Appendix D – MBK Final Hydraulic Analysis for River Islands at Lathrop

River Islands at Lathrop
Hydraulic Impact Analysis

Prepared for

River Islands at Lathrop

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1. Introduction

The proposed River Islands at Lathrop ("River Islands") Project is located within the City of Lathrop in San Joaquin County, CA. River Islands is a 5,000 acre mixed-use master planned community located on Stewart Tract, a high ground island (the interior of the island is above sea level) located in the Secondary Zone of the San Joaquin/Sacramento Delta. Stewart Tract is adjacent to the Paradise Cut Flood Bypass ("Paradise Cut") which was designed to divert flood waters away from urban areas along the San Joaquin River to the San Francisco Bay. Paradise Cut is part of the San Joaquin River Flood Control Project levee system. The flow split between the San Joaquin River and the Paradise Cut is not functioning as envisioned by the original design by the United States Army Corps of Engineers (USACE). The existing channel configuration sends more water down the San Joaquin River to the urban areas than the original design intent of the federal project. The federal project is not functioning as intended by the USACE design. This condition is attributable to the limited hydraulic modeling capabilities at the time of the project design and/or changes in the channel geometry that may have occurred since the project was constructed. This issue is discussed in greater detail in Section 4.

The proposed project would enlarge and improve portions of Paradise Cut by setting back the right bank levee and excavating a portion of the floodway just downstream of the Paradise Weir. These features would improve the hydraulic efficiency of the Paradise Cut, allowing additional flood flows through the channel, which will help to restore the original design flow split.

River Islands is divided into two phases. Phase 1 includes approximately 40% of the development area and is not subject to any additional Federal actions. Infrastructure for Phase 1 is currently under construction. Phase 2 requires a Section 404 permit for the fill of wetlands and waters of the United States, Section 10 Rivers & Harbors Act approvals (e.g. bridges), and authorization under 33 U.S.C. 408 for the approval of alterations to the Federal Project Levees.

The USACE is currently preparing an Environmental Impact Statement (EIS) for River Islands that will include a hydraulic impact analysis associated with the proposed project. This analysis will include both a traditional deterministic analysis, as well as a Risk Analysis, as required by the USACE to support the Section 408 Summary Report. The "Ground Rules" for the Risk Analysis are included as Attachment A; documentation of the Risk Analysis is included in Attachment B (River Islands at Lathrop, Hydraulic Analysis in Support of Risk Based Hydraulic Impact Analysis) and Attachment C (Conditional Risk Analysis for the River Islands at Lathrop Project).

2. Hydraulic Simulation Model

A HEC-RAS computer simulation model of the lower San Joaquin River (LSJR Model) was used to perform hydraulic analyses. HEC-RAS is a computer program developed by the USACE Hydrologic Engineering Center that performs one-dimensional steady and unsteady hydraulic calculations for a full network of natural and constructed channels. Version 4.1 of HEC-RAS was used for this analysis. The LSJR Model was calibrated using the January 1997 flood event and the February 1998 high flow event. The development, calibration, and verification of the model are described in detail in the MBK Engineers report "Lower San Joaquin River (LSJR) HEC-RAS Hydraulic Computer Simulation Model Development, Calibration and Verification", dated January 27, 2006 (MBK 2006a). MBK 2006a presents a calibration simulation and results from the HEC-RAS version 3.1.3 version of the LSJR model and has not yet been updated to incorporate the current HEC-RAS version 4.1 model. However, maximum water surface elevation profiles have been prepared showing the HEC-RAS version 4.1 model results and comparing these to the version 3.1.3 model. These updated calibration water surface elevation profiles are provided in Attachment D.

The LSJR Model study area includes the San Joaquin River from Vernalis to the Stockton Deep Water Channel; Old River from the San Joaquin River to the west end of Fabian Tract near Clifton Court Forebay; Middle River from Old River to Highway 4; and the entirety of Paradise Cut, Salmon Slough and Grant Line Canal. A schematic of the LSJR Model river reaches is provided in Figure 1.

The vertical datum used for the hydraulic model is National Geodetic Vertical Datum of 1929 (NGVD29). All elevation results presented herein have been converted to North American Vertical Datum of 1988 (NAVD88) by adding 2.4 feet to the NGVD29 elevation. The conversion factor was determined by Carlson, Barbee and Gibson, Inc., as documented in Attachment E.

