 1,771 acres of potential borrow sites identified and there are 71 acres of on-site mitigation proposed for Alternative SB-8.

The potential design features of Alternative SB-8 (Reaches 2 – 16) include the following

Reach	Station	Length (feet)	Primary Design Measures
2A North	180+00 to 202+50	2,250	Cutoff wall with 100-foot-wide undrained seepage berm
2B	202+50 to 218+66	1,616	Cutoff wall with 100-foot-wide undrained seepage berm
3	218+66 to 300+66	8,200	Cutoff wall with 100-foot-wide undrained seepage berm (218+66 to 231+00) Cutoff wall (230+00 to 231+00)
4	300+66 to 410+67	11,001	Cutoff wall
5	410+67 to 478+68	6,801	Cutoff wall (410+67 to 478+65) Cutoff wall with 300-foot-wide undrained seepage berm (453+00 to 478+00)
6 FIP	478+68 to 512+00	3,332	Cutoff wall
6 SB	478+68 to 512+00	3,332	Remove the existing levee and construct a setback levee with 65-foot-deep (from degrade line) cutoff wall
7	512+00 to 596+00	8,563	Cutoff wall (512+00 to 596+00) Cutoff wall with relief wells (545+00 to 570+00) Erosion Protection (High-Performance Turf Reinforced Mat) (547+00 to 596+00)
8	596+00 to 654+75	5,875	Cutoff wall (596+00 to 654+75) Erosion Protection (High-Performance Turf Reinforce Mat) (596+00 to 604+60)
9	654+75 to 706+50	5,175	Cutoff wall
10	706+50 to 774+00	6750	Cutoff wall
11	774+00 to 830+00	5,600	Cutoff wall
12	830+00 to 845+00	1,500	No proposed design measure with exceptions below Cutoff wall (transition only, at both ends of this reach) Cutoff wall, transition only (830+00 to 831+50) Cutoff wall, transition only (844+50 to 845+00)
13	845+00 to 927+00	8,200	Cutoff wall Cutoff wall with full levee degrade and re-construction (844+50 to 897+50)
14	927+00 to 954+40	2,740	No proposed rehabilitation measure
15	954+40 to 968+50	1,410	No proposed rehabilitation measure
16	968+50 to 1080+00	11,150	Jet grouting cutoff wall at 5th Street bridge crossing (1006+04 to 1007+90) Toe berm, 23 feet wide, at 10th Street bridge crossing (1023+90 to 1027+50) Cutoff wall and backfill landside toe depression, transition only (1077+85 to 1080+00)

The potential design features of Alternative SB-8 (Reaches 17 – 27) include the following:

Reach	Station	Length (feet)	Primary Design Measures
17	1080+00 to 1130+86	5,086	Backfill landside toe depression (1107+00 to 1125+70) Cutoff wall (1080+00 to 1096+00) Jet grouting cutoff wall at Yuba City water treatment plant (1095+80 to 1098+30 Cutoff wall (1098+10 to 1129+50) Jet grouting cutoff wall at railroad north of Yuba City (1129+50 to 1130+67) Cutoff wall (1130+20 to 1130+86) Stop log closure structure or equivalent at 1130+00
18	1130+86 to 1213+85	8,299	Cutoff wall
19	1213+85 to 1297+83	8,398	Cutoff wall
20	1297+83 to 1374+33	7,650	Cutoff wall
21	1374+33 to 1433+83	5,950	Cutoff wall (1374+33 to 1432+50) Cutoff wall with levee relocation (20 feet riverward, transition only), (1432+50 to 1433+83) Sutter Butte Canal relocation (1429+00 to 1433+83)
22	1433+83 to 1503+83	7,000	Cutoff wall with levee relocation (20 feet riverward) (1433+83 to 1450+00) Cutoff wall with levee relocation (20 feet riverward, transition only) (1450+50 to 1451+50) Cutoff wall with full levee degrade and re-construction (1455+00 to 1461+00) Cutoff wall (1461+00 to 1503+83)
23	1503+83 to 1609+37	10,554	Cutoff wall (1503+83 to 1608+75) Cutoff wall with levee relocation (20 feet riverward, transition only)(1608+50 to 1609+37) Erosion Protection: High-Performance Turf Reinforce Mat (1582+00 to 1601+00)
24	1609+37 to 1623+86	1,449	Cutoff wall with levee relocation (20 feet riverward, transition only) (1609+37 to 1612+00) Cutoff wall with levee relocation (20 feet riverward) (1612+00 to 1623+00) Cutoff wall with levee relocation (20 feet riverward, transition only) (1623+00 to 1623+86)
25	1623+86 to 1674+37	5,051	Cutoff wall with levee relocation (20 feet riverward, transition only) (1623+86 to 1624+50) Cutoff wall (transition only)(1623+86 to 1625+00) Cutoff wall (transition only)(1673+00 to 1674+37) Cutoff wall with levee relocation (20 feet riverward, transition only) (1673+00 to 1674+37)
26	1674+37 to 1707+11	3,274	Cutoff wall with levee relocation (20 feet riverward, transition only) (1674+37 to 1675+00) Cutoff wall with levee relocation (20 feet riverward) (675+00 to 1707+11)
27	1707+11 to 1721+60	1,449	Cutoff wall with levee relocation (20 feet riverward) (1707+11 to 1721+60)

The potential design features of Alternative SB-8 (Reaches 28 – 41) include the following:

Reach	Station	Length (feet)	Primary Design Measures
28	1721+60 to 1769+31	4,771	Cutoff wall with levee relocation (20 feet riverward)(1721+60 to 1753+00) Cutoff wall with levee relocation (20 feet riverward, transition only)(1753+00 to 1754+50) Sutter Butte Canal Relocation (1752+00 to 1766+00) Cutoff wall (1754+50 to 1769+31)
29	1769+31 to 1813+33	4,402	No proposed rehabilitation measure
30	1813+33 to 1902+00	8,867	Cutoff wall (1813+33 to 1900+50) Jet grouting cutoff wall (1900+00 to 1902+00)
31	1902+00 to 1958+00	5,600	Jet grouting cutoff wall (1902+00 to 1904+00) Cutoff wall (1904+50 to 1958+00)
32	1958+00 to 1989+00	3,100	Cutoff wall
33	1989+00 to 2122+00	13,300	Cutoff wall
34	2122+00 to 2182+00	6,000	Cutoff wall
35	2182+00 to 2224+00	4,200	Cutoff wall
36	2224+00 to 2259+00	3,500	Cutoff wall
37	2259+00 to 2290+00	3,100	Cutoff wall
38	2290+00 to 2303+00	1,300	Seepage berm up to 11 feet high tapering to a distance 170 feet from the centerline of the existing levee (2290+00 to 2303+00) Seepage berm with cutoff wall (transition only, extend from reach 37 into reach 38 Cutoff wall (transition only) (2290+00 to 2292+00)
39	2303+00 to 2319+00	1,600	No proposed rehabilitation measure
40	2319+00 to 2359+00	4,000	No design measure: 2319+00 to 2331+00 Seepage berm 120 feet wide (2331+00 to 2335+00) Seepage berm 100 feet wide (2335+00 to 2359+00)
41	2359+00 to 2368+00	900	Seepage berm 100 feet wide with filter drain (2359+00 to 2368+00)

No Modification Required

There are 7 levee sections along the Feather River West Levee alignment where modification is not required. These sections are between: (1) 831+50 and 844+50, (2) 923+75 and 1006+24, (3) 1007+70 and 1024+00, (4) 1027+50 and 1078+00, (5) 1625+00 and 1673+00, (6) 1769+40 and 1813+30, and (7) 2303+00 and 2331+00, approximately. Existing cutoff walls (30 to 50 feet in depth) are present within the first four levee sections.

Cutoff Wall Only

There are 14 levee sections along the Feather River West Levee alignment where cutoff wall is the only modification feature required. These sections are between: (1) 231+00 and 453+00, (2) 478+68 and 512+00, (3) 570+00 and 831+50, (4) 1078+00 and 1096+00, (5) 1098+10 and 1107+00, (6) 1125+70 and 1129+99, (7) 1130+20 and 1429+00, (8) 1451+50 and 1455+00, (9) 1461+00 and 1608+50, (10) 1624+70 and 1625+00, (11) 1673+00 and 1673+30, (12) 1766+00 and 1769+40, (13) 1813+30 and 1900+50, and (14) 1903+50 and 2290+00.

Jet Grouting Cutoff Wall Only

There are 4 levee sections along the Feather River West Levee alignment where jet grouting cutoff wall is the only modification feature required. These levee sections are between: (1) 1006+04 and 1007+90, (2) 1095+80 and 1098+30, (3) 1129+50 and 1130+67, and (4) 1900+00 and 1904+00.

Seepage Berm Only

There are 3 levee sections along the Feather River West Levee alignment where seepage berm is the only modification feature required. These levee sections are between: (1) 1024+00 and 1027+50, (2) 2290+00 and 2303+00, and (3) 2331+00 and 2368+00.

Cutoff Wall with Full Levee Degrade and Relief Wells

There are 2 levee sections along the Feather River West Levee alignment where the levee will be fully degraded and reconstructed with a cutoff wall along the levee centerline These levee sections area between: (1) 844+50 and 897+50, and (2) 1455+00 and 1461+00.
The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 52 relief wells, a drainage ditch and pump stations) between station 844+50 and station 897+50.

Cutoff Wall with Relief Wells

Cutoff wall is required for the area between station 512+00 and station 570+00. The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 24 relief wells, a drainage ditch and pump stations) between station 512+00 and station 545+00. A new seepage collector system (including 22 relief wells and a 2,500-foot long concrete lined V-ditch) will be installed between station 545+00 and station 570+00 at 120-foot

interval. The new seepage interceptor system will be tied in with the existing one at station 545+00.

A cutoff wall is also required for the area between station 897+50 and station 923+75. The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 24 relief wells, drain ditch and pump stations).

Cutoff Wall with Seepage Berm

There are 2 levee sections where both a cutoff wall and a seepage berm are required. These levee sections are between: (1) 180+00 and 231+00, and (2) 453+00 and 478+68.

Cutoff Wall with Levee Relocation

The existing levee will be relocated 20 feet toward the river at three locations, between: (1) 1432+70 and 1451+50, (2) 1608+50 and 1624+70, and (3) 1673+30 and 1754+30. A cutoff wall is required at these locations and will be constructed along the relocated levee alignment.

Cutoff Wall with Canal Relocation

The Sutter Butte Main Canal will be relocated away from the existing levee toe at two locations: (1) between 1429+00 and 1432+70, and (2) between 1754+30 and 1766+00. The existing canal sections will be backfilled. A cutoff wall is required at these locations and will be constructed along the levee centerline.

Cutoff Wall with Landside Toe Fill

A cutoff wall is required for the area between 1107+00 and 1125+70. The landside toe depression in this area will be filled.

Soil- Bentonite versus Deep Soil Mix (DSM) Cutoff Wall

The proposed cutoff walls vary in depth along the project alignment. At locations where a cutoff wall is the required (except for the jet grouting sites), the cutoff wall will be: soil bentonite cutoff wall (if the wall is less than 75 feet in depth) or DSM cutoff wall (if the wall is greater than 75 feet in depth). There are 10 levee sections along the FRWL alignment where DSM cutoff walls are required. These sections are between: (1) 230+00 and 250+00, (2) 1125+00 and 1129+99, (3) 1130+20 and 1151+50, (4) 1224+00 and 1248+00, (5) 1987+25 and 2002+00, (6) 2016+75 and 2036+75, (7) 2067+00 and 2088+00, (8) 2137+00 and 2148+00, (9) 2182+00 and 2196+50, (10) 2245+75 and 2292+00, approximately (see Table 5-2 for more details). The wall's depth at these locations will vary between 75 and 120 feet. Between 844+50 and 897+50, an 85-foot deep soil bentonite cutoff wall is considered adequate for this area.

Erosion Protection

An anchored HPTRM is required on the landside slope for two initial overtopping levee sections located in reaches 7 and 23 between: (1) 547+00 and 604+60, and (2) 1582+00 and 1601+00 to increase the sections' resiliency and enhance flood warning and evacuation time prior to overtopping failure from events that exceed the design event.

Closure Structure

A stop log closure structure or equivalent is required at station 1130+00, where the UPRR crosses the FRWL alignment

As previously noted, the 41 reaches along the Feather River are broken into two increments: Alternative SB-7 (Reaches 2-21) and Alternative SB-8 (Reaches 2 – 41). The reaches are then broken into 7 construction contracts including A, B, C1, C2, D1, and D2. The following below tables are an inventory of potential lands required for construction, operation and maintenance of alternative SB7 and SB8

Reach 2 (Station 180+00 to Laurel Ave) Cutoff wall with undrained seepage berm and staging area

SB7, SB8 REACH 02 LERRDs REQUIRED FOR CONSTRUCTION 11 Parcels

APN	REACH	OWNER	PARCEL AREA	P.R.E.	F.P.L.E.	Total Sum
	ID		GIS ACRES	(O&M)		by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
25-210-008	02	PRIVATELY OWNED	88.95	1.522	2.049	3.57
25-210-015	02	SAC & SAN JOAQUIN DRAINAGE DIST	5.74	0.636	4.526	5.16
25-210-016	02	SAC & SAN JOAQUIN DRAINAGE DIST	4.66		4.656	4.66
25-260-026	02	PRIVATELY OWNED	30.95	0.381	0.999	1.38
25-260-031	02	SAC & SAN JOAQUIN DRAINAGE DIST	1.00	0.379	0.267	0.65
25-260-036	02	PRIVATELY OWNED	5.98	0.323	1.829	2.15
25-260-040	02	NATIONAL AUDUBON SOCIETY	5.14	0.233	4.057	4.29
25-260-041	02	SAC & SAN JOAQUIN DRAINAGE DIST	3.00	0.269	2.446	2.72
			145.40	3.74	20.83	24.57
APN	REACH	PROPOSED STAGING AREAS		TWAE		
25-210-008	02 A09	PRIVATELY OWNED	88.95	1.378		
25-260-036	02 A08	PRIVATELY OWNED	5.98	1.457		

Note: 4 Sponsor owned parcels P.R.E. = Permanent Road Easement F.P.L.E = Flood Protection Levee Easement T.W.A.E. = Temporary Work Area Easement

Reach 03 (Station 218+66 to 300 + 66) Cutoff wall with undrained seepage berm and staging area

SB7, SB8 REACH 03 LEVEE AND ROAD EASEMENTS REQUIRED 16 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	
25-190-015	03	GARDEN HWY MUTUAL WATER CO	1.94	0.457	1.005	1.46
25-190-016	03	PRIVATELY OWNED	66.88	0.900	4.462	5.36
25-190-037	03	PRIVATELY OWNED	353.14	0.782	4.553	5.34
25-210-020	03	NATIONAL AUDUBON SOCIETY INC	356.14	1.937	4.912	6.85
25-250-013	03	PRIVATELY OWNED	64.29	1.706	8.434	10.14
25-250-017	03	PRIVATELY OWNED	13.93	0.027	0.008	0.03
25-250-025	03	PRIVATELY OWNED	15.37	0.582	2.977	3.56
25-250-026	03	PRIVATELY OWNED	18.85	0.546	2.724	3.27
25-260-007	03	PRIVATELY OWNED	35.44	0.802	7.800	8.60
Cypress Ave.	03	PUBLIC RIGHT OF WAY	0.89	0.041	0.218	0.26
Levee Access Rd.	03	PUBLIC RIGHT OF WAY	1.40	0.031	0.205	0.24
			928.28	7.81	37.30	45.11
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E.		
25-190-037	03 A04	PRIVATELY OWNED	353.14	1.565		
25-210-020	03 A07	NATIONAL AUDUBON SOCIETY INC	356.14	0.115		
25-250-013	3 A05	PRIVATELY OWNED	64.29	1.463		
25-250-025	03 A06	PRIVATELY OWNED	15.37	1.927		
25-260-007	03 A07	PRIVATELY OWNED	35.44	0.787		

Reach 04 (Station 300+66 to 410 + 67) Cut off wall and staging area

SB7, SB8 REACH 04 LEVEE AND ROAD EASEMENTS REQUIRED 17 Parcels

APN	REACH	OWNER	PARCEL AREA	P.R.E.	FPLE	Total Sum
	ID		GIS ACRES	(O&M)		by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
25-120-003	04	PRIVATELY OWNED	24.14	0.377	1.215	1.59
25-120-004	04	PRIVATELY OWNED	46.18	0.945	8.499	9.44
25-120-005	04	PRIVATELY OWNED	17.24	0.191	0.633	0.82
25-120-006	04	FEATHER WATER DIST	1.40	0.096	0.368	0.46
25-140-005	04	PRIVATELY OWNED	72.54	1.234	9.869	11.10
25-140-015	04	PRIVATELY OWNED	13.28	0.622	4.538	5.16
25-140-020	04	PRIVATELY OWNED	320.04	1.662	5.105	6.77
25-140-021	04	PRIVATELY OWNED	190.04	0.837	2.675	3.51
25-190-012	04	PRIVATELY OWNED	35.06	0.395	1.316	1.71
25-190-013	04	PRIVATELY OWNED	16.71	0.195	0.552	0.75
25-190-014	04	PRIVATELY OWNED	15.37	0.183	0.579	0.76
25-190-020	04	PRIVATELY OWNED	72.17	1.226	7.711	8.94
25-190-021	04	PRIVATELY OWNED	28.36	0.374	1.702	2.08
25-190-022	04	PRIVATELY OWNED	30.85	0.485	1.795	2.28
Central Ave.	04	PUBLIC RIGHT OF WAY	1.07	0.028	0.124	0.15
			884.45	8.85	46.68	55.53
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E.		
25-140-020	04	PRIVATELY OWNED	320.04	4.493		
25-190-022	04	PRIVATELY OWNED	30.85	1.248		

Reach 5 (Station 410 + 67 to 475+35) Cut off wall and staging area

SB7, SB8 REACH 05 LEVEE AND ROAD EASEMENTS REQUIRED 19 Parcels

APN	REACH	OWNER	PARCEL AREA	P.R.E.	FPLE	Total Sum
	ID		GIS ACRES	(O&M)		by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
2010-0001863	05	PUBLIC RIGHT OF WAY	58.05	2.487	15.018	17.50
25-060-004	05	DEPT OF FISH & GAME	83.52	0.302	3.360	3.66
25-060-005	05	DEPT OF FISH & GAME	134.24	0.609	7.988	8.60
25-060-018	05	DEPT OF FISH & GAME	43.55	0.356	0.818	1.17
25-060-019	05	PRIVATELY OWNED	43.80	0.628	5.695	6.32
25-060-039	05	DEPT OF FISH & GAME	105.93	0.083	0.220	0.30
25-090-010	05	PRIVATELY OWNED	25.27	0.814	12.373	13.19
25-090-017	05	PRIVATELY OWNED	17.16	0.411	6.504	6.91
25-100-003	05	PRIVATELY OWNED	41.80	0.183	0.521	0.70
25-100-015	05	PRIVATELY OWNED	18.93	0.301	1.333	1.63
25-100-019	05	PRIVATELY OWNED	61.26	0.414	1.442	1.86
25-120-001	05	PRIVATELY OWNED	34.94	0.569	1.519	2.09
Public ROW	05	PUBLIC RIGHT OF WAY	0.33	0.027	0.080	0.11
Wilkie Ave.	05	PUBLIC RIGHT OF WAY	0.59	0.018	0.072	0.09
			669.36	7.20	56.94	64.15
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E.		
2010-0001863	05 B14		58.05	0.755		
25-060-039	05 B15	DEPT OF FISH & GAME	105.93	1.517		
25-090-010	05 B16	PRIVATELY OWNED	25.27	0.695		
25-100-003	05 B16	PRIVATELY OWNED	41.80	0.521		
25-120-001	05 B17	PRIVATELY OWNED	34.94	1.433		

Reach Star Bend Setback Levee (Station 514+00 to 514+50)

SB7, SB8 REACH 06 LEVEE AND ROAD EASEMENTS REQUIRED 2 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
25-080-015	06	PRIVATELY OWNED	35.33	0.033	0.010	0.04
Shannon Rd.	06	PUBLIC RIGHT OF WAY	0.48	0.020	0.110	0.13
			35.33	0.05	0.12	0.17

Reach 7 includes approximately 11 parcels. Cutoff wall and and Cutoff wall with relief wells.
Station 510+37 to 596+00

SB7, SB8 REACH 07 LEVEE AND ROAD EASEMENTS REQUIRED 11 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
23-300-051	07	PRIVATELY OWNED	3.70	0.258	3.416	3.67
23-300-052	07	PRIVATELY OWNED	20.93	0.387	0.165	0.55
23-300-053	07	PRIVATELY OWNED	3.90	0.214	0.096	0.31
23-300-085	07	PRIVATELY OWNED	126.31	2.636	7.249	9.88
23-300-086	07	PRIVATELY OWNED	96.88	1.953	9.318	11.27
23-300-126	07	DEPT OF FISH & GAME	147.49	0.465	4.052	4.52
Star Bend Rd.	07	PUBLIC RIGHT OF WAY	0.74	0.033	0.284	0.32
			399.95	5.944	24.580	30.52
APN		PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E.		
23-300-053	07 B14	PRIVATELY OWNED	3.90	0.083		
23-300-085	07 B12	PRIVATELY OWNED	126.31	1.360		
23-300-086	07 B13	PRIVATELY OWNED	96.88	1.417		
Star Bend Rd.	07 B14		0.74	0.109		

Reach 8 (Station 596+00 to 654+75) cutoff wall tip elevation +15 feet and staging area

SB7, SB8 REACH 08 LEVEE AND ROAD EASEMENTS REQUIRED 15 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
23-253-006	08	FEATHER WATER DIST	2.09	0.132	0.307	0.44
23-253-007	08	FEATHER WATER DIST	2.39	0.098	0.735	0.83
23-253-008	08	DEPT OF FISH & GAME	10.49	0.289	3.088	3.38
23-253-009	08	DEPT OF FISH & GAME	6.49	0.164	1.968	2.13
23-253-011	08	DEPT OF FISH & GAME	6.78	0.162	1.979	2.14
23-253-015	08	PRIVATELY OWNED	17.79	0.187	0.023	0.21
23-253-016	08	PRIVATELY OWNED	35.44	0.560	0.015	0.57
23-253-022	08	PRIVATELY OWNED	2.58	0.186	0.885	1.07
23-253-023	08	PRIVATELY OWNED	40.14	0.750	3.716	4.47
23-300-084	08	PRIVATELY OWNED	84.15	1.205	0.051	1.26
23-300-127	08	DEPT OF FISH & GAME	267.62	1.635	18.482	20.12
			475.97	5.370	31.249	36.62
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
23-253-008	08 B09	DEPT OF FISH & GAME	10.49	2.906		
23-253-009	08 B09	DEPT OF FISH & GAME	6.49	1.126		
23-300-084	08 B10	PRIVATELY OWNED	84.15	1.464		
23-300-127	08 B11	DEPT OF FISH & GAME	267.62	1.300		

Reach 9 (Station 654+75 to 706+50) Cut off wall and staging area

SB7, SB8 REACH 09 LEVEE AND ROAD EASEMENTS REQUIRED 9 Parcels

APN	REACH	OWNER	PARCEL AREA	P.R.E.	FPLE	Total Sum
	ID		GIS ACRES	(O&M)		by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
23-180-019	09	PRIVATELY OWNED	32.82	0.851	1.776	2.63
23-180-020	09	SUTTER COUNTY OF	5.25	0.369	1.927	2.30
23-234-003	09	PRIVATELY OWNED	16.57	0.399	2.122	2.52
23-234-004	09	PRIVATELY OWNED	11.61	0.292	1.618	1.91
23-234-008	09	PRIVATELY OWNED	2.33	0.107	0.016	0.12
23-234-011	09	PRIVATELY OWNED	1.82	0.162	0.014	0.18
23-234-014	09	PRIVATELY OWNED	24.45	0.443	3.792	4.23
			94.85	2.624	11.264	13.89
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E.		
23-180-020	09 B07	SUTTER COUNTY OF	5.25	0.989		
23-234-014	09 B08	PRIVATELY OWNED	24.45	0.860		

Reach 10 Station 706+50 to 774+00 Cut off wall and staging area

SB7, SB8 REACH 10 LEVEE AND ROAD EASEMENTS REQUIRED 9 Parcels

APN	REACH	OWNER	PARCEL AREA	P.R.E.	FPLE	Total Sum
	ID		GIS ACRES	(O&M)		by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
23-040-019	10	PRIVATELY OWNED	7.41	0.449	0.932	1.38
23-040-020	10	LEVEE DIST 1	2.89	0.096	2.670	2.77
23-040-077	10	YUBA CITY OF	273.21	2.164	13.950	16.11
23-180-005	10	PRIVATELY OWNED	20.98	1.023		1.02
23-180-006	10	PRIVATELY OWNED	4.30	0.557	0.341	0.90
23-234-005	10	PRIVATELY OWNED	34.45	0.904	4.909	5.81
Garden Hwy	10	PUBLIC RIGHT OF WAY	2.53	0.570	0.255	0.83
			345.77	5.764	23.058	28.82
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
23-180-005	10 B06	PRIVATELY OWNED	20.98	1.443		
23-180-006	10 B05	PRIVATELY OWNED	4.30	0.680		

Reach 11 Station 774+00 to 830+00 Cut off wall and staging area

SB7, SB8 REACH 11 LEVEE AND ROAD EASEMENTS REQUIRED 8 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
23-040-014	11	PRIVATELY OWNED		0.117	0.250	0.37
23-040-018	11	PRIVATELY OWNED	18.38	0.068		0.07
23-040-050	11	YUBA CITY OF	276.32	2.241	9.824	12.07
23-040-051	11	DEPT OF FISH & GAME ETAL	110.55	0.469	3.081	3.55
23-040-078	11	DEPT OF FISH & GAME ETAL	12.10	0.690	2.644	3.33
			432.33	3.586	15.80	19.39
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
23-040-014	11 B04	PRIVATELY OWNED	14.98	1.418		
23-040-050	11 C1-03	YUBA CITY OF	276.32	1.262		
23-040-078	11 B02	DEPT OF FISH & GAME ETAL	12.10	1.201		

Reach 12 (Station 830+00 to 845+00) This reach is the Shanghai Bend Setback Levee. No proposed Rehabilitation measure except at reach to overlap with existing cutoff wall and staging area.