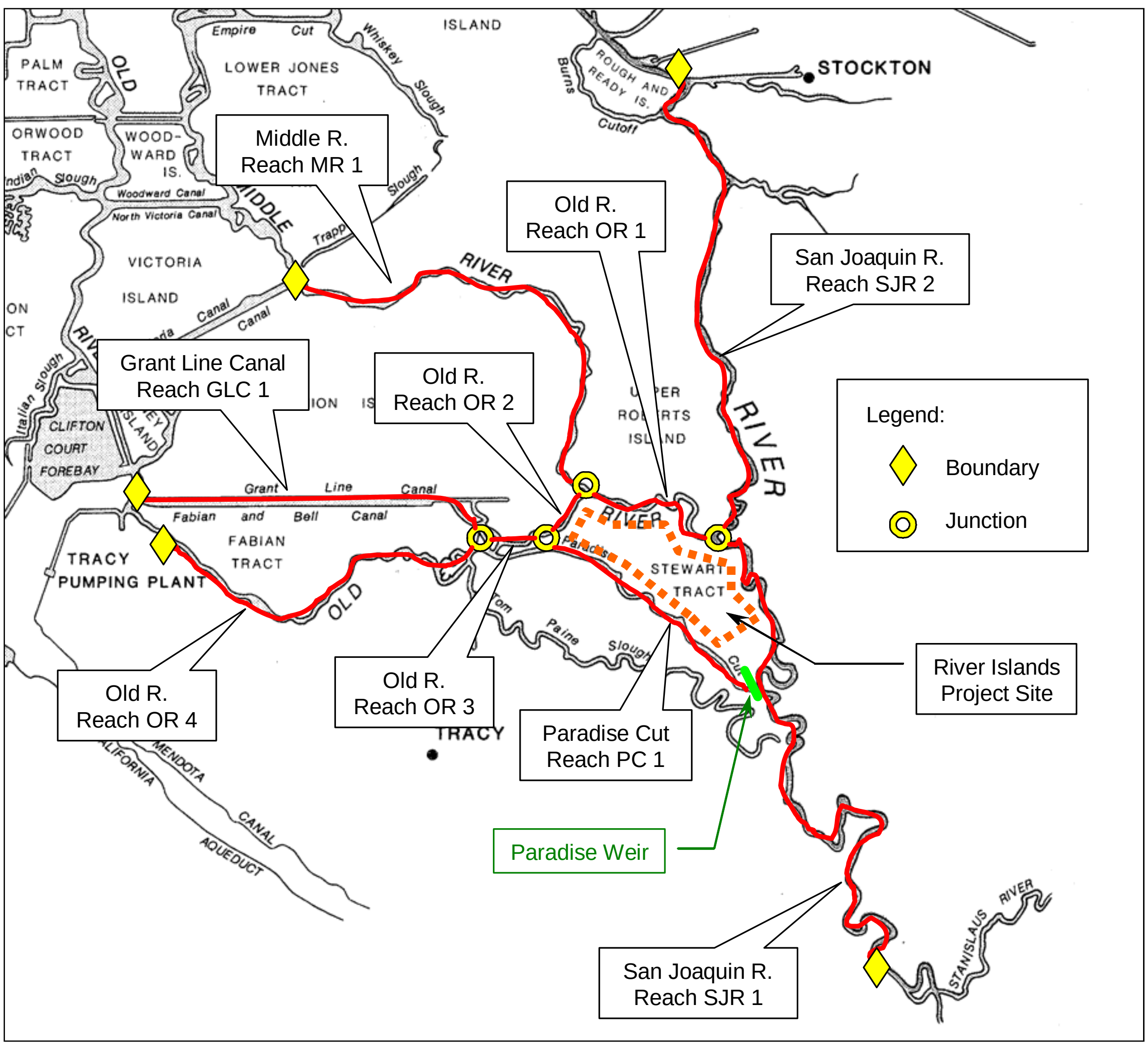

Figure 1. Lower San Joaquin River HEC-RAS Model River Reach Schematic

3. Hydrology

The hydrologic data used for the analysis consists of flow data at the upstream model boundary and stage data at the downstream boundaries. The upstream boundary flow data was extracted from hydraulic simulations of the San Joaquin River and tributaries UNET model developed by USACE as part of the Sacramento and San Joaquin River Basin Comprehensive Study (Comp Study) (USACE 2002). USACE performed simulations for two levee performance scenarios: 1) levees overtop without failing, and 2) levees fail when water reaches the “Likely Failure Point,” which is defined by USACE as the 50% probability of failure elevation. The upstream boundary flows used in LSJR Model simulations were selected from Comp Study San Joaquin River UNET Model simulations with similar levee performance assumptions. That is, the upstream boundary flows in LSJR Model simulations in which levees are assumed to overtop without failing came from Comp Study San Joaquin River UNET Model simulations that assumed levees overtop without failing. Since USACE did not simulate a top of levee failure scenario, MBK set up and ran simulations of the “Likely Failure Point” Comp Study UNET model with levee failure trigger elevations changed to the top of levee elevation to produce upstream flow hydrographs for the LSJR Model top of levee failure simulations. The first scenario provides the basis for the risk based hydraulic impact analysis as outlined in Attachment A. This scenario is an extreme, deterministic assumption preferred by many design engineers and routinely used prior to the development of Risk Analysis procedures. The second scenario as modified by MBK provides a realistic analysis of the impacts levee failures have on the system hydraulics. For example, during the 1997 flood over 30 levee failures occurred in the San Joaquin River levee system. The 1997 flood has a probability slightly greater than a 100-year flood (also known as the 1-in-100 annual exceedance probability (AEP) flood). The levee system is essentially the same now as it was in 1997, therefore a significant number of levee failures can be expected for floods equal to or greater than the 100-year flood because the levee system was designed for a 50-year flood.

The Comp Study hydraulic analysis included simulations of a number of storm centerings that were designed to stress the flood control system at specific locations. The River Islands hydraulic analysis used flow data from the Comp Study simulation of the San Joaquin River Mainstem at Latitude of Vernalis storm centering

The San Joaquin River Comp Study hydrologic data set contains flow data for the following flood frequencies: 10-year (1-in-10 AEP), 25-year (1-in-25 AEP), 50-year (1-in-50 AEP), 100-year (1-in-100 AEP), 200-year (1-in-200 AEP), and 500-year (1-in-500 AEP).

Simulation results for the 50-year, 100-year, 200-year, and 500-year flood events are presented in this report. A summary table of the peak flows at the latitude of Vernalis for the simulated flood events is provided in Table 1. For comparison, peak flows from a table provided by USACE from the draft Lower San Joaquin River Feasibility Study are also included.

Table 1. Summary and Comparison of Peak Flows at Latitude of Vernalis					
		Peak Flow at Latitude of Vernalis (cfs)			
Source	Levee Scenario	50-year	100-year	200-year	500-year
River Islands hydraulic impact analysis	Top of levee failure trigger	43,600	71,000	110,300	162,800
	Overtop without failure	47,700	78,100	144,400	224,000
USACE	Infinite Levee	58,400	90,800	145,500	233,700
	Overtop without failure	47,700	78,200	144,500	224,100
	"Likely failure point" trigger	50,300	77,300	113,300	166,600

4. Paradise Weir Deficiencies

The Paradise Weir does not currently function as originally intended. The original design (USACE 1955) indicated that 15,000 cubic feet per second (cfs) of the design flow of 52,000 cfs in the San Joaquin River would be diverted to Paradise Cut. Simulation of the 52,000 cfs design flow with the LSJR HEC-RAS model indicates that approximately 13,400 cfs will be diverted to Paradise Cut. This deficiency appears to be due to differences in the San Joaquin River stage at Paradise Weir and not due to any maintenance issues in Paradise Cut. The design flood plane elevation at Paradise Weir is 25.0 ft. (NGVD29) (USACE 1955); whereas, the water surface elevation at Paradise Weir computed by the LSJR HEC-RAS model is 23.3 ft. (NGVD29) (see Figure 2). It is stated in USACE 1955 that water begins to flow into Paradise Cut when the flow in the San Joaquin River is about 14,000 cfs. Recent observations of actual flood flows, supported by LSJR model simulations, indicate that flow into Paradise Cut does not start until the flow in the San Joaquin River is closer to 18,000 cfs.

The actual system performance has shown that river stages have been significantly lower than was anticipated by the USACE design engineers in 1955. It is possible that the San Joaquin River thalweg has lowered over time due to scour. It is also possible that the Manning's n roughness coefficients assumed in the 1955 analysis were too high, resulting in an over-estimation of the water surface elevation in the San Joaquin River at the Paradise Weir. In addition, the 1955 analysis was likely based on hand calculated step-backwater calculations with limited geometric (i.e., cross-section) data and limited observed flood stage data for calibration. The LSJR HEC-RAS model includes detailed geometric data as well as streamgage and high water mark data from multiple flood events that are the basis for calibration of the model.

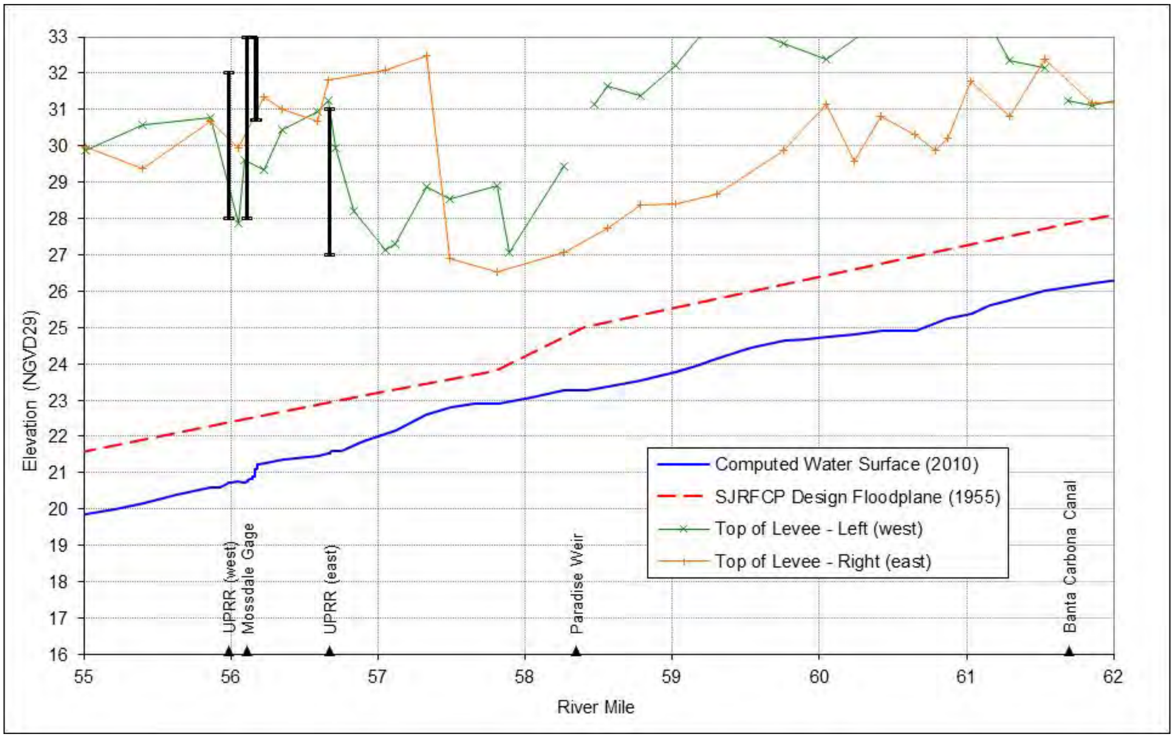

Figure 2. San Joaquin River Profile, Federal Project Design Discharge

5. Study Scenarios

The analysis was performed for four scenarios:

1) Base Condition ("Base"): System prior to construction of the River Islands interior levees that form the Phase 1 protected area shown in Figure 3.
2) Existing Condition ("Existing"): This scenario includes the existing levee alignments and channel geometry for Stewart Tract and the surrounding area, as shown in Figure 3. Approximately 25% of the project area has already been removed from the 100-year floodplain to allow for development. This Phase 1 levee system was constructed in 2006 and recently accredited by FEMA.
3) Modified Condition, Cumulative with No Federal Action ("No Action"): This scenario evaluates hydraulic impacts for flood protection which could be built without triggering a Federal action. This scenario consists of a FEMA accredited interior levee that does not come in contact with Federal Project levee or any waters of the U.S., as shown in Figure 4. Urban levees are assumed to have a minimum of three feet of freeboard on the 200-year flood event.
4) Modified Condition, Cumulative With Project ("With Project"): This scenario includes the improvements for River Islands, as described in "Lower San Joaquin River HEC-RAS Model, Modeling of River Islands at Lathrop Post-Project Conditions", dated May 10, 2006 (MBK 2006b), with the following changes: the proposed "back-bays" on Old River, designated as OR1 through OR7 in MBK 2006b, have been removed: a setback of the Old River left levee between Middle River and Paradise Cut has been added. The "With Project" alternative is shown in Figure 5. Urban levees are assumed to have a minimum of three feet of freeboard on the 200-year flood event.

In all scenarios, it is assumed that all of the San Joaquin River Flood Control Project (SJRFCP) levees are in compliance with minimum design freeboard requirements. That is, if existing top of levee elevation data indicated that a levee is freeboard deficient relative to the SJRFCP design flood plane (1955 Profile), the hydraulic model was modified to increase the top of levee to meet the minimum authorized height. The USACE requires the local sponsors to maintain the original design levee profile. Therefore any levee elevation deficiencies will be rectified during the normal maintenance activities.

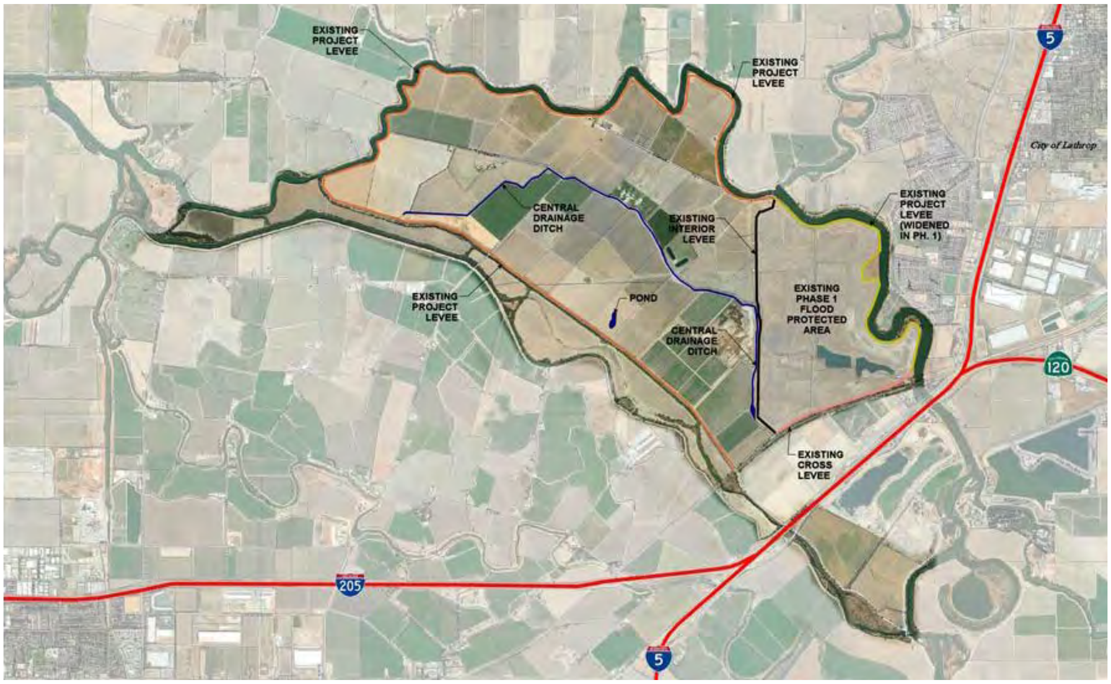

Figure 3. Existing Scenario

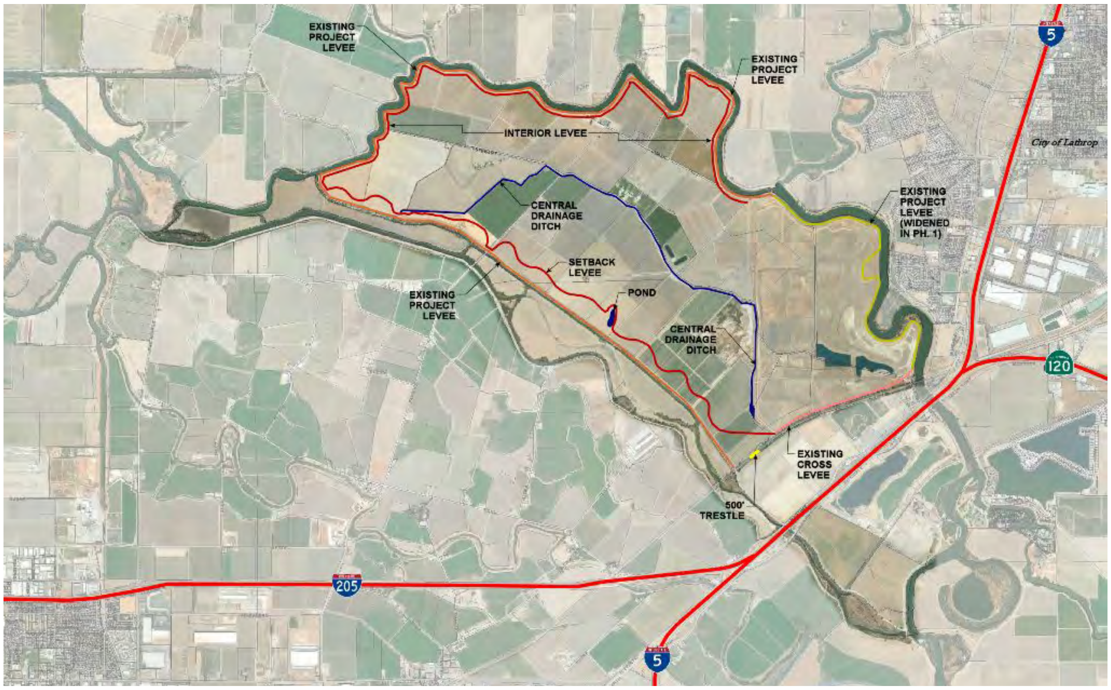

Figure 4. No Action Scenario

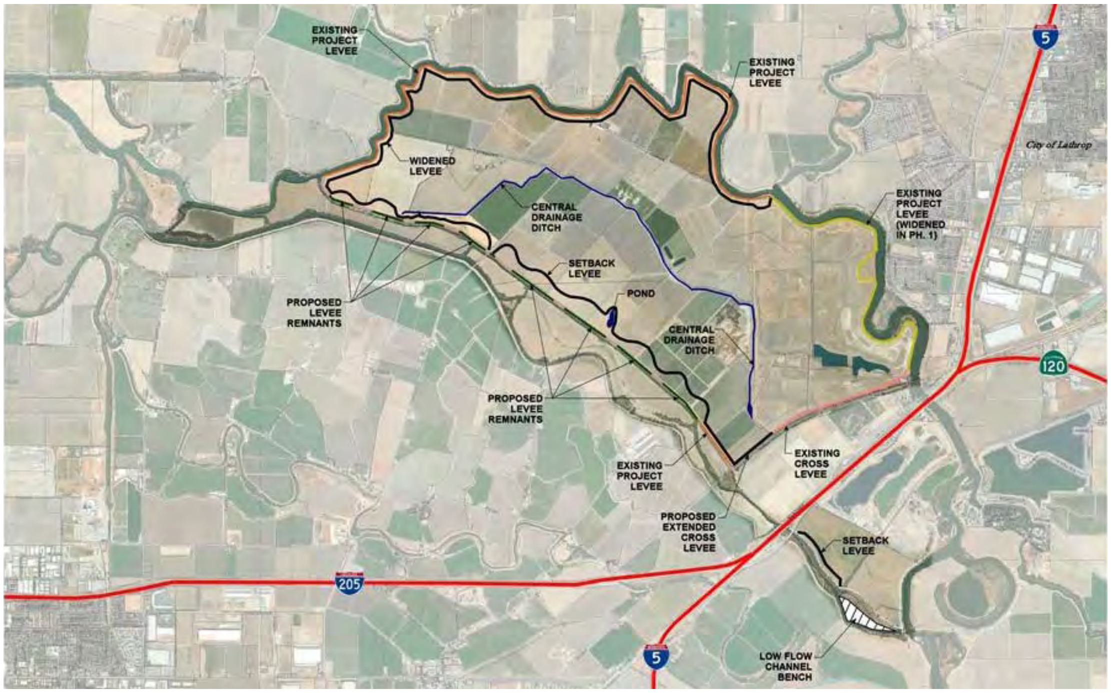

Figure 5. With Project Scenario

6. Analysis

All of the reaches in the Lower San Joaquin River HEC-RAS model have levees on both sides of the river. The levees on the San Joaquin River, Paradise Cut, and Old River above Sugar Cut are Federal Project levees and have a design elevation that is based on a flood event with an estimated recurrence interval of approximately 50 years (1955 Profile) or a 1-in-50 AEP. In the hydraulic analysis, an assumption had to be made with regard to how levees will perform when subjected to flood events greater than the system design, which in this analysis are the 100-year, 200-year, and 500-year flood events. USACE guidance for risk analysis (e.g. EM 1110-2-1619 and ER 1105-2-101) does not specify levee performance criteria for risk analysis. A demonstration application of risk based hydraulic impact analysis performed by West Consultants, Inc. for the USACE (WEST 2009) used the assumption that levees would fail if overtopped by 1 foot of water for 3 hours. However, the procedure developed in coordination with the USACE for the risk based hydraulic impact analysis for the Natomas Levee Improvement Project, which is the basis of the procedure outlined in Attachment A, specified that the analysis would assume that levees overtop without failing. Based on hydraulic model simulations with Comp Study hydrology, the lower San Joaquin River levees do not overtop in the 50-year flood event, experience some overtopping in the 100-year event, and experience significant overtopping in the 200-year and 500-year flood events. There are approximately 52 miles of levee on the San Joaquin River, Old River, and Paradise Cut at and upstream of Stewart Tract. Almost 20 out of the 52 miles of levee are overtopped in the 200-year flood event and 29 miles of levee are overtopped in the 500-year flood event. The extent of overtopping, along with maximum depth of overtopping, are summarized in Tables 2 and 3. Maps showing the extent of overtopping are provided in Attachment F. Clearly numerous levee failures would result from such massive levee overtopping. Given these conditions, increases in water surface elevations within the river channels for the 200-year and 500-year flood events are not the primary indicator of the change in flood risk, especially when the floodplain adjacent to the levees is already inundated from upstream levee overtopping and/or failures.

Deterministic hydraulic analysis results are presented herein for both a likely condition that levees will fail when water reaches the top of levee and the condition that levees will overtop without failing as outlined in the risk analysis Ground Rules in Attachment A. The hydraulic impacts for NEPA purposes are based on the assumption of that levees will fail when water reaches the top of levee. This has been selected as the “most likely” levee failure assumption. Historically, levees failures in the study area have occurred below the top of levee. These failures have been due to geotechnical modes of failure and have occurred with water surface elevations at varying distances from the top of levee with no documented system wide trends correlating elevation from top of levee to likely failure. For these reasons, top of levee is selected as a conservative estimate of when the levee would likely fail based on a geotechnical mode of failure. In the hydraulic analysis, it is assumed that a levee failure occurs at every location where the water surface reaches the prescribed failure trigger.

The information on the overtopping without failure analysis is presented for informational purposes.

Table 2. Length and Depth of Levee Overtopping - Left Levee

Reach	Total Reach Length	Length of Overtopped Levee (Maximum Depth of Overtopping)			
		50-year	100-year	200-year	500-year
San Joaquin River					
Vernalis to Paradise Cut	11.4 mi.	0	0	4.4 mi. (1.0 ft.)	6.8 mi. (1.5 ft.)
Paradise Cut to Old River	5.0 mi.	0	0	1.5 mi. (3.0 ft.)	1.6 mi. (4.8 ft.)
Paradise Cut					
Paradise Weir to I-5	1.2 mi.	0	0	0.6 mi. (2.1 ft.)	1.1 mi. (4.0 ft.)
I-5 to UPRR	0.6 mi.	0	0	<0.1 mi. (0.3 ft.)	0.6 mi. (2.4 ft.)
UPRR to Old River	4.0 mi.	0	0	0	0
Old River					
San Joaquin R. to Middle R.	4.1 mi.	0	0	0	0.5 mi. (2.0 ft.)

Notes:
Side of river is referenced to looking downstream.
From hydraulic model simulations of existing conditions with levees allowed to overtop without failing.

Table 3. Length and Depth of Levee Overtopping - Right Levee					
Reach	Total Reach Length	Length of Overtopped Levee (Maximum Depth of Overtopping)			
		50-year	100-year	200-year	500-year
San Joaquin River					
Vernalis to Paradise Cut	11.4 mi.	0	0.5 mi. (0.3 ft.)	9.5 mi. (2.8 ft.)	10.6 mi. (4.6 ft.)
Paradise Cut to Old River	5.0 mi.	0	0.8 mi. (1.4 ft.)	1.0 mi. (4.4 ft.)	1.2 mi. (6.2 ft.)
Paradise Cut					
Paradise Weir to I-5	1.2 mi.	0	0	0.9 mi. (1.4 ft.)	1.2 mi. (3.2 ft.)
I-5 to UPRR	0.6 mi.	0	0	0	0.2 mi. (0.6 ft.)
UPRR to Old River	4.0 mi.	0	0	1.3 mi. (1.6 ft.)	3.8 mi. (4.2 ft.)
Old River					
San Joaquin R. to Middle R.	4.1 mi.	0	0	0.6 mi. (1.4 ft.)	1.6 mi. (2.4 ft.)
Notes: Side of river is referenced to looking downstream. From hydraulic model simulations of existing conditions with levees allowed to overtop without failing.					