SB7, SB8 REACH 12 LEVEE AND ROAD EASEMENTS REQUIRED 5 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
55-010-019	12	STATE OF CALIFORNIA ETAL	13.99	0.374	3.346	3.72
55-180-080	12	YUBA CITY OF	3.49	0.246	0.085	0.33
Shanghai Bend Rd	12	PUBLIC RIGHT OF WAY	1.32	0.094	0.830	0.92
			18.79	0.713	4.260	4.97
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
55-180-080	12 B01	YUBA CITY OF	3.49	0.558		
Shanghai Bend Rd	12 B01	PUBLIC RIGHT OF WAY	1.32	0.253		

Reach 13 (Station 845+00 to 927+00) Cutoff Wall Rehabilitation of existing relief wells, where needed and staging area

SB7, SB8 REACH 13 LEVEE AND ROAD EASEMENTS REQUIRED 13 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
22-090-007	13	SUTTER COUNTY OF	10.32	0.523	2.460	2.98
22-090-010	13	SUTTER COUNTY OF	50.55	1.853	9.547	11.40
22-090-012	13	SUTTER COUNTY OF	41.58	1.273	6.708	7.98
22-090-013	13	SUTTER COUNTY OF	19.37	1.377	7.652	9.03
23-040-036	13	SUTTER COUNTY OF	3.10	0.216	2.056	2.27
53-500-048	13	PRIVATELY OWNED	9.99	0.037	0.006	0.04
Feather Rvr	13	PUBLIC RIGHT OF WAY	4.89	0.223	0.009	0.23
			139.81	5.501	28.437	33.94
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
20-160-061	13 C1-04	SUTTER COUNTY OF	11.25	1.422		
54-081-012	13 C1-03a	PRIVATELY OWNED	2.00	1.264		
22-090-010	13 C1-03a	SUTTER COUNTY OF	50.55	0.254		
54-010-039	13 C1-02	PRIVATELY OWNED	11.34	0.449		
22-090-012	13 C1-02	SUTTER COUNTY OF	41.58	0.858		
55-010-032	13 C1-01	DEPT OF TRANSPORTATION	38.88	8.524		

Reach 14 (Station 927+00 to 954+40) No proposed rehabilitation measure - Staging Area only

SB7, SB8 REACH 14 LEVEE AND ROAD EASEMENTS REQUIRED 3 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
20-160-071	14	SUTTER COUNTY OF	35.02	2.405	20.176	22.58
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
20-160-065	14 C1-05	SUTTER COUNTY OF	15.17	1.259		
20-160-071	14 C1-04	SUTTER COUNTY OF	35.02	0.043		

Reach 15 (Station 954+40 to 968+50) No proposed rehabilitation measure – Staging area only

SB7, SB8 REACH 15 LEVEE AND ROAD EASEMENTS REQUIRED 63 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
2nd St.	15	PUBLIC RIGHT OF WAY	6.73	1.527	0.292	1.82
Levee Rd.	15	PUBLIC RIGHT OF WAY	135.44	5.761	52.497	58.26
			142.18	7.288	52.789	60.08
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
52-570-006	15 C1-06	LEVEE DIST 1		4.71	0.307	
Levee Rd.	15 B16	PUBLIC RIGHT OF WAY		135.44	0.068	
Levee Rd.	15 B14	PUBLIC RIGHT OF WAY		135.44	0.022	
Levee Rd.	15 C1-06	PUBLIC RIGHT OF WAY		135.44	2.058	

Reach 16 (Station 968+50 to1080+00) Monitoring for waterside slope distress during and after high water events. Closure of gaps in existing wall at two bridge crossings 5th Street Bridge crossing: cutoff wall 10th Street Bridge crossing: toe berm Cutoff Wall at the end of Reach 16 to Overlap existing cutoff wall.

SB7, SB8 REACH 16 LEVEE AND ROAD EASEMENTS REQUIRED

APNS	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
51-470-001	16	SUTTER COUNTY OF	5.44	0.085	0.190	0.28
51-530-020	16	PRIVATELY OWNED	3.21	0.349	0.107	0.46
51-530-021	16	PRIVATELY OWNED	11.06	1.256	3.641	4.90
51-530-022	16	YUBA CITY OF	114.05	0.650	6.697	7.35
51-530-023	16	YUBA CITY OF	5.78	0.354	5.176	5.53
51-550-003	16	PRIVATELY OWNED	3.26	0.337	0.106	0.44
51-580-004	16	PRIVATELY OWNED	4.48	0.296	0.260	0.56
52-430-003	16	PUBLIC RIGHT OF WAY	0.15	0.066	0.016	0.08
52-430-004	16	LEVEE DIST 1	0.23	0.058		0.06
52-471-007	16	PRIVATELY OWNED	0.17	0.020		0.02
52-471-008	16	PRIVATELY OWNED	0.16	0.023		0.02
52-471-015	16	PRIVATELY OWNED	0.14	0.027		0.03
52-471-020	16	LEVEE DIST 1	0.23	0.109	0.027	0.14
52-471-021	16	PRIVATELY OWNED	0.48	0.069	0.010	0.08
52-490-001	16	PRIVATELY OWNED	0.30	0.005		0.01
52-490-002	16	PUBLIC RIGHT OF WAY	1.26	0.096	0.702	0.80
52-490-003	16	PUBLIC RIGHT OF WAY	0.15		0.140	0.14
52-515-012	16	PRIVATELY OWNED	0.30	0.056	0.006	0.06
52-515-017	16	PRIVATELY OWNED	0.28	0.058	0.006	0.06
52-516-003	16	PRIVATELY OWNED	0.10	0.034		0.03
52-516-005	16	PRIVATELY OWNED	0.58	0.050		0.05
52-534-001	16	SUTTER COUNTY OF	2.82	0.158	1.066	1.22
52-535-003	16	PRIVATELY OWNED	0.13	0.046	0.015	0.06
52-535-004	16	PRIVATELY OWNED	0.46	0.046		0.05
52-535-005	16	PRIVATELY OWNED	0.39	0.040		0.04
52-535-006	16	PRIVATELY OWNED	0.25	0.024		0.02
52-535-007	16	PRIVATELY OWNED	0.25	0.025		0.02
52-552-001	16	PRIVATELY OWNED	0.22	0.023	0.010	0.03
52-552-002	16	PRIVATELY OWNED	0.39	0.039		0.04
52-552-003	16	PRIVATELY OWNED	0.37	0.039	0.033	0.07
52-552-004	16	PRIVATELY OWNED	0.29	0.035	0.007	0.04
52-552-005	16	PRIVATELY OWNED	0.27	0.035	0.008	0.04
52-552-006	16	PRIVATELY OWNED	0.22	0.029	0.006	0.04

APN	REACH	OWNER	PARCEL AREA IN GIS ACRES	P.R.E.	F.P.L.E.	TOTAL SUM
52-552-007	16	PRIVATELY OWNED	0.49	0.050	0.097	0.15
52-570-001	16	PRIVATELY OWNED	0.07	0.021		0.02
52-570-002	16	PRIVATELY OWNED	0.06	0.020		0.02
52-570-003	16	PRIVATELY OWNED	0.09	0.028		0.03
52-570-004	16	PRIVATELY OWNED	0.09	0.030		0.03
52-580-003	16	PRIVATELY OWNED	0.43	0.061		0.06
52-580-004	16	PRIVATELY OWNED	0.10	0.019		0.02
52-580-005	16	PRIVATELY OWNED	0.10	0.021		0.02
52-580-006	16	PRIVATELY OWNED	0.09	0.023		0.02
52-580-007	16	PRIVATELY OWNED	0.09	0.023		0.02
52-580-008	16	LEVEE DIST 1	0.32	0.092	0.009	0.10
52-580-009	16	PRIVATELY OWNED	0.14	0.045		0.04
52-580-015	16	PRIVATELY OWNED	0.32	0.048	0.018	0.07
B St	16	PUBLIC RIGHT OF WAY	0.45	0.036	0.049	0.09
C St	16	PUBLIC RIGHT OF WAY	0.24	0.022	0.018	0.04
Keyser St	16	PUBLIC RIGHT OF WAY	0.29	0.028	0.011	0.04
Teegarden Ave	16	PUBLIC RIGHT OF WAY	0.27	0.010		0.01
Twin Cities Mem. Brg	16	PUBLIC RIGHT OF WAY	0.25	0.016	0.178	0.19
Yuba City	16	PUBLIC RIGHT OF WAY	31.59	2.002	14.499	16.50
		Totals	193.37	7.133	33.108	40.24
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
51-470-007	16 C1-11	PRIVATELY OWNED	12.04	1.387		
51-530-021	16 C1-10	PRIVATELY OWNED	11.06	1.320		
51-550-003	16 C1-09	PRIVATELY OWNED	3.26	0.556		
51-550-017	16 C1-09	PRIVATELY OWNED	0.50	0.386		
51-550-018	16 C1-09	PRIVATELY OWNED	0.50	0.389		
52-471-008	16 C1-08	PRIVATELY OWNED	0.16	0.139		
52-471-009	16 C1-08	PRIVATELY OWNED	0.15	0.117		
52-490-001	16 C1-08	PRIVATELY OWNED	0.30	0.259		
52-534-001	16 C1-07	SUTTER COUNTY OF	2.82	0.250		
B St	16 C1-07	PUBLIC RIGHT OF WAY	0.45	0.029		
Yuba City	16	PUBLIC RIGHT OF WAY	31.52	0.172		

Reach 17 (Station 1080+00 to 1130+86) Cutoff wall, with landside toe depression filled staging area

SB7, SB8 REACH 17 LEVEE AND ROAD EASEMENTS REQUIRED 10 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
18-070-002	17	PRIVATELY OWNED	15.97	0.415	5.557	5.97
51-470-027	17	PRIVATELY OWNED	4.22	1.371	1.288	2.66
51-490-031	17	PRIVATELY OWNED	1.00	0.044		0.04
51-580-005	17	PRIVATELY OWNED	138.85	1.099	11.359	12.46
51-580-009	17	PRIVATELY OWNED	4.58	0.828	0.643	1.47
Access	17	PUBLIC RIGHT OF WAY	0.15	0.042	0.006	0.05
SP RR	17	SOUTHERN PACIFIC RAILROAD	5.29	0.442	1.648	
			164.78	3.799	18.854	22.65
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
18-070-002	17 C1-13	PRIVATELY OWNED	15.97	6.912		
51-470-027	17 C1-12	PRIVATELY OWNED	4.22	0.191		
51-580-020	17 C1-12	PRIVATELY OWNED	3.07	1.201		

Reach 18 (Station 1130+86 to 1213+85) Cut off wall and staging area

SB7, SB8 REACH 18 LEVEE AND ROAD EASEMENTS REQUIRED 13 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
10-270-001	18	PRIVATELY OWNED	145.35	1.134	0.268	1.40
10-270-003	18	PRIVATELY OWNED	89.02	1.108	8.624	9.73
10-270-004	18	PRIVATELY OWNED	32.37	0.522	5.032	5.55
10-270-005	18	PRIVATELY OWNED	48.06	0.633	0.281	0.91
10-270-007	18	PRIVATELY OWNED	160.37	0.975	8.825	9.80
10-270-009	18	PRIVATELY OWNED	1.20	0.195	0.147	0.34
10-270-010	18	PRIVATELY OWNED	44.89	1.227	0.613	1.84
18-070-001	18	PRIVATELY OWNED	110.38	0.209	1.231	1.44
Rednall Rd.	18	PUBLIC RIGHT OF WAY	0.64	0.019	0.018	0.04
B	18	PUBLIC RIGHT OF WAY	1.91	0.079	0.729	0.81
			634.18	6.099	25.767	31.87
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
10-270-001	18 C2-15	PRIVATELY OWNED	145.35	2.445		
10-270-009	18 C2-14	PRIVATELY OWNED	1.20	0.821		
10-270-010	18 C2-14	PRIVATELY OWNED	44.89	0.486		

Reach 19 (Station 1213+85 to 1297+83) Cut off wall and Staging Area

SB7, SB8 REACH 19 LEVEE AND ROAD EASEMENTS REQUIRED 12 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
10-170-010	19	DEPT OF FISH & GAME	13.37	0.028		0.03
10-170-013	19	DEPT OF FISH & GAME	17.31	0.456	2.462	2.92
10-170-050	19	PRIVATELY OWNED	28.42	0.914	3.970	4.88
10-170-052	19	PRIVATELY OWNED	25.71	0.286	0.709	0.99
10-170-054	19	PRIVATELY OWNED	74.19	0.321	0.758	1.08
10-220-008	19	PRIVATELY OWNED	98.79	1.256	3.291	4.55
10-220-046	19	PRIVATELY OWNED		1.085	5.412	6.50
10-220-047	19	PRIVATELY OWNED	38.91	0.951	4.914	5.87
10-220-053	19	PRIVATELY OWNED	141.30	1.453	3.957	5.41
Morse Rd.	19	PUBLIC RIGHT OF WAY	0.43	0.024	0.139	0.16
			491.05	6.744	25.612	32.36
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
10-220-047	19 C2-18	PRIVATELY OWNED	38.91	1.401		
10-220-053	19 C2-17	PRIVATELY OWNED	141.30	1.121		

Reach 20 (Station 1297+83 to 1374+33) Cut offf wall and staging area

SB7, SB8 REACH 20 LEVEE AND ROAD EASEMENTS REQUIRED 18 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
10-120-003	20	PRIVATELY OWNED	20.10	0.450	0.184	0.63
10-120-004	20	PRIVATELY OWNED	26.28	0.762	0.508	1.27
10-130-005	20	PRIVATELY OWNED	62.50	0.376	0.396	0.77
10-130-012	20	PRIVATELY OWNED	12.96	0.429	3.434	3.86
10-130-013	20	PRIVATELY OWNED	92.45	0.499	3.521	4.02
10-130-014	20	PRIVATELY OWNED	67.22	0.281	2.100	2.38
10-130-028	20	PRIVATELY OWNED	48.27	0.365	0.565	0.93
10-130-040	20	PRIVATELY OWNED	70.47	0.335	2.422	2.76
10-130-041	20	PRIVATELY OWNED	150.69	0.506	3.435	3.94
10-130-043	20	PRIVATELY OWNED	92.99	0.766	2.104	2.87
10-170-012	20	PRIVATELY OWNED	92.41	0.482	4.209	4.69
10-170-015	20	PRIVATELY OWNED	29.98	0.257	0.219	0.48
10-170-017	20	PRIVATELY OWNED	8.03	0.483	0.242	0.72
10-170-043	20	PRIVATELY OWNED	55.68	0.344	2.269	2.61
Koch Ln.	20	PUBLIC RIGHT OF WAY	1.04	0.025	0.097	0.12
			831.06	6.360	25.703	32.06
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
10-120-004	20 C2-21	PRIVATELY OWNED	26.28	1.249		
10-130-041	20 C2-20	PRIVATELY OWNED	150.69	1.525		
10-170-012	20 C2-19	PRIVATELY OWNED	92.41	4.828		

Reach 21 (Station 1374+33 to 1433+83) Cut off wall and staging area

SB7, SB8 REACH 21 LEVEE AND ROAD EASEMENTS REQUIRED (REACH SB7 ENDS) 13 Parcels

APN	REACH	OWNER	PARCEL AREA	P.R.E.	FPLE	Total Sum
	ID		GIS ACRES	(O&M)		by APN
SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
09-305-002	21	SUTTER EX WATER DIST	0.91	0.014	0.199	0.21
10-045-002	21	PRIVATELY OWNED	7.03	0.372	2.203	2.58
10-061-002	21	PRIVATELY OWNED	15.09	0.247	1.567	1.81
10-061-003	21	PRIVATELY OWNED	18.40	0.246	1.600	1.85
10-062-003	21	PRIVATELY OWNED	8.86	0.137	0.739	0.88
10-062-004	21	PRIVATELY OWNED	10.16	0.193	1.054	1.25
10-280-024	21	BUTTE WATER DIST	10.05	2.107	0.597	2.70
Bridgeford Ave.	21	PUBLIC RIGHT OF WAY	1.15	0.043	0.143	0.19
Clark Rd.	21	PUBLIC RIGHT OF WAY	1.25	0.035	0.118	0.15
Hermansen Ave.	21	PUBLIC RIGHT OF WAY	1.95	0.044	0.137	0.18
			74.85	3.437	8.357	11.79
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
10-045-004	21 C1-23	PRIVATELY OWNED	34.10	1.126		
10-062-003	21 C1-22	PRIVATELY OWNED	8.86	1.309		
10-280-024	21 C1-23	BUTTE WATER DIST	10.05	0.367		

Reach 22 (Station 1433+83 to 1503+83) Cutoff wall and Full levee degrade and re-construction of portion of reach and staging area

SB8 REACH 22 LEVEE AND ROAD EASEMENTS REQUIRED 14 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
09-240-006	22	PRIVATELY OWNED	2.53	0.268	1.456	1.72
09-240-007	22	PRIVATELY OWNED	15.28	0.585	1.529	2.11
09-295-003	22	PRIVATELY OWNED	24.99	0.541	1.517	2.06
09-295-005	22	PRIVATELY OWNED	4.22	0.472	1.493	1.97
09-295-008	22	PRIVATELY OWNED	3.32	0.418	1.385	1.80
09-295-022	22	PRIVATELY OWNED	2.94	0.503	1.233	1.74
09-304-002	22	PRIVATELY OWNED	13.67	0.630	2.892	3.52
09-305-003	22	PRIVATELY OWNED	4.62	0.270	1.648	1.92
09-310-005	22	SUTTER EX WATER DIST ETAL	39.64	0.128	1.873	2.00
Bishop Ave.	22	PUBLIC RIGHT OF WAY	0.62	0.040	0.109	0.15
Paseo Ave.	22	PUBLIC RIGHT OF WAY	2.52	0.035	0.307	0.34
			114.35	3.89	15.44	19.33
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
09-240-007	22 C2-26	PRIVATELY OWNED	15.28	0.853		
09-295-003	22 C2-25	PRIVATELY OWNED	24.99	1.300		
09-305-003	22 C2-24	PRIVATELY OWNED	4.62	1.129		

Reach 23 (Station 1503+83 to 1609+37) Cut off wall and staging area

SB8 REACH 23 LEVEE AND ROAD EASEMENTS REQUIRED 25 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
09-050-002	23	PRIVATELY OWNED	12.90	0.540	0.633	1.17
09-050-003	23	PRIVATELY OWNED	4.32	0.610	1.634	2.24
09-120-008	23	PRIVATELY OWNED	70.33	1.015	1.840	2.86
09-130-003	23	PRIVATELY OWNED	24.75	0.842	2.484	3.33
09-130-006	23	PRIVATELY OWNED	56.91	0.478	0.560	1.04
09-130-007	23	PRIVATELY OWNED	50.01	0.360	1.696	2.06
09-130-008	23	PRIVATELY OWNED	31.47	0.365	2.065	2.43
09-130-010	23	PRIVATELY OWNED	51.96	0.401	0.035	0.44
09-130-011	23	PRIVATELY OWNED	2.61	0.084	0.261	0.34
09-130-012	23	PRIVATELY OWNED	42.95	1.023	1.457	2.48
09-230-001	23	SAC & SAN JOAQUIN DRAINAGE DIST	18.77	0.547	3.259	3.81
09-230-005	23	PRIVATELY OWNED	17.03	0.084		0.08
09-240-010	23	PRIVATELY OWNED	20.76	1.861	6.308	8.17
09-241-012	23		22.92	0.213		0.21
Archer Ave.	23	PUBLIC RIGHT OF WAY	0.49	0.002		0.00
Archer Rd.	23	PUBLIC RIGHT OF WAY	1.42	0.558	0.245	0.80
Cooley Rd.	23	PUBLIC RIGHT OF WAY	0.53	0.015	0.054	0.07
Feather Rvr.	23	PUBLIC RIGHT OF WAY	8.46	0.103	0.076	0.18
Pennington Rd.	23	PUBLIC RIGHT OF WAY	2.39	0.082	0.233	0.31
			440.99	9.18	22.84	32.02
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
09-050-002	23 C2-31	PRIVATELY OWNED	12.90	1.200		
09-120-008	23 C2-30	PRIVATELY OWNED	70.33	1.410		
09-130-003	23 C2-29	PRIVATELY OWNED	24.75	1.404		
09-130-006	23 C2-28	PRIVATELY OWNED	56.91	1.403		
09-240-010	23 C2-27	PRIVATELY OWNED	20.76	0.247		
09-241-012	23 C2-27	PRIVATELY OWNED	22.92	1.278		

1 sponsor owned parcel

Reach 24 (Station 1609+37 to1623+86) Cut off wall and staging area

SB8 REACH 24 LEVEE AND ROAD EASEMENTS REQUIRED 2 Parcels

APN	REACH	OWNER	PARCEL AREA	P.R.E.	FPLE	Total Sum
	ID		GIS ACRES	(O&M)		by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
09-050-004	24	PRIVATELY OWNED	3.61	0.376	1.483	1.86
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
09-050-004	24 C2-32	PRIVATELY OWNED	3.61	0.027		

Reach 25 (Station 1623+86 to 1674+37) No proposed rehabilitation measure (except for transitions at ends of reach where adjacent to reaches needing rehabilitation) and staging area

SB8 REACH 25 LEVEE AND ROAD EASEMENTS REQUIRED 11 Parcels

APN	REACH	OWNER	PARCEL AREA	P.R.E.	FPLE	Total Sum
	ID		GIS ACRES	(O&M)		by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
024-210-019-000	25	PRIVATELY OWNED	3.63	0.170	0.311	0.48
024-210-020-000	25	PRIVATELY OWNED	40.40	0.602	1.689	2.29
024-210-024-000	25		2.29	0.339	0.920	1.26
024-210-028-000	25	PRIVATELY OWNED	70.94	0.230	0.881	1.11
024-210-031-000	25	PRIVATELY OWNED	13.44	0.204	0.027	0.23
09-030-001	25	PRIVATELY OWNED	25.98	0.712	1.041	1.75
09-030-002	25	PRIVATELY OWNED	59.10	0.539	2.696	3.23
09-030-003	25	PRIVATELY OWNED	16.14	0.119	0.379	0.50
09-030-004	25	PRIVATELY OWNED	38.22	0.251	0.962	1.21
09-030-007	25	PRIVATELY OWNED	22.07	0.637	0.987	1.62
09-050-001	25	PRIVATELY OWNED	105.04	0.248	1.069	1.32
			397.26	4.05	10.96	15.01
APN	REACH	PROPOSED STAGING AREAS	PARCEL AREA	T.W.A.E		
09-030-001	25 D1-01	PRIVATELY OWNED	25.98	1.772		
09-050-001	25 C2-32	PRIVATELY OWNED	105.04	0.570		

Reach 26 (Station 1674+37 to 1707+11) Cutoff wall and landside slope reconstruction and staging area

SB8 REACH 26 LEVEE AND ROAD EASEMENTS REQUIRED 4 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
024-210-010-000	26	PRIVATELY OWNED	186.58	1.138	4.455	5.59
024-210-023-000	26	PRIVATELY OWNED	17.06		0.047	0.05
			203.64	1.14	4.50	5.64
APN	REACH	PROPOSED STAGING AREAS BUTTE COUNTY	PARCEL AREA	T.W.A.E		
024-210-010-000	26 D1-03	PRIVATELY OWNED	1.33	1.334		
024-210-010-000	26 D1-02	PRIVATELY OWNED	1.61	1.605		

Reach 27 (Station 1707+11 to 1721+60) Cutoff wall and landside slope reconstruction and staging area)

SB8 REACH 27 LEVEE AND ROAD EASEMENTS REQUIRED 2 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
024-180-044-000	27	PRIVATELY OWNED	97.09	0.565	1.014	1.58
024-180-022-000	27	PRIVATELY OWNED	12.91	0.111	0.150	0.26
			110.00	0.68	1.16	1.84

Reach 28 (Station 1721+60 1769+31) Cutoff wall and landside slope reconstruction and staging area
8 REACH 28 LEVEE AND ROAD EASEMENTS REQUIRED 7 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
024-180-052-000	28	PRIVATELY OWNED	3.03	0.035		0.04
024-180-060-000	28	PRIVATELY OWNED	55.91		0.050	0.05
024-180-068-000	28	PRIVATELY OWNED	25.50	0.168	0.157	0.32
024-180-069-000	28	PRIVATELY OWNED	12.88	0.082	0.083	0.17
024-180-999-000	28	PRIVATELY OWNED	11.36	0.316	5.140	5.46
024-130-051-000	28	PRIVATELY OWNED	62.28	0.896	3.332	4.23
			222.54	2.25	10.16	12.41
APN	REACH	PROPOSED STAGING AREAS BUTTE COUNTY	PARCEL AREA	T.W.A.E		
024-180-023-000	28 D1-04	PRIVATELY OWNED	1.51	1.515		

Reach 29 (Station 1769+31 to 1813+33) No proposed rehabilitation measure staging area
SB8 REACH 29 LEVEE AND ROAD EASEMENTS REQUIRED 6 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
024-130-052-000	29	PRIVATELY OWNED	29.97	0.541	0.147	0.69
024-130-053-000	29	PRIVATELY OWNED	4.90	0.712	2.160	2.87
024-130-055-000	29	PRIVATELY OWNED	41.90	0.730	0.106	0.84
024-240-999-000	29	PRIVATELY OWNED	147.59	0.239	0.534	0.77
024-130-046-000	29	PRIVATELY OWNED	24.56	0.431	0.138	0.57
			248.92	2.65	3.08	5.74
APN	REACH	PROPOSED STAGING AREAS BUTTE COUNTY	PARCEL AREA	T.W.A.E		
024-130-055-000	29 D1-06	PRIVATELY OWNED	1.51	1.509		

Reach 30 (Station 1813+33 to 1902+00) Cutoff wall Monitoring of waterside slope distress during and after high water events and staging area

REACH 30 LEVEE AND ROAD EASEMENTS REQUIRED 13 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M) ACRES	FPLE ACRES	Total Sum by APN ACRES
BUTTE/SUTTER COUNTY PARCELS						
024-130-047-000	30	PRIVATELY OWNED	36.86	0.362	1.164	1.53
024-130-049-000	30		20.81	0.633	1.559	2.19
024-220-017-000	30	PR IVATELY OWNED	41.25	1.453	4.120	5.57
024-220-018-000	30	PRIVATELY OWNED	296.92	1.167	2.366	3.53
024-220-019-000	30	PRIVATELY OWNED	81.52	2.446	6.611	9.06
024-220-028-000	30	PRIVATELY OWNED	73.06	0.008		0.01
024-220-030-000	30		45.82	0.872	3.822	4.69
Feather Rvr.	30	PUBLIC RIGHT OF WAY	2.98	0.103	0.076	0.18
025-200-038-000	30		20.28	0.496	8.016	8.51
			619.50	7.54	27.74	35.27
APN	REACH	PROPOSED STAGING AREAS BUTTE COUNTY	PARCEL AREA	T.W.A.E		
024-220-018-000	30 D1-09	PRIVATELY OWNED	1.73	3.666		
024-220-019-000	30 D1-09	PRIVATELY OWNED	1.73	0.031		
024-220-030-000	30 D1-11		1.68	1.679		
024-130-049-000	30 D1-07		4.22	4.224		

Reach 31 (Station 1902+00 to 1958+00) Cutoff wall Waterside slope flattening or other appropriate measures

SB8 REACH 31 LEVEE AND ROAD EASEMENTS REQUIRED 4 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M) ACRES	FPLE ACRES	Total Sum by APN ACRES
BUTTE/SUTTER COUNTY PARCELS						
025-200-141-000	31	PRIVATELY OWNED	355.41	0.208	6.224	6.43
025-210-999-000	31		75.89		0.521	0.52
E. Gridley Rd.	31	PUBLIC RIGHT OF WAY	3.24	0.025	0.442	0.47
025-180-007-000	31	PRIVATELY OWNED	219.71	2.542	11.424	13.97
			434.54	0.23	7.19	7.42

Reach 32 (Station 1958+00 to 1989+00) Cut off wall

SB8 REACH 32 LEVEE AND ROAD EASEMENTS REQUIRED 3 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M) ACRES	FPLE ACRES	Total Sum by APN ACRES
BUTTE/SUTTER COUNTY PARCELS						
025-180-024-000	32	PRIVATELY OWNED	87.40	0.772	0.083	0.85
025-180-025-000	32	PRIVATELY OWNED	5.77	0.121		0.12
025-130-004-000	32	PRIVATELY OWNED	19.62	0.409	1.808	2.22
			114.09	1.30	1.89	3.19