7. Results

Hydraulic impacts to peak water surface elevations in the river channels were determined at the Index Points shown in Figure 6. The computed peak water surface elevations and impacts for the three simulated scenarios are summarized in Table 4 for the assumption that levees will fail when water reaches the top of the levee and peak water surface elevation profile plots are provided in Attachment G. Attachment G also includes profile plots of the changes in the maximum water surface elevations for Existing to With Project and for No Action to With Project. The peak water surface elevations and water surface elevation profile plots from the sensitivity analysis that assumed that levees will overtop without failing are provided in Table 7 and in Attachment H.

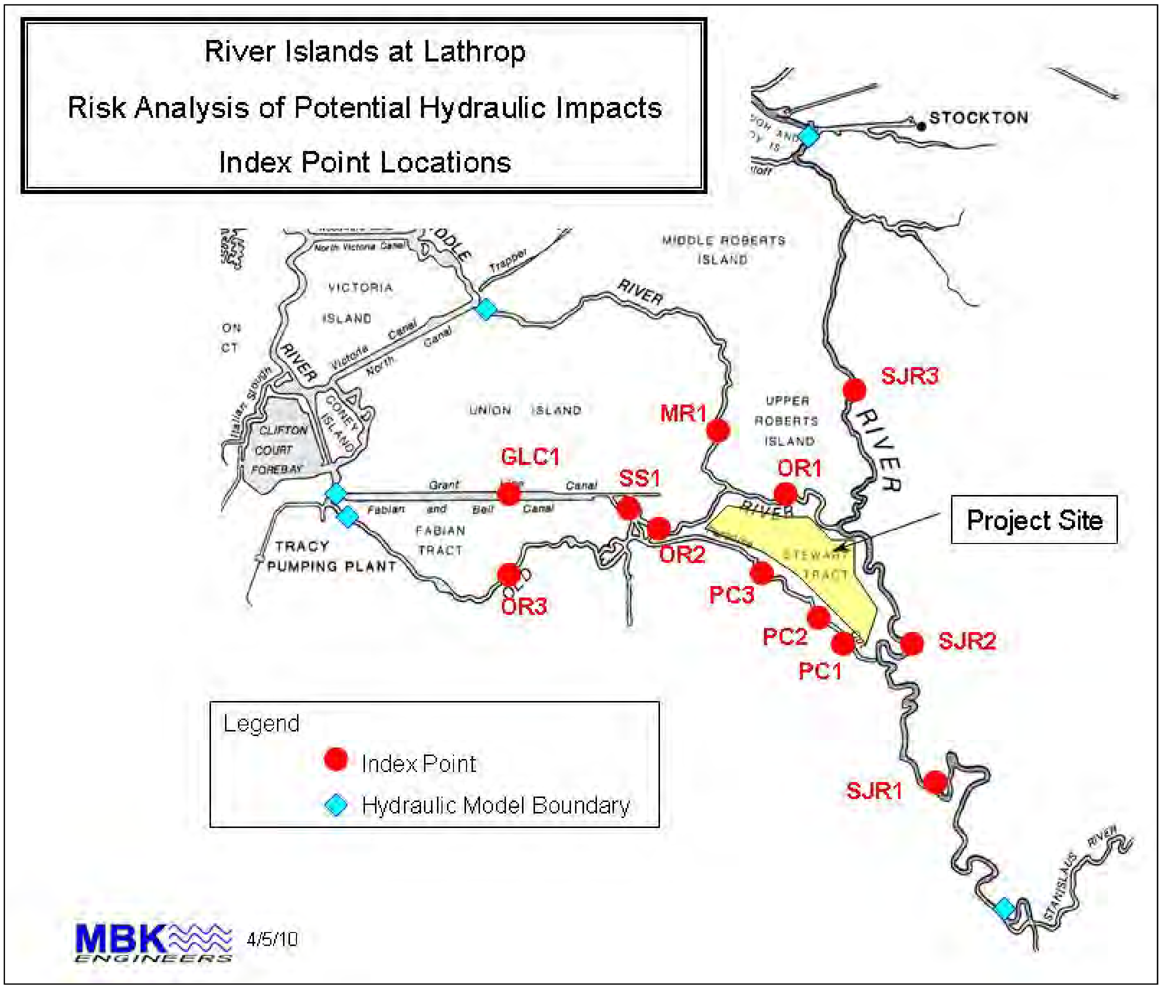

Figure 6. Index Point Locations

As previously noted, significant levee overtopping occurs in the 200-year and 500-year flood simulations resulting in the inundation of adjacent agricultural areas. Under this condition, the traditional approach of measuring impacts in the river channel needs to be supplemented with an assessment of impacts in the floodplains. When land adjacent to the channel, but separated from the channel by a levee, is flooded from either upstream levees overtopping or from an upstream levee failure, the risk of flooding is no longer related to the adjacent stage in the river channel. For this reason, changes to peak water surface elevations and flooded area in the floodplain areas shown in Figure 7 are also presented herein. The peak water surface elevations in the floodplain and maximum inundation areas for the likely condition, in which levees fail when water reaches the top of the levee, are summarized in Tables 5 and 6. Study area maps showing inundation areas for the Existing, With Project, and No Action conditions are provided in Figures 8, 9, and 10, respectively. More detailed inundation maps for the 200-year flood event comparing Existing and No Action conditions with the With Project condition, with close-up details of areas with structures, are provided in Attachment I. The peak water surface elevations in the floodplain and maximum inundation areas for the sensitivity analysis in which levees are assumed to overtop without failing are provided in Tables 8 and 9.