Reach 33 (Station 1989+00 to 2122+00) Slope Flattening to 2.3H:1V or flatter

SB8 REACH 33 LEVEE AND ROAD EASEMENTS REQUIRED 17 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
025-130-009-000	33	PRIVATELY OWNED	19.74	0.036		0.04
025-130-010-000	33	PRIVATELY OWNED	19.81	1.540	4.573	6.11
025-130-025-000	33	PRIVATELY OWNED	94.58	1.525	2.163	3.69
025-130-028-000	33		3.57	0.421	1.127	1.55
025-130-030-000	33	PRIVATELY OWNED	55.18	1.182	6.959	8.14
025-130-031-000	33		0.71	0.069	0.244	0.31
025-130-042-000	33	PRIVATELY OWNED	34.57	1.362	4.870	6.23
025-130-043-000	33	PRIVATELY OWNED	2.24	0.127	0.332	0.46
025-130-048-000	33		34.58	0.006		0.01
025-180-015-000	33	PRIVATELY OWNED	31.37	0.998	2.866	3.86
025-180-016-000	33	PRIVATELY OWNED	8.55	0.573	0.896	1.47
025-180-017-000	33	PRIVATELY OWNED	29.84	0.454	1.911	2.37
025-180-019-000	33	PRIVATELY OWNED	41.72	1.103	3.317	4.42
025-180-023-000	33	PRIVATELY OWNED	62.88	0.140		0.14
025-180-026-000	33	PRIVATELY OWNED	113.46	0.207		0.21
Almond Ave.	33	PUBLIC RIGHT OF WAY	0.61	0.035	0.095	0.13
025-140-004-000	33		57.46	0.249	0.443	0.69
			610.85	10.03	29.80	39.82

Reach 34 (Station 2122+00 to 2182+00) Cut off wall

SB8 REACH 34 LEVEE AND ROAD EASEMENTS REQUIRED 14 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
025-140-008-000	34	PRIVATELY OWNED	45.13	1.181	4.547	5.73
025-150-008-000	34	PRIVATELY OWNED	20.79	0.039	0.036	0.08
025-150-016-000	34	PRIVATELY OWNED	19.33	0.863	0.652	1.52
025-150-016-000	34	PRIVATELY OWNED	19.33	0.863	0.652	1.52
025-150-017-000	34	PRIVATELY OWNED	19.68	0.058	0.015	0.07
025-150-026-000	34	PRIVATELY OWNED	3.03	0.277	2.743	3.02
025-150-027-000	34	PRIVATELY OWNED	25.68	0.034	0.034	0.07
025-150-028-000	34	PRIVATELY OWNED	4.32	0.545	1.237	1.78
025-150-029-000	34	PRIVATELY OWNED	20.87	0.798	1.896	2.69
025-150-030-000	34	PRIVATELY OWNED	0.15		0.152	0.15
025-150-035-000	34	PRIVATELY OWNED	21.54	0.454	0.989	1.44
Cherry Ave.	34	PUBLIC RIGHT OF WAY	2.03	0.071	1.963	2.03
Palm Ave.	34	PUBLIC RIGHT OF WAY	3.03	0.056	1.003	1.06
025-050-004-000	34	PRIVATELY OWNED	8.32	0.421	2.516	2.94
			213.22	5.66	18.44	24.09

Reach 35 (Station 2182+00 to 2224+00) Cut off wall

SB8 REACH 35 LEVEE AND ROAD EASEMENTS REQUIRED 13 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
025-050-014-000	35		0.93	0.181	0.548	0.73
025-050-017-000	35	PRIVATELY OWNED	6.24	0.320	2.316	2.64
025-050-018-000	35	PRIVATELY OWNED	14.25	0.430	0.600	1.03
025-050-019-000	35		9.25	0.164	0.452	0.62
025-050-020-000	35		1.56	0.058	0.219	0.28
025-050-025-000	35		24.48	0.422	1.987	2.41
025-150-007-000	35	PRIVATELY OWNED	16.98	0.506	1.190	1.70
025-150-019-000	35		12.94	0.077	0.186	0.26
025-150-020-000	35		4.74	0.467	3.122	3.59
Hixon_Cherry Ave.	35	PUBLIC RIGHT OF WAY	0.73	0.017	0.028	0.04
Walnut Ave.	35	PUBLIC RIGHT OF WAY	1.77	0.016		0.02
Walnut St.	35	PUBLIC RIGHT OF WAY	1.90	0.037	0.136	0.17
025-050-002-000	35	PRIVATELY OWNED	64.26	0.903	2.660	3.56
			160.01	3.60	13.44	17.04

Reach 36 (Station 2224+00 to 2259+00) Cut off wall

SB8 REACH 36 LEVEE AND ROAD EASEMENTS REQUIRED 8 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
025-050-015-000	36		7.68	0.117	0.408	0.53
025-050-021-000	36		6.33	0.298	3.928	4.23
025-050-022-000	36	PRIVATELY OWNED	1.57	0.133	0.143	0.28
025-050-023-000	36	PRIVATELY OWNED	1.38		0.056	0.06
025-050-024-000	36	PRIVATELY OWNED	1.45	0.036	0.079	0.11
025-290-021-000	36	PRIVATELY OWNED	34.37	1.100	6.670	7.77
025-290-025-000	36	PRIVATELY OWNED	145.70	1.248	2.040	3.29
025-290-018-000	36		5.19	0.635	3.894	4.53
			203.68	3.57	17.22	20.79

Reach 37 (Station 2259+00 to 2290+00) Cut off wall and staging area

SB8 REACH 37 LEVEE AND ROAD EASEMENTS REQUIRED 3 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
025-290-027-000	37	PRIVATELY OWNED	30.77	0.408	0.697	1.11
025-280-018-000	37	PRIVATELY OWNED	10.94	0.201	0.493	0.69
			41.71	0.61	1.19	1.80
APN	REACH	PROPOSED STAGING AREAS BUTTE COUNTY	PARCEL AREA	T.W.A.E		
025-290-020-000	37 D2-21	D2-21 Staging	1.26	1.262		

Reach 38 (Station 2290+00 to 2303+00) 2290+00 to 2292+00: Cutoff wall with tip elevation of +45 feet to extend from Reach 37 into Reach 38.2290+00 to 2292+00: Transition to full seepage berm width per that between station 2291+00 and 2303+00. 2291+00 to 2303+00 Seepage berm to elevation 200 year + 4 feet

SB8 REACH 38 LEVEE AND ROAD EASEMENTS REQUIRED 2 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
025-290-019-000	38		38.45	0.021	0.009	0.03
025-280-007-000	38	PRIVATELY OWNED	81.57	1.223	5.820	7.04
			120.02	1.24	5.83	7.07

SB8 Reach 39 (Station 2303+00 to 2319+00 No proposed rehabilitation measure as existing berm is present.

Reach 40 (Station 2319+00 to 2359+00) Seepage Berm

SB8 REACH 40 LEVEE AND ROAD EASEMENTS REQUIRED 4 Parcels

APN	REACH ID	OWNER	PARCEL AREA GIS ACRES	P.R.E. (O&M)	FPLE	Total Sum by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
025-280-008-000	40	State of California - DWR	17.37	0.034	0.007	0.04
025-280-011-000	40	PRIVATELY OWNED	43.84	1.289	8.654	9.94
030-340-016-000	40		56.10	0.971	4.950	5.92
030-340-008-000	40		12.21	0.137	0.418	0.56
			129.52	2.43	14.03	16.46

Reach 41 (Station 2359+00 to 2368+00) Seepage berm with filter drain - Near Thermalito Afterbay dam and outfall facility and old Sutter Butte Canal channel

SB8 REACH 41 LEVEE AND ROAD EASEMENTS REQUIRED 1 Parcel

APN	REACH	OWNER	PARCEL AREA	P.R.E.	FPLE	Total Sum
	ID		GIS ACRES	(O&M)		by APN
BUTTE/SUTTER COUNTY PARCELS				ACRES	ACRES	ACRES
State of CA	41	State of California - DWR	52.42	0.653	1.664	2.32

Potential Borrow Sites

Potential borrow sites have been identified in various regions in the project area and each are summarized below. An investigation of each of the identified sites was based upon the quantity of available material, hauling distance, material composition, groundwater elevation, and prospects for acquisition. The purpose of the investigation was to identify the potential sites with the greatest potential to provide material economically for the project. Economical hauling has been determined to be within a 2-miles radius and marginally economic hauling within a 10-mile radius. Borrowing outside this radius is not recommended and additional sites would be identified to supply material within these limits. The borrow sites are the same for SB7 and SB8 since SB7 is located within the SB8 footprint.

22 Potential Borrow Site Locations

Parcels	Proposed Borrow Easement Acres
025-230-999-000	11.737
025-280-007-000	2.122
025-280-008-000	12.296
025-280-009-000	24.811
025-280-010-000	7.655
025-280-011-000	2.824
025-280-019-000	4.677
025-280-020-000	9.037
025-280-021-000	20.057
025-280-022-000	9.926
025-290-019-000	21.878
025-290-020-000	5.075
06-470-046	26.27
08-220-013	38.213
08-220-030	0.221
08-220-031	0.490
08-220-032	38.609
08-220-033	38.719
08-260-043	39.245
10-071-001	40
13-270-033	40
10-032-018	12

Mitigation Sites

Star Bend will be used for the majority of the on-site mitigation needs. Additional requirements will be purchased from existing banks.

Star Bend Mitigation Site (Reach 6)
2 Parcels

Parcels	Mitigation Acres
2010-0001863	8.979
2010-0001863	1.096

Proposed Disposal Sites

Implementation of Alternatives SB-7 and SB-8 may generate up to 813,000 cubic yards of solid waste that would require disposal. Solid waste related to construction activities would include levee material, structural debris from removal of residences and agricultural structures, and roadway pavements.

The solid waste facilities nearest to the project area are the Ostrom Landfill (located east of the Project site, approximately 30 road miles south of Reach 2) and the Neal Road Landfill (located 25 miles north of Reach 40).

The 225-acre Class II Ostrom Landfill is permitted to accept the following types of waste: solid waste; wastewater treatment sludge; construction debris; food and green waste; some types of contaminated soils; and non-friable asbestos. The Neal Road Facility is permitted to accept the following types of waste: municipal solid waste, inert industrial waste, demolition materials, special wastes containing non-friable asbestos; and septage.

5. LERRDs Owned by the NFS and Crediting

In the event the recommended plan is authorized, crediting will follow standard procedures as set out in the model Project Partnership Agreement (PPA). No credit will be afforded to any lands or interests previously acquired and credited for any applicable Federal project. Credit will only be applied to the acreage within the "project footprint, namely the lands or corridor required for the recommended Plan of improvements. Lands outside of the project requirements and lands that may be acquired for the sponsor's own purposes would not be creditable LERRDs. Only land deemed necessary that has not been previously cost shared on a project will be credited.

Corps' policy also prescribes that credit will not be afforded for lands purchased with Federal funds or grants where the granting of such credit is not permissible, whether as prescribed by statute, or as determined by the head of the Federal agency and administer such grants or programs. The Federal Emergency Management Agency (FEMA's) floodplain hazard mitigation and elimination grants are examples of such Federal grant programs where credit would not be allocated.

The non-Federal sponsors own an estimated 30 or more parcels in the study area which are identified in the tract registers.

6. Standard Federal Estates and Non Standard Estates

Non-Standard Estates:

Non -standard estates are not anticipated for the proposed project**.**

Standard Estates:

The following **s**tandard estates are anticipated to support project purposes and features.

Fee

The fee simple title to (Tracts No's) ,subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Flood Protection Levee Easements (FPLE)

A perpetual and assignable right and easement in to construct, maintain, repair, operate, patrol and replace a flood protection levee, including all appurtenances thereto; reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Temporary Work Area Easements (TWAE)

A temporary easement and right-of-way in, on, over and across for a period not to exceed 2 years after the execution of the construction contract, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Sutter Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Permanent Road Easement (PRE)

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in the tract register) for the location, construction, operation, maintenance, alternation and replacement of (a) road(s) and appurtenances thereto; together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; (reserving, however, to the owners, their heirs and assigns, the right to cross over or under the right-of-way as access to their adjoining land at the

locations indicated in Schedule B); [1] subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Borrow Easement

A perpetual and assignable right and easement to clear, borrow, excavate and remove soil, dirt, and other materials from (the land described in Tract register) subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

Utility or Pipeline Easement

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in the Tract register) for the location, construction, operation, maintenance, alteration; repair and patrol of (overhead) (underground) (specifically name type of utility or pipeline); together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Drainage Ditch Easement

A perpetual and assignable easement and right-of-way in, over and across (the land described in Tract Register) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

7. Description of Any Existing Federal Project in or Partially in the Proposed Project Area

The Sacramento River Flood Control Project is an existing federal project, Star Bend Setback Levee is part of the current Sutter Pilot feasibility study and has been constructed and the sponsors have applied for Section 104 credit and SBFCA in conjunction with the CVFPB plans to seek in-kind credit under the provisions of Section 221 of the Flood Control Act of 1970, as amended, to be applied towards the required non-Federal cost of the Sutter Basin project recommended in this draft report. A description of the existing federal projects is described below.

Sacramento River Flood Control Project

The history of the Sacramento River Flood Control Project (SRFCP) dates back to the mid 1800's with the initial construction of levees along the Sacramento, Feather, Yuba, and American rivers. The early history of the system was characterized by trial and error, with initial construction followed by a levee failure, followed by improvements (strengthening and/or raising), followed by another levee failure, etc. This continued until the California Debris Commission produced the "Jackson Report" in 1910 which was a comprehensive plan for controlling the floodwaters of the Sacramento River and its tributaries. This comprehensive plan was authorized by the California Legislature in the Flood Control Act of 1911 which also established the California Reclamation Board which was empowered to approve plans for the construction of levees along the Sacramento River or its tributaries or within any of the overflow basins. The comprehensive plan of improvement was authorized by the U.S. Congress in the Flood Control Act of 1917, Pub. L. 64-367, HR 14777), Chap. 144, Sec. 2, 39 STAT. 948, 949-950 (1917); which authorized Federal participation with the State of California in construction of the flood control system.

Federal participation in the SRFCP began shortly after authorization in 1917 and continued for approximately 40 years. The Completed flood control system was documented in 1957 in a design memorandum, which included design water surface profiles. To this day, these are the profiles which govern the operation and maintenance requirements of the levee system.

The system is designed to keep flows from flood events within the river up to a certain magnitude and to divert larger flows, and then to divert larger flows into the bypass system. The Sutter Bypass, part of the SRFCP borders the study area on the southwest and receives flood flows from the Sacramento River and from Butte Basin.

Advance Work by Local Interests in Study Area

As required by Section 14 of the Rivers and Harbors Act of 1899, 33 U.S.C. § 408 [hereinafter Section 408] temporary or permanent alteration, occupation, or use of any public works, including levees, for any purpose is allowable only with the permission of the Secretary of the Army. Under the terms of Section 408, any proposed modification to an authorized Federal levee project, such as the existing levees in the study area that are part of the SRFCP, requires a determination by the Secretary that the proposed alteration, permanent occupation, or use of a Federal project will not be injurious to the public interest and will not impair the usefulness of the levee. The authority to make this determination and approve modifications to Federal works under Section 408 has been delegated to the Chief of Engineers, USACE.

Section 104 of the Water Resources Development Act of 1986 Pub.L.No. 104-303, § 104, 110 Stat. 3658 (1996) [hereinafter Section 104]and Section 221 of the Flood Control Act of 1970 Pub.L.No. 91-611, §221, 84 Stat. 1831(1970) [hereinafter Section 221], as amended, provide authorization for non-Federal sponsors to apply the cost of local advanced work to the required local contribution for the Federal project. Section 104 authorizes credit for local work accomplished prior to authorization of the Federal project, provided that the ASA(CW) has

approved the proposed work prior to initiation of construction, and that the locally constructed work is compatible with the Federal project.

Section 221 authorizes in-kind credit for local work accomplished after execution of an agreement with the ASA(CW). If the non-Federal sponsors propose to undertake construction prior to execution of the Project Partnership Agreement (PPA), an in-kind Memorandum of Understanding must be executed; however, any work undertaken by a non-Federal sponsor pursuant to an in-kind MOU is at its own risk and responsibility. Credit will be applied only in accordance with the PPA and only for local work that is determined to be integral to the authorized Federal project.

Star Bend Setback Levee Project

Levee District 1 has completed construction of 3,400 feet of setback levee along the Feather River in the vicinity of Star Bend, approximately 7 miles south of Yuba City, under DWR's EIP. EIPs are for the construction of projects that rehabilitate, reconstruct, replace, improve, or add to the facilities of the State Plan of Flood Control (SPFC). DWR provides bond funds to cost share for early implementation of state-Federal system modifications for flood risk management. The Star Bend Setback Levee Project replaced a critical section of the right bank of the Feather River levee system to address critical through-seepage, under-seepage, and flow constriction issues and returned about 50 acres of land to the floodplain. Construction was completed in 2010. Levee District 1 received Section 408 approval for the project in June 2009. Section 104 credit consideration for the local project was approved by the ASA(CW) in June 2010. Section 104 requires the consideration of the costs and benefits of a proposed project the costs and benefits produced by any project approved for Section 104 credit consideration. Accordingly, the locally completed Star Bend Setback Levee is not considered to be part of the Sutter Basin "without-project condition"; i.e., for project formulation and evaluation purposes it is assumed that the locally constructed Star Bend setback levee project is not in place.

Feather River West Levee Project

SBFCA is proposing to construct a levee improvement project along the Feather River West Levee under DWR's EIP. The Feather River West Levee Project (FRWLP) would involve the construction of slurry walls, stability berms, and seepage berms to remediate the identified geotechnical problems, including through-seepage, under-seepage, and embankment instability, for about 41 miles of the existing Feather River project levees from Thermalito Afterbay south to a point approximately 4 miles north of the Feather River-Sutter Bypass confluence. The FRWLP is a distinct project formulated independently and separate from the Federal Sutter Basin pilot project. The FRWLP is intended to advance the implementation of local flood risk–reduction measures in conjunction with implementation of a Federal project. Subject to the availability of EIP funding, SBFCA anticipates being able to initiate construction of the FRWLP in 2013, in advance of the authorization and construction of the Federal project. SBFCA in conjunction with the CVFPB plans to seek in-kind credit under the provisions of Section 221 of the Flood Control Act of 1970, as amended, to be applied towards the required non-Federal cost of the Sutter Basin project recommended in this draft report. The FRWLP has not been constructed, and

construction of the FRWLP has not been assumed for the identification and evaluation of alternatives for this report.

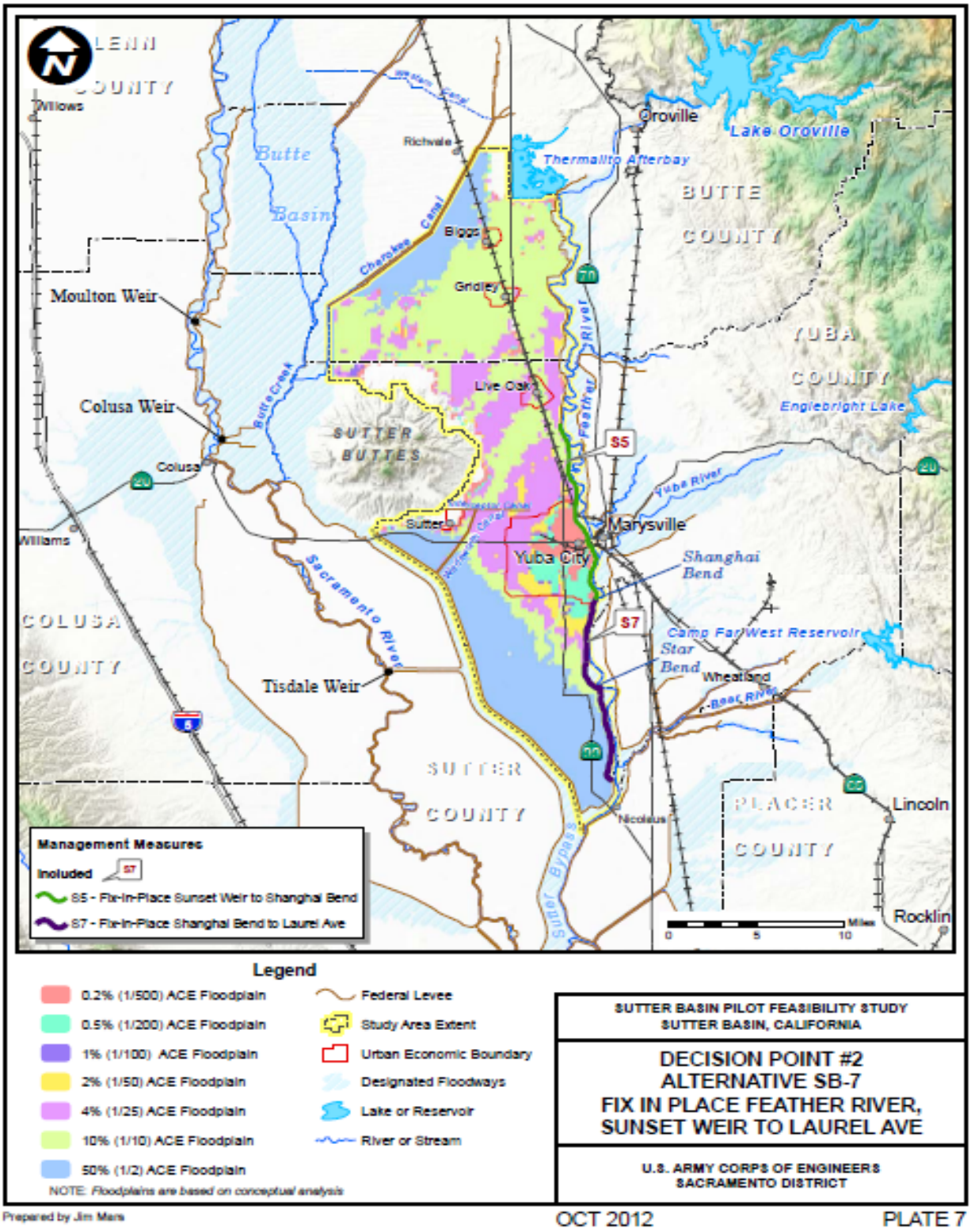
8. Description of any Federally Owned Land Needed for the Project

There does not appear to be any federally owned land available to support the construction, operation and/or maintenance of Alternatives SB-7 or SB-8. The lands needed for the project are state owned, county owned, city owned and/or privately owned.

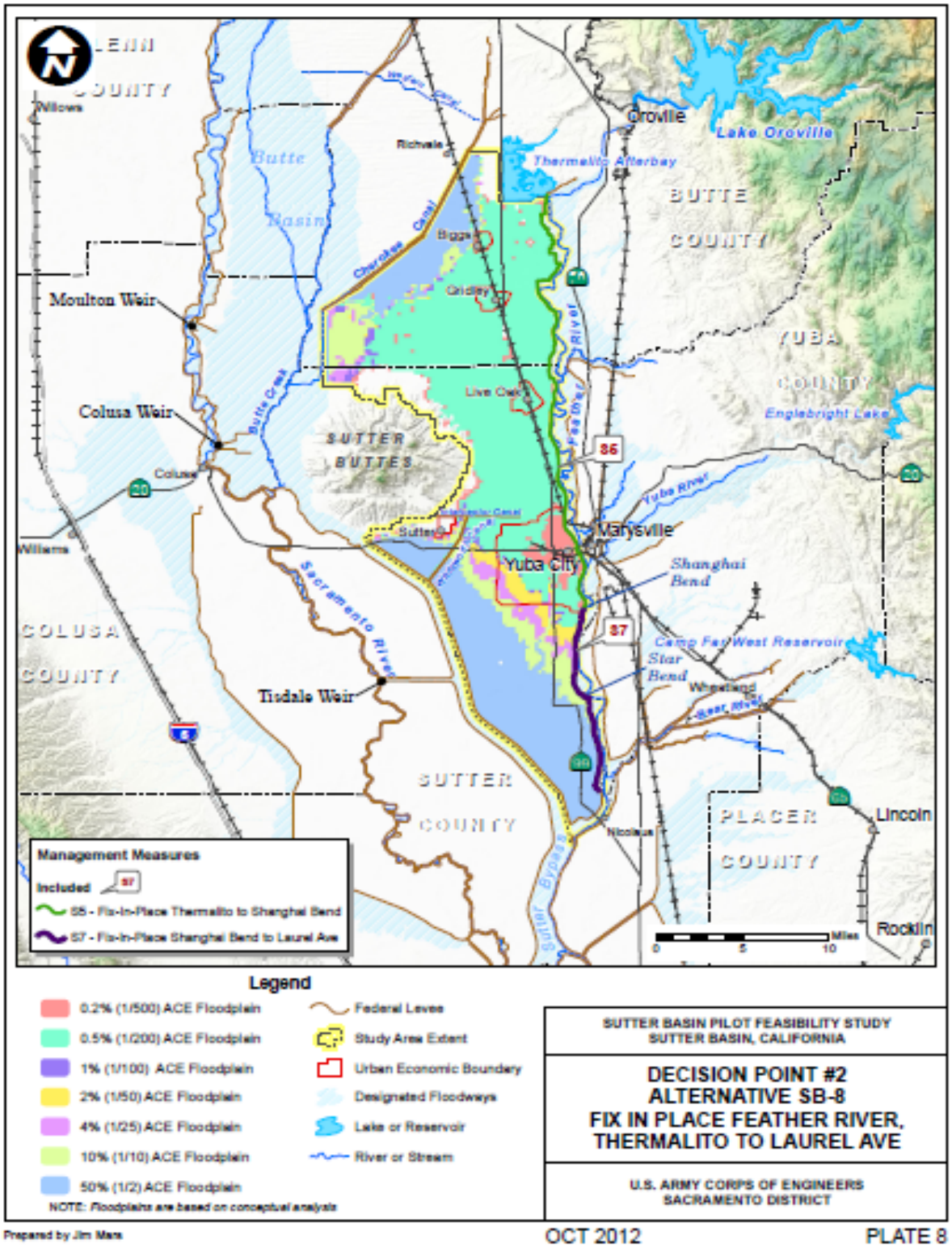
9. Application of Navigational Servitude to the LERRDs Requirement

The levees at issue in the implementation of Alternative SB-7 and Alternative SB-8 are set back from the Feather River. Accordingly, there do not appear to be any lands required for the construction, operation and maintenance of either Alternative SB-7 or SB-8 that fall within the navigational servitude

10. Project Map Alternative SB7 Fix in Place Feather River Sunset Weir to Laurel



Project Map Alternative SB8 Fix in Place Thermalito to Laurel Ave.



11. Anticipated Increased Flooding and Impacts

Change in Water Surface Elevations and Flood Safety Attributable to Project Design.

Alternative SB-8 represents minor design modifications to the proposed action analyzed in the FRWLP Final EIS. SB-8 includes the proposed realignment of 11,600 linear feet of existing levee where it lies directly adjacent to the Sutter-Butte Canal (Canal). The modification would move the levee about 20 feet waterward to provide a 10-foot maintenance road between the Canal and the project levee. To evaluate whether moving the levee waterward would affect water surface elevations and increase the potential risk of flooding, changes to flow, depth, duration, and velocity were estimated using a hydraulic model. The hydraulic model results were also used to perform a transfer of risk analysis using Risk and Uncertainty based methods.

The hydraulic model results indicated no measureable change in flow, depth, duration, and velocity within the Feather River (stage change less than 0.005 feet). The 20 foot realignment is located where the levee toe is higher than the 0.5% (1/200) ACE water surface elevation. Therefore, any change in water surface elevation would only occur for flood events more rare than 0.5% (1/200) ACE. In addition, this reach of river is over 5000 feet wide and the 20 foot realignment of the levee is a small change in the overall hydraulic cross section.