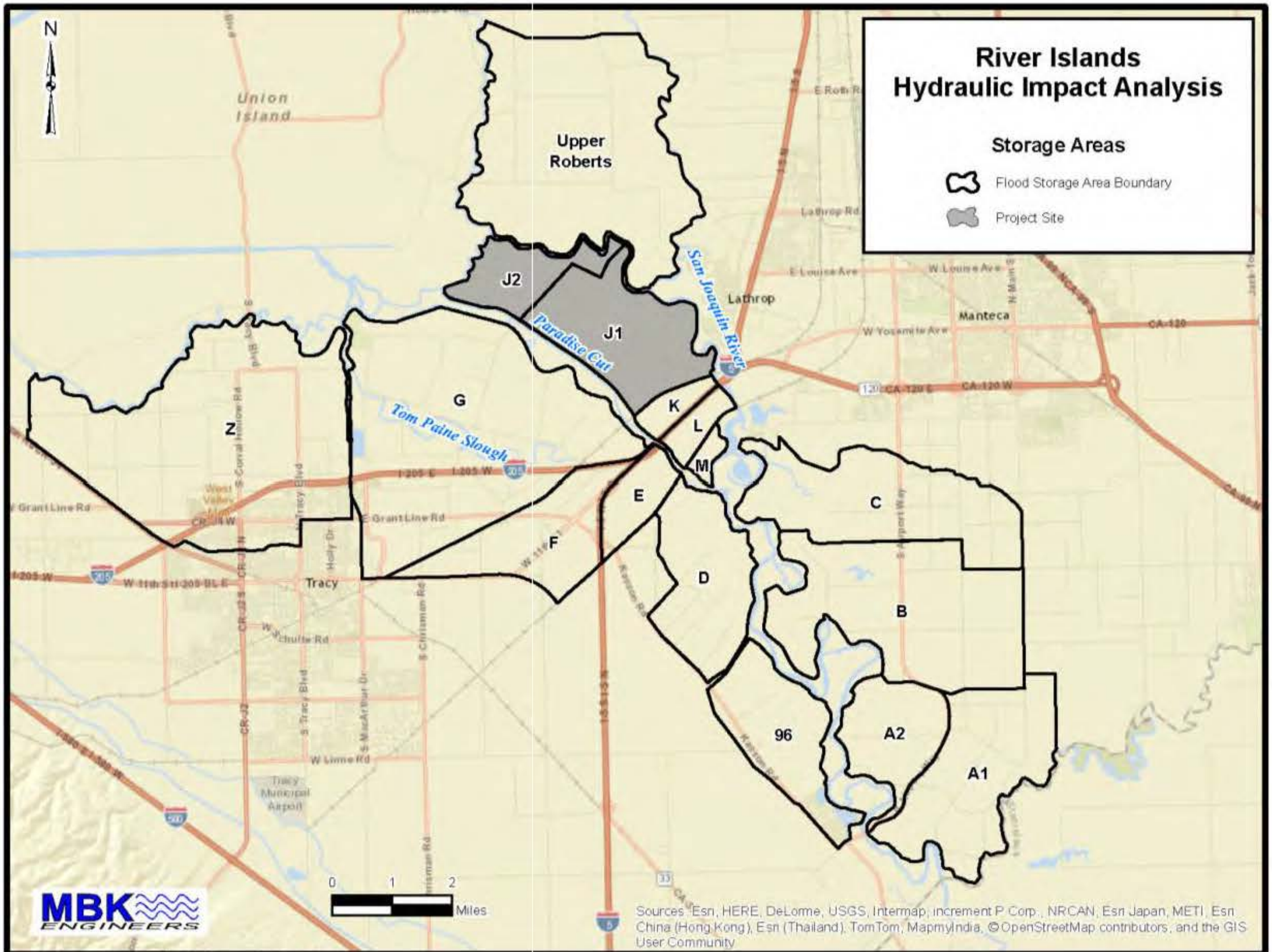

Figure 7. Floodplain Impact Locations

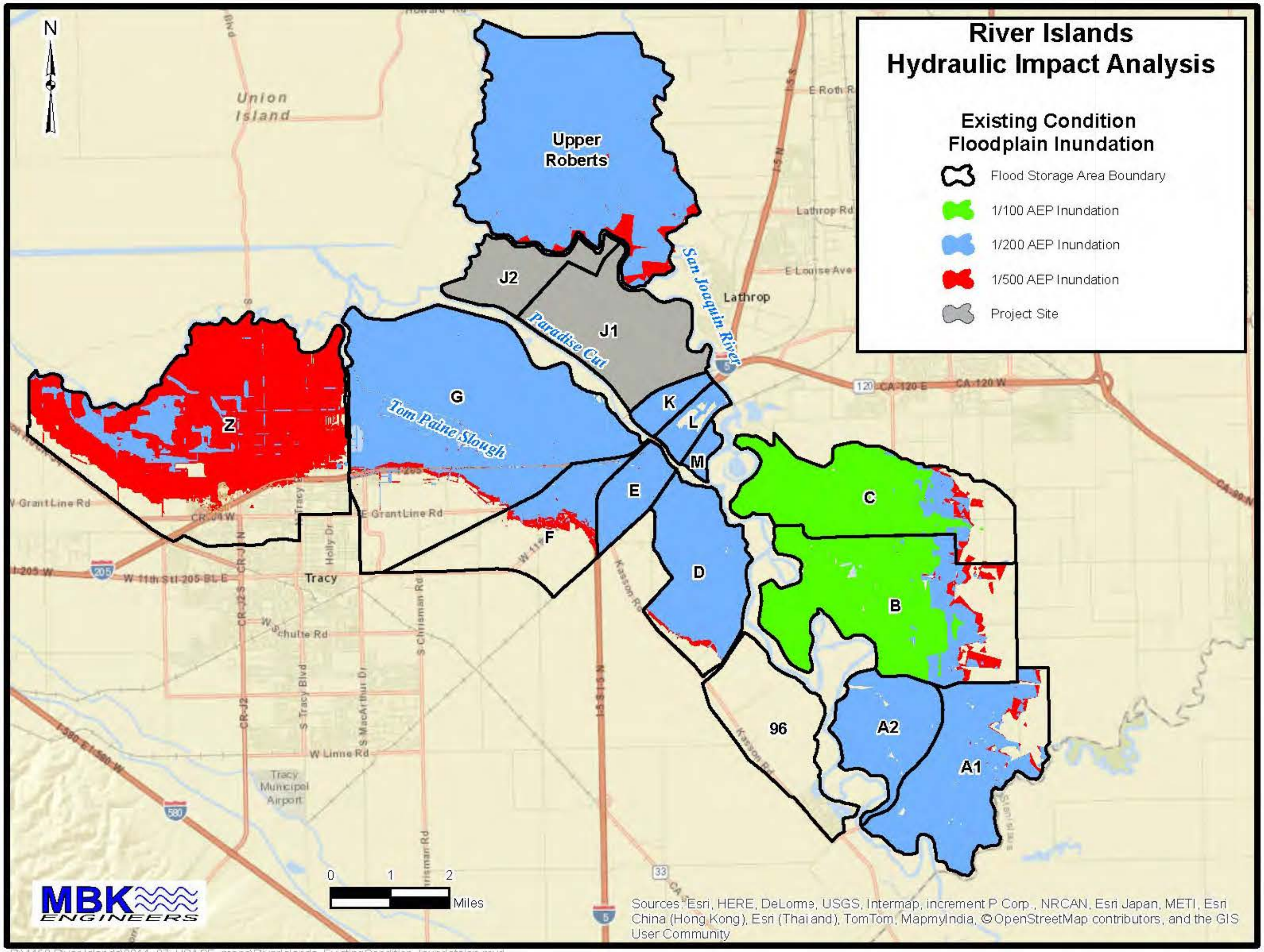

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Figure 8. Existing Condition Floodplain Inundation Area