Transfer of flood risk was evaluated by comparing with-project and without-project levee performance values at index points throughout the system. For purposes of evaluating system impacts, the risk analysis is limited to hydrologic and hydraulic parameters and their uncertainties. This approach is consistent with Section 3.b (2) of the memorandum "Clarification Guidance on the Policy and Procedural Guidance for the Approval of Modifications and Alterations of Corps of Engineers Projects" (USACE, 2008). The analysis is described in detail in the Hydraulic Design and Analysis Appendix.

Analysis of the Alternative SB-8 found no transfer of flood risk. As described above, the hydraulic model created for Alternative SB-8 computed the same water surface elevations as Alternative SB-1 (No Action Alternative). Since the water surface elevations are the input to the Risk and Uncertainty model, and they did not change, there is no change in the project performance and no transfer of flood risk.

Based on this hydraulic analysis there were no anticipated increased flooding or impacts of any significance applicable to Alternatives SB-7 or SB-8.

12. Cost Estimate Summary for Lands and Damages and Relocations

The following is a preliminary analysis estimating the costs of acquiring the required LERRDs to support both Alternative SB-7 and Alternative SB-8 to assist in the determination of federal interest for a cost benefit analysis. The table below estimates the costs associated with acquiring real property interests necessary to construct, operate and maintain a local levee project primarily located along the Feather River within the Counties of Butte and Sutter. The date of the approved cost estimate was December 6, 2012.

Alternative SB-7 Features	Acres	Land Costs	Incremental Land Costs 30 %	Improvements 20%	Total Fed and Non Fed Admin costs 292 parcels	Total Costs Rounded
Levees, O&M Roads, Staging Areas	242.17	$3,910,436	$1,173,131	$787,087		$5,870,000
Potential Borrow Sites	1,771.25	$13,259,901	$3,977,970	$2,651,980		
Potential Mitigation Lands	70.97	$205,097	$61,529	$41,019		
			Total Borrow and Mitigation			$20,200,000
				Total Lands and Damages SB7	Fed -$7,300,000 N Fed - $14,135,278 $21,435,278	$47,500,000 Rounded
Utility Relocation Costs					Total	$40,444,033
PL 91-646 Estimated Moving Expenses and Replacement Housing Costs					Total	$882,500.00
				Total	Relocation	$41,326,533
Star Bend Fix in Place (NED Plan) SB7	23.1	$135,360	$40,608	$27,072		$200,000

Alternative SB-8 Features	Acres	Land Costs	Incremental Land Costs 30 %	Improvements 20%	Total Fed and Non Fed Admin costs 468 Parcels	Total Costs Rounded
Levee easements, O&M Roads, Staging Areas	401.6	$6,401,533	$1,929,460	$1,280,307		$9,600,000
Potential Borrow Sites	1,771.25	$13,259,901	$3,977,970	$2,651,980		
Potential Mitigation Lands	70.97	$205,097	$61,529	$41,019		
			Total Borrow and Mitigation			$20,200,000
				Total SB8 Lands and Damages	Fed $11,700,000 Non Fed $21,337,905 $33,037,905	**$62,800,000 Rounded**
Utility Relocation Costs					Total	$121,669,791
PL 91-646 Estimated Moving Expenses and Replacement Housing Assistance					Total	$1,374,000
				Total	Relocation	$123,043,791
*Star Bend Set Back (SB8) LPP	0.17	$487	$146	$97		$1,000

*The land cost estimate for Star Bend Setback levee for Alternative SB-8 includes the levee land only - the additional estate required for the setback lands have been calculated as fee mitigation lands and have been included above in the mitigation column.

13. Relocation Assistance Benefits

The relocation assistance benefits anticipated to be required in accordance with P.L. 91-646 are calculated on a case-by-case basis and take into account the number of persons, pets, farms and businesses that may be displaced as a consequence of project implementation. The relocation inventory was created by viewing conceptual design polygons over Google earth. The estimated costs of such potential displacements are required for estimating project costs and will be refined by the non federal sponsor when construction designs are completed.

The following relocations and consequent cost estimates have been identified for Alternative SB-7: [$882,500]

The following relocations and consequent cost estimates have been identified for Alternative SB-8: [$1,374,000]

Reach Station ID	Structure	Cost
Reach 16	Residential	$ 32,500.00
Reach 16	Business	$40,000.00
Reach 16	Business	$40,000.00
Reach 16	Residential	$32,500.00
Reach 16	Sutter County Small Claims	$40,000.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
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Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Business	$40,000.00
Reach 16	Residential	$32,500.00
Reach 16	Residential	$32,500.00
Reach 16	Business	$40,000.00
Reach 16	Residential	$32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00

Reach Station ID	Structure	Cost
Reach 16	Total Relocation Assistance Payments for SB7	$882,500.00
Reach 31	Building Contents	$40,000.00
Reach 28	Building Contents	$40,000.00
Reach 28	Residential	$32,500.00
Reach 28	Residential	$32,500.00
Reach 28	Residential	$32,500.00
Reach 26	Residential	$32,500.00
Reach 26	Residential	$32,500.00
Sub Total Relocations		$1,124,500.00
Relocations due to Canal and Levee Relocations		
Station 1744 Reach 28	Residential	$32,500.00
Station 1734 Reach 28	Ag Building Contents	$32,500.00
Station 1730 Reach 28	Residential	$32,500.00
Station 1726 Reach 28	Residential	$32,500.00
Station 1700 Reach 26	Residential	$32,500.00
Station 1665 Reach 25	2 Ag Building Contents	$22,000.00
Station 1610 Reach 25	Residential	$32,500.00
Station 1470 Reach 22	Residential	$32,500.00
Total est. all Relocations	Total Relocation Assistance Payments for SB8	$1,374,000.00

Availability of Replacement Housing: There are currently over 300 single family homes for sale in Yuba City. At this time there is replacement housing available.

The foregoing impacts and estimates relating to potential displacements and the anticipated need to provide relocation assistance benefits are provided exclusively for project cost estimating purposes only and are not intended to be relied upon for provision of benefits and/or the payment of the estimates referenced herein. A draft relocation assistance plan has been provided by the sponsors and is currently being reviewed by a relocation specialist.

14. Mineral/Timber Activity/Water Rights

Mineral/Timber Activity: here does not appear to be any effect on the availability of aggregate resources because no structures are anticipated to be constructed that would otherwise interfere with access to permitted mineral resources, and no permitted mineral resource extraction mines exist in the project corridor.

Neither proposed alternative is anticipated to cause the loss of a known mineral resource of regional or local importance as a result of placement according to NEPA and CEQA.

There is no timber harvesting activities going on in the project footprint. There are small portions of agricultural lands (orchards and row crops) that are located in the project footprint, but those have been assessed and are included in the cost estimate.

No natural gas wells are in or near the construction footprint.

Water Rights:

The Sutter-Butte Main Canal (the Canal) delivers Feather River water supply to all four districts that are located generally south and west of Lake Oroville and the Feather River along the eastern side of the Sacramento Valley. The Districts include Sutter Extension Water District, Butte Water District, Richvale Water District and Biggs/West Gridley Water District. In the case of the Canal (which encroaches into the proposed ROW at four locations along the FRWL alignment)\ four potential measures were considered for each area to address ROW needs: construction of a retaining wall in the landside slope, construction of a flood wall, levee relocation and Canal relocation. The proposed measures were also coordinated with the U.S. Fish and Wildlife Service. The flood wall\, retaining wall and Canal relocation options were generally eliminated because these structures were deemed to create substantial barriers to movement of terrestrial wildlife species. Each measure was evaluated based on construction cost and impacts with the conclusion that levee relocation had the least impacts and costs.

Levee relocation was deemed to have the least overall impact and was selected as the primary measure for addressing the issue. The relocated levee is required to meet the minimum levee design criteria and height requirement. The cutoff wall would be constructed at the centerline of there located levee sections.

Relocation of the Canal was, however, selected for a small section along the alignment where the FRWL is too close to the Feather River's main channel to relocate the levee. This option was also selected for a small section of the Canal near the Sunset Weir Pump Station, around station 1430+00, because it was deemed to be more cost effective than the levee relocation option which would require relocation of the pump station' electrical system. Additional coordination with the non federal sponsors is still required concerning the canal relocation because the sponsors did not intend to relocate the canal.

It is presently understood that the Sutter Extension Water District, the Butte Water District, the Richvale Water District and Biggs/West Gridley Water District hold senior water rights on the Feather River, predating the State Water Project. Following the construction of the Sate Water Project's Oroville Dam and related downstream facilities, the Canal began taking supply from a new turnout at the Thermalito Afterbay. The Canal route runs roughly north to south, with major turnouts to each of the four districts' internal distribution systems. The Canal is approximately 17 miles long and is predominantly unlined. The existing operating capacity ranges from approximately 1,600 cubic feet per second (cfs) at the upstream end to approximately 500 cfs at the downstream end. Operation and maintenance (O&M) of the Canal is conducted by the Joint Water Districts Board, which includes representatives of each of the four districts referenced above. The Canal operates as the backbone of a gravity irrigation

distribution system, with check dams at regular intervals used to maintain water surface levels at sufficient height to allow gravity diversions to adjacent users.

Presently, neither alternative anticipates the need for acquisition of potential water rights held by the four water districts for project implementation purposes. Temporary bypass systems may be provided, if legally required and/or permissible, to minimize disruption to irrigation and other utility services. Additional real estate needs may potentially include the acquisition of private irrigation canals, and damages for such acquisitions are included in the cost estimate.

15. Non-Federal Sponsor's Ability to Acquire

The State of California Central Valley Flood Protection Board has partnered with the Corps on several prior projects and has a full Real Estate staff capable of fulfilling its' responsibilities as a non-Federal sponsor.

The assessment of Non-Federal Sponsor's Real Estate Acquisition Capability has been provided to SBFCA and the Corps is awaiting their response.

16. Zoning Anticipated in Lieu of Acquisition

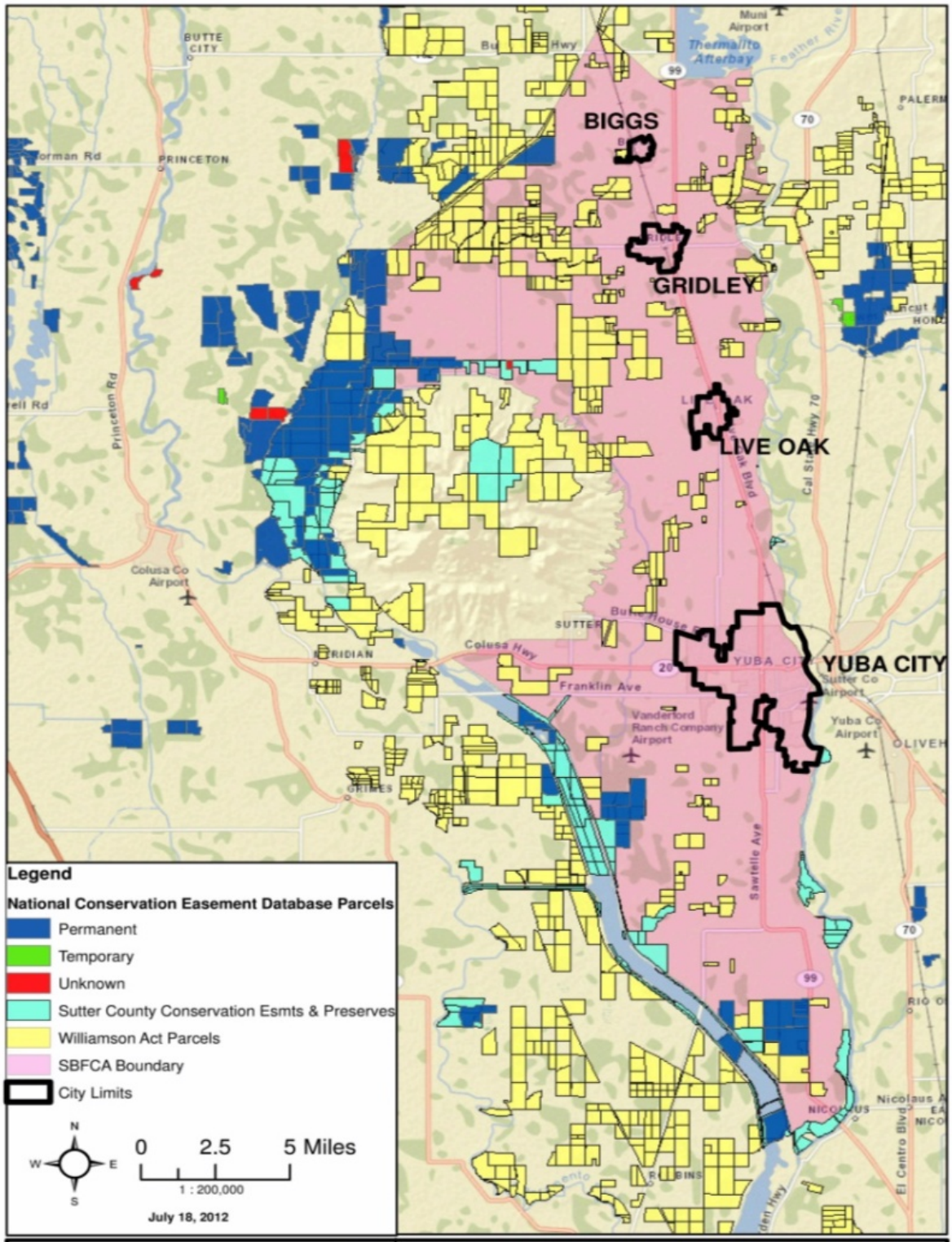
There is no zoning anticipated in lieu of acquisition. The wise use of flood plains, include the zoning in lieu of acquisition to preserve lands as described below and shown in the map below. These are all existing conditions and do not require taking of real property or just compensation to be paid as part of the federal project. The following lands described below prevent local development from occurring in the floodplain.

Senate Bill 5 State of California (SB5) : Development in southern, deep flooding portion of basin is precluded by SB5 due to lack of 200-year ACE as shown in the map below (purple). This bill is already enacted and does not require the taking of any properties. It just prohibits any new construction until the level of protection has increased. Senate Bill 5 (SB 5) signed into law in October 2007 updates the California Health & Safety Code to require the Department of Water Resources (DWR) to propose updated requirements to the California Building Standards Code. The requirements proposed for adoption and approval by the California Building Standards Commission (BSC) would be for construction in areas protected by the facilities of the Central Valley Flood Protection Plan where flood levels are anticipated to exceed three feet for the 200-year flood event. Before DWR proposes the amendments to the California Building Standards Code, the Department is to consult with the Central Valley Flood Protection Board, the Division of the State Architect, and the Office of the State Fire Marshal. Senate Bill 5 (SB-5) mandates that the State of California must have a plan in place by 2015 to achieve 200-yr level of flood protection by year 2025 for urban and urbanizing areas, including Yuba City.

Williamson Act Contracts: These rolling 10-year agreements between government and farmers to preserve the agricultural and open space in rural California offer landowners tax breaks on the assessed land value as shown in the map below (yellow). These contracts are a existing condition and are voluntary and do not require takes of any properties for the federal project.

Conservation Easements: Voluntary Existing Agreements between landowners and an agency (USFWS, etc) which permanently precludes future development as shown in the map below (blue).

Both Williamson Act Contracts and conservation easement will continue in perpetuity.



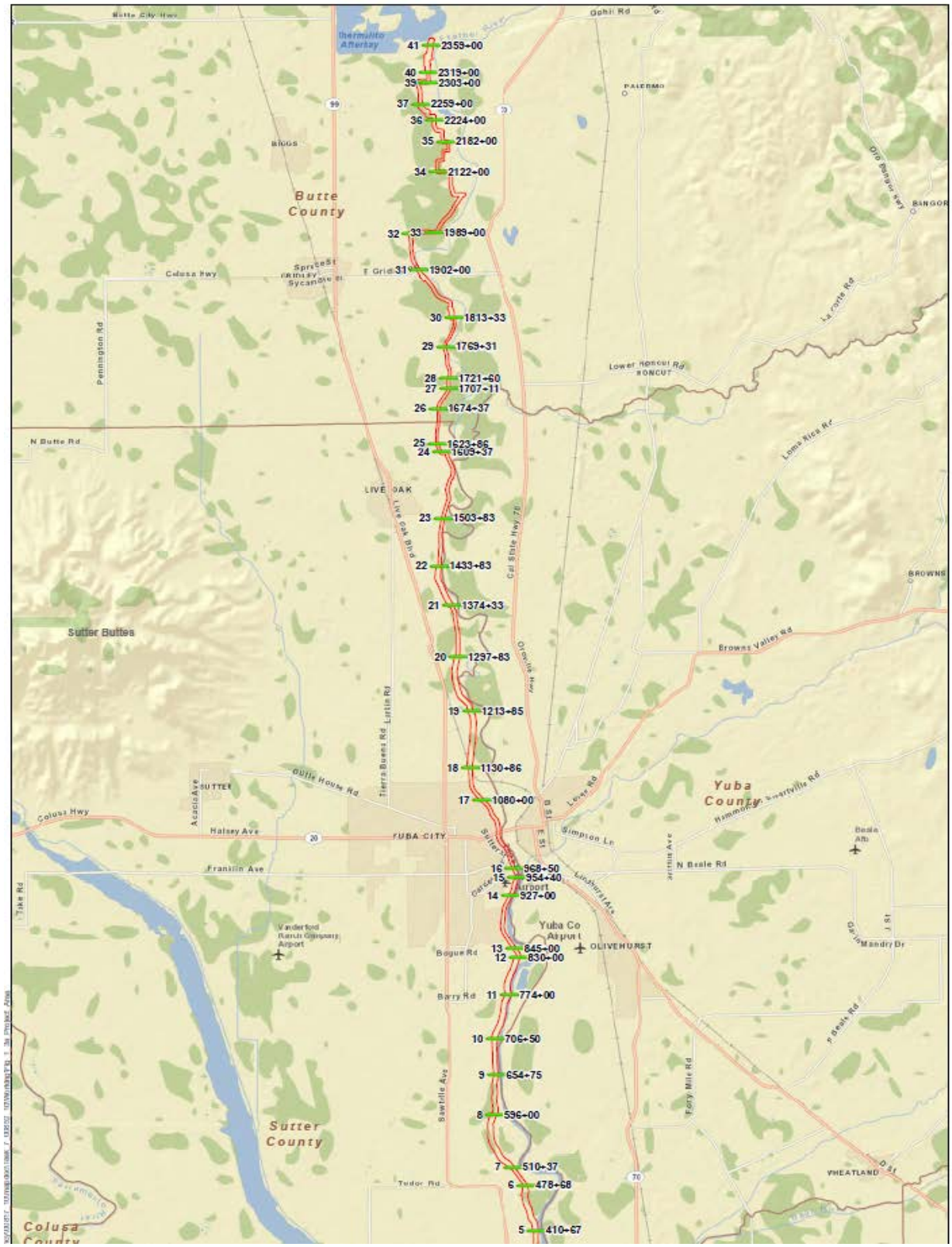
SUTTER BASIN FEASIBILITY STUDY

SUMMARY OF WILLIAMSON ACT LANDS
AND CONSERVATION EASEMENTS
WITHIN THE SUTTER BASIN

17. **Acquisition Schedule**

The non-Federal sponsors will be directed to begin real property acquisition for the project only after the PPA is fully executed. A risk letter has been sent from the Corps to Sutter Butte Flood Control Agency and the State of California alerting them to the risks associated with purchasing project lands in advance of the PPA being executed. The construction contracts extend out ten years. Durations of each tasking after the PPA is executed is estimated at 3 to 6 months per construction contract.

REAL ESTATE ACQUISITION SCHEDULE				
Project Name: Sutter Feasibility Contracts A, Starbend FIP, B, C1, C2, D1, D2	COE Start	COE Finish	NFS Start	NFS Finish
Receipt of preliminary drawings from Engineering/PM	2011	2012	2010	2011
Receipt of final drawings from Engineering/PM	2014	2014	2011	2013
Execution of PPA/Finalize Chief's Report	Feb - June 2014 Depending on HQ and SPD Review times			
Formal transmittal of final drawings & instruction to acquire LERRDS	2015			
Years for Construction Contract A (Reaches 2 -5) Contract Starbend FIP (Reach 6) Contract B (Reaches 7-12) Contract C1 (Reaches 13-18) Contract C2 (Reaches 19-25) Contract D1 (Reaches 26-33) Contract D1 (Reaches 34-41)			 2022 2021 2021 2017 2018 2019 2020	 2023 2022 2022 2018 2019 2020 2021
Conduct Landowner Meetings			2016	2023
Prepare/review mapping & legal descriptions			2016	2023
Obtain/review title evidence			2016	2023
Obtain/review tract appraisals			2016	2023
Conduct negotiations			2016	2023
Prepare/review condemnations			2016	2023
Perform condemnations			2016	2023
Obtain Possession			2016	2023
Complete/review PL 91-646 benefit assistance			2016	2023
Certify all necessary LERRDS are available for construction			2016	2023
Prepare and submit credit requests			2016	2023
Review/approve or deny credit requests	2016	2023	2016	2023
Establish value for creditable LERRDS	2016	2023	2016	2023



Description of Facility and Utility Relocations Utility Station ID Map

18. **Description of Facility and Utility Relocations**

On January 10, 2013, the USACE issued a new policy guidance letter (PGL) No. 31 – Real Estate Support to Civil Works Planning Paradigm 3x3x3 pertaining to relocations where the estimated total cost to modify all project utilities does not exceed 30 percent of the total project cost, the District Office of Real Estate shall, in lieu of an attorney's preliminary opinion of compensability, prepare a real estate assessment. Consistent with the provisions of PGL No. 3, the use of a real estate assessment does not eliminate the need to obtain a final attorney's opinion of compensability prior to execution of the PPA.

Reaches 2 thru 21 represent Alternative SB-7. Based the cost estimate provided by the non-Federal sponsors, which has been reviewed by the Sacramento District Office of Real Estate, the real estate assessment for Alternative SB-7 yields utility/facility relocation costs in the estimated amount of $40,444,033.

Reaches 2 thru 41 represent Alternative SB-8. Based on the cost estimate provided by the non-Federal sponsors, which has been reviewed by the Sacramento District Office of Real Estate, the real estate assessment for Alternative SB-8 yields utility/facility relocation costs in the estimated amount of $121,669,791.

The Utility Inventory table, maps and costs discussed herein are available in Exhibit A - DVD.

ANY CONCLUSION OR CATEGORIZATION CONTAINED IN THIS REAL ESTATE PLAN (AND THE REPORT) THAT AN ITEM IS A UTILITY OR FACILITY RELOCATION TO BE PERFORMED BY THE NON-FEDERAL SPONSOR AS PART OF ITS LERRD RESPONSIBILITIES AND/OR IS OTHERWISE COMPENSABLE OR NON-COMPENSABLE IS PRELIMINARY AND FOR DISCUSSION PURPOSES ONLY. THE GOVERNMENT WILL MAKE A FINAL DETERMINATION OF THE RELOCATIONS NECESSARY FOR THE CONSTRUCTION, OPERATION, OR MAINTENANCE OF THE PROJECT AFTER FURTHER ANALYSIS AND COMPLETION AND APPROVAL OF THE FINAL ATTORNEY'S OPINIONS OF COMPENSABILITY FOR EACH OF THE IMPACTED UTILITIES AND FACILITIES DURING FINAL DESIGNS.

19. Hazardous,Toxic, and Radiological Waste Impacts

A preliminary Phase I Environmental Site Assessment (ESA) has been conducted to identify potential HTRW sites. No known contamination due to HTRW was confirmed within the construction zone, however, a full Phase I ESA has not been conducted.

To further investigate the potential for hazardous toxic radioactive wastes (HTRW) in the project area, a full Phase I Environmental Site Assessment (ESA) would be performed during the project design phase. If the Phase I ESA indicates the presence of HTRW, a Phase II ESA would be performed involving chemical analysis for hazardous substances and/or petroleum hydrocarbons. If hazardous substances are encountered during construction, USACE or its contractor will implement required measures for the proper transport and disposal of such materials in accordance with the appropriate local, state, and Federal laws and regulations.

If any evidence of potential HTRW is found during construction, all work would cease, and the Corps and non-Federal sponsor would be notified for further evaluation of the potential contamination. Any unanticipated hazardous materials encountered during construction would be handled according to applicable federal, state, and local regulations. The Corps would require that a contingency plan that outlines steps to be taken before and during construction activities to document soil conditions, as well as procedures to be followed if unexpected conditions are encountered, be prepared by the contractor.

The non-Federal sponsor is responsible for 100 percent of the cost to develop the clean-up procedures (remedial action plan) and to treat the contaminate in place or relocate the material (ER 1110-2-1150).

20. Attitude of Landowners

To date, the results of the outreach program from the public scoping meetings have been very favorable, constructive, and supportive. The tone and substance of the input has been consistent with the voter-approved assessment to fund the local share of the project.

EXHIBIT B

ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY
SUTTER PILOT FEASIBILITY STUDY

SPONSORS: The State of California, Central Valley Flood Protection Board (CVFPB), Sutter Butte Flood Control Agency (SBFCA)

I. Legal Authority:

a. Do the sponsors have legal authority to acquire and hold title to real property for project purposes? Yes CVFPB; Yes SBFCA

b. Do the sponsors have the power of eminent domain for this project? Yes CVFPB; Yes SBFCA

c. Do the sponsors have "quick-take" authority for this project? Yes CVFPB; Yes SBFCA

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? No CVFPB; No SBFCA

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? No CVFPB; SBFCA Response: Some of the lands are owned by public entities, including local and state agencies. Under California law, it is more difficult to condemn property owned by public entities. Some of the property within the project area is owned by a railroad company. Condemning railroad property is also more difficult due to federal pre-emption issues.

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? Yes CVFPB; No SBFCA

b. If the answer to a. is "yes," has a reasonable plan been developed to provide such training? Yes CVFPB; SBFCA N/A

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? Yes CVFPB; Yes SBFCA

d. Is the sponsor's project in-house staffing level sufficient considering its other workload, if any,
and the project schedule? Yes CVFPB; Yes SBFCA

e. Can the sponsor obtain contractor support, if required, in a timely fashion? Yes CVFPB; Yes SBFCA

f. Will the sponsor likely request USACE assistance in acquiring real estate? No CVFPB; No SBFCA

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? Yes CVFPB; Yes SBFCA

b. Has the sponsor approved the project real estate schedule/milestones? Yes CVFPB; SBFCA Response: No, the approval occurs during the preconstruction, engineering and design phase.

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? Yes CVFPB; SBFCA Response: SBFCA has not worked on other USACE projects.

b. With regard to this project, the sponsor is anticipated to be: The State of California, Central Valley Flood Protection Board and Sutter Butte Flood Control Agency

V. Coordination:

a. Has this assessment been coordinated with the sponsor? Yes CVFPB; SBFCA Response: SBFCA has coordinated with USACE throughout the Sutter Pilot Feasibility Study.

b. Does the sponsor concur with this assessment? Yes CVFPB; SBFCA Response: SBFCA concurs with USACE at the feasibility stage of the project. SBFCA anticipates refinements during preconstruction, engineering and design.

Prepared by:

_____
Laurie Parker
Realty Specialist
Acquisition Branch

Date _____

Reviewed and Approved by:

_____
Sharon Caine
Chief, Real Estate Division
U.S. Army Engineer District, Sacramento

Date _____

EXHIBIT A
CADASTRAL MAP AND TRACT REGISTERS AND UTILITY RELOCATION TABLE
AVAILABLE UPON REQUEST
ON CD