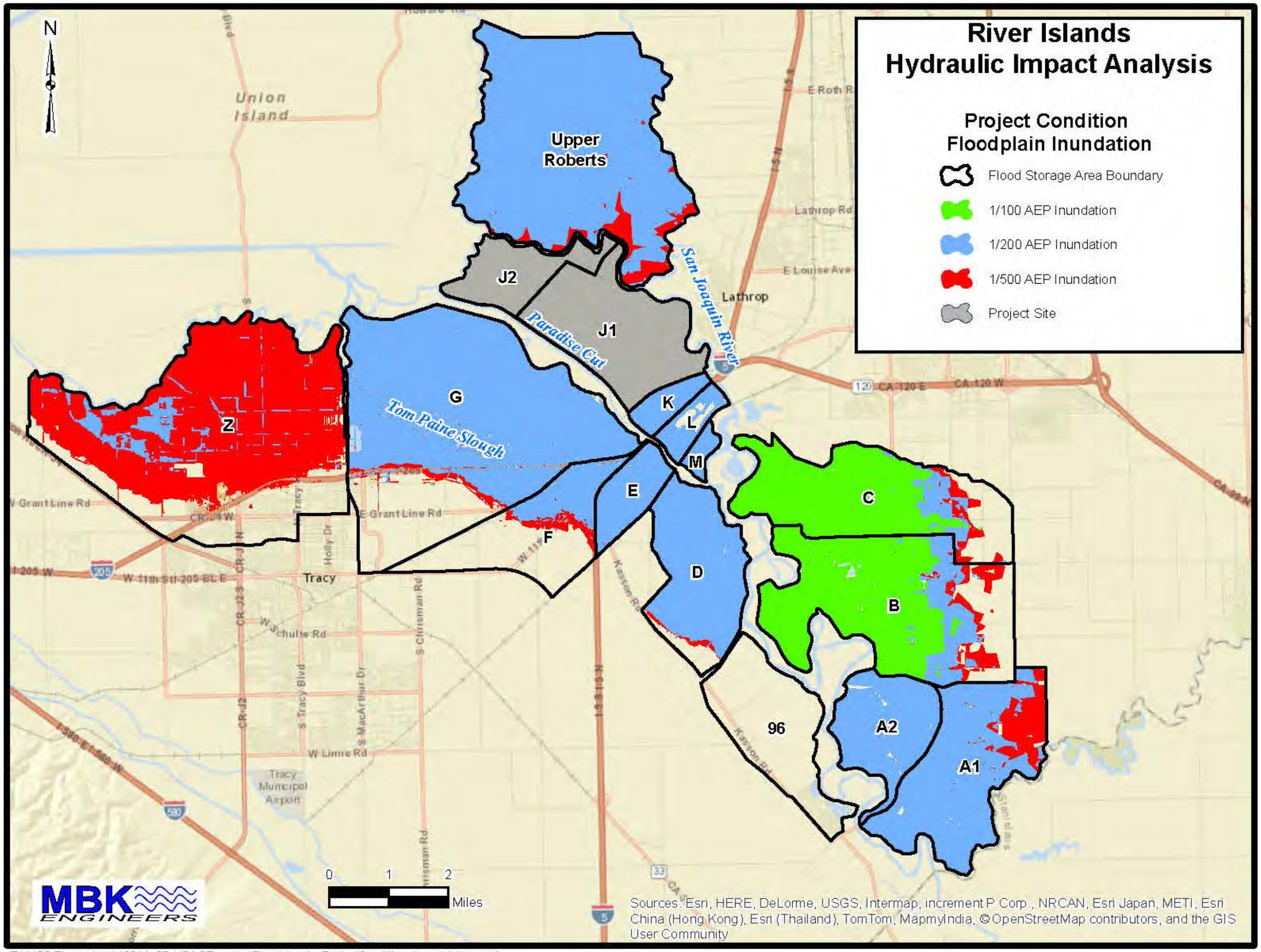

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Figure 9. Project Condition Floodplain Inundation Area

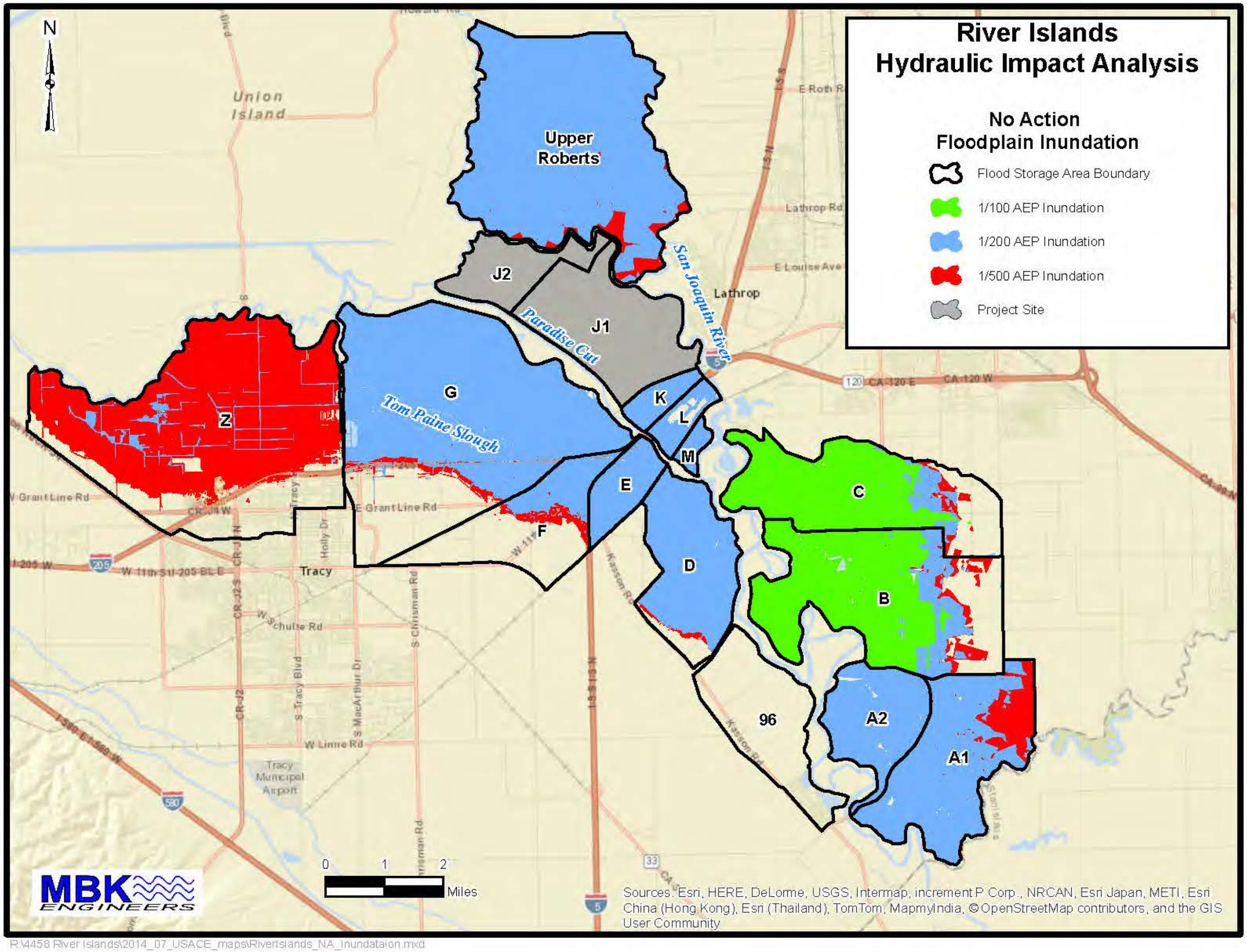

Figure 10. No Action Condition Floodplain Inundation Area

Table 4. Impact on Maximum Water Surface Elevations in RIVER (Levees Fail When Water Reaches Top of Levee)

		Max. Water Surface Elevation (ft. NAVD88[1])				Change (ft.)				
									Cumulative	
Index Point	Flood Event	Base [1]	Existing [2]	No Action [3]	With Project [4]	Existing to No Action [3]-[2]	No Action to With Project [4]-[3]	Existing to With Project [4]-[2]	Base to No Action [3]-[1]	Base to With Action [4]-[1]
SJR1	50-yr	28.06	28.06	28.06	27.99	0	-0.07	-0.07	0	-0.07
(RM	100-yr	33.12	33.12	33.12	33.11	0	-0.01	-0.01	0	-0.01
63.24)	200-yr	34.42	34.42	34.42	34.39	0	-0.03	-0.03	0	-0.03
	500-yr	34.60	34.60	34.60	34.59	0	-0.01	-0.01	0	-0.01
SJR2	50-yr	23.49	23.49	23.49	23.35	0	-0.14	-0.14	0	-0.14
(RM	100-yr	28.05	28.05	28.04	28.02	-0.01	-0.02	-0.03	-0.01	-0.03
57.81)	200-yr	30.25	30.25	30.25	30.23	0	-0.02	-0.02	0	-0.02
	500-yr	31.06	31.06	31.08	31.38	+0.02	+0.30	+0.32	+0.02	+0.32
SJR3	50-yr	15.39	15.39	15.39	15.33	0	-0.06	-0.06	0	-0.06
(RM	100-yr	17.98	17.98	17.97	17.98	-0.01	+0.01	0	-0.01	0
47.80)	200-yr	19.38	19.38	19.38	19.39	0	+0.01	+0.01	0	+0.01
	500-yr	19.70	19.71	19.70	19.99	-0.01	+0.29	+0.28	0	+0.29
PC1	50-yr	20.81	20.81	20.81	20.81	0	0	0	0	0
(Sta.	100-yr	24.49	24.49	24.48	24.49	-0.01	+0.01	0	-0.01	0
267.9)	200-yr	27.71	27.73	27.70	28.03	-0.03	+0.33	+0.30	-0.01	+0.32
	500-yr	28.75	28.75	28.77	28.72	+0.02	-0.05	-0.03	+0.02	-0.03
PC2	50-yr	18.00	18.00	18.00	17.65	0	-0.35	-0.35	0	-0.35
(Sta.	100-yr	20.48	20.48	20.48	20.22	0	-0.26	-0.26	0	-0.26
239.3)	200-yr	23.91	23.92	24.23	25.47	+0.31	+1.24	+1.55	+0.32	+1.56
	500-yr	24.96	24.97	25.06	26.05	+0.09	+0.99	+1.08	+0.10	+1.09
PC3	50-yr	15.30	15.30	15.30	14.95	0	-0.35	-0.35	0	-0.35
(Sta.	100-yr	17.98	17.98	17.97	17.78	-0.01	-0.19	-0.2	-0.01	-0.2
115.7)	200-yr	20.96	20.95	22.80	22.23	+1.85	-0.57	+1.28	+1.84	+1.27
	500-yr	23.47	23.50	24.24	23.81	+0.74	-0.43	+0.31	+0.77	+0.34
OR1	50-yr	16.49	16.49	16.49	16.43	0	-0.06	-0.06	0	-0.06
(Sta.	100-yr	20.04	20.04	20.04	20.06	0	+0.02	+0.02	0	+0.02
142.0)	200-yr	21.62	21.62	21.62	21.64	0	+0.02	+0.02	0	+0.02
	500-yr	22.85	22.90	22.86	22.95	-0.04	+0.09	+0.05	+0.01	+0.10
OR2	50-yr	12.65	12.65	12.65	12.67	0	+0.02	+0.02	0	+0.02
(Sta.	100-yr	15.31	15.31	15.31	15.39	0	+0.08	+0.08	0	+0.08
-70.4)	200-yr	18.89	18.93	19.17	19.37	+0.24	+0.20	+0.44	+0.28	+0.48
	500-yr	21.26	21.30	21.34	21.37	+0.04	+0.03	+0.07	+0.08	+0.11
OR3	50-yr	10.84	10.84	10.84	10.85	0	+0.01	+0.01	0	+0.01
(Sta.	100-yr	12.95	12.95	12.95	13.01	0	+0.06	+0.06	0	+0.06
-314.3)	200-yr	15.96	15.99	16.20	16.37	+0.21	+0.17	+0.38	+0.24	+0.41
	500-yr	17.65	17.69	17.75	17.94	+0.06	+0.19	+0.25	+0.10	+0.29
MR1	50-yr	13.74	13.74	13.74	13.71	0	-0.03	-0.03	0	-0.03
(RM	100-yr	15.95	15.95	15.95	15.98	0	+0.03	+0.03	0	+0.03
26.251)	200-yr	17.21	17.21	17.37	17.43	+0.16	+0.06	+0.22	+0.16	+0.22
	500-yr	18.13	18.14	18.21	18.34	+0.07	+0.13	+0.20	+0.08	+0.21
SS1	50-yr	12.44	12.44	12.44	12.46	0	+0.02	+0.02	0	+0.02
(Sta.	100-yr	15.06	15.06	15.06	15.14	0	+0.08	+0.08	0	+0.08
146.8)	200-yr	18.61	18.65	18.89	19.09	+0.24	+0.20	+0.44	+0.28	+0.48
	500-yr	20.97	21.01	21.05	21.08	+0.04	+0.03	+0.07	+0.08	+0.11
GLC1	50-yr	11.27	11.27	11.27	11.29	0	+0.02	+0.02	0	+0.02
(Sta.	100-yr	13.29	13.29	13.28	13.35	-0.01	+0.07	+0.06	-0.01	+0.06
23.6)	200-yr	16.12	16.15	16.34	16.50	+0.19	+0.16	+0.35	+0.22	+0.38
	500-yr	18.07	18.10	18.13	18.16	+0.03	+0.03	+0.06	+0.06	+0.09

[1] Elevations in hydraulic model are referenced to NGVD29 vertical datum and have been converted to NAVD88 vertical datum for this report by adding 2.4 ft. as determined by Carlson, Barbee and Gibson, Inc.

Table 5. Impact on Maximum Water Surface Elevations in FLOODPLAIN (Levees Fail When Water Reaches Top of Levee)										
		Max. Water Surface Elevation (ft. NAVD88[1])				**Change (ft.)**				
									Cumulative	
Storage Area Name (approx. ground elevation range)	**Flood Event**	**Base [1]**	**Existing [2]**	**No Action [3]**	**With Project [4]**	**Existing to No Action [3]-[2]**	**No Action to With Project [4]-[3]**	**Existing to With Project [4]-[2]**	**Base to No Action [3]-[1]**	**Base to With Action [4]-[1]**
A1	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(22 ft. to	200-yr	35.03	35.03	35.03	35.03	0	0	0	0	0
HG)	500-yr	35.34	35.34	35.34	35.38	0	+0.04	+0.04	0	+0.04
A2	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(17 ft. to	200-yr	35.02	35.02	35.02	35.02	0	0	0	0	0
HG)	500-yr	35.33	35.34	35.33	35.37	-0.01	+0.04	+0.03	0	+0.04
96	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(19 ft. to	200-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
HG)	500-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
B	100-yr	27.75	27.75	27.75	27.61	0	-0.14	-0.14	0	-0.14
(12 ft. to	200-yr	30.27	30.27	30.27	30.24	0	-0.03	-0.03	0	-0.03
HG)	500-yr	31.13	31.13	31.14	31.44	+0.01	+0.30	+0.31	+0.01	+0.31
C	100-yr	27.75	27.75	27.75	27.61	0	-0.14	-0.14	0	-0.14
(12 ft. to	200-yr	30.26	30.26	30.25	30.23	-0.01	-0.02	-0.03	-0.01	-0.03
HG)	500-yr	31.09	31.09	31.11	31.41	+0.02	+0.30	+0.32	+0.02	+0.32
D	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(16 ft. to	200-yr	26.96	26.98	27.09	27.17	+0.11	+0.08	+0.19	+0.13	+0.21
HG)	500-yr	28.43	28.44	28.45	28.47	+0.01	+0.02	+0.03	+0.02	+0.04
E	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(12 ft. to	200-yr	25.44	25.46	25.6	24.8	+0.14	-0.8	-0.66	+0.16	-0.64
HG)	500-yr	28.33	28.33	28.34	28.31	+0.01	-0.03	-0.02	+0.01	-0.02
F	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(12 ft. to	200-yr	21.17	21.17	21.19	21.54	+0.02	+0.35	+0.37	+0.02	+0.37
HG)	500-yr	23.85	23.86	24.04	24.04	+0.18	0	+0.18	+0.19	+0.19
G	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(7 ft. to	200-yr	21.10	21.09	21.12	21.48	+0.03	+0.36	+0.39	+0.02	+0.38
HG)	500-yr	22.55	22.55	23.09	23.20	+0.54	+0.11	+0.65	+0.54	+0.65
K	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(11 to 19	200-yr	26.65	27.05	24.83	28.52	-2.22	+3.69	+1.47	-1.82	+1.87
ft.)	500-yr	26.58	26.98	25.33	28.76	-1.65	+3.43	+1.78	-1.25	+2.18
L	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(11 to 19	200-yr	28.91	28.91	28.91	29.02	0	+0.11	+0.11	0	+0.11
ft.)	500-yr	29.55	29.55	29.55	30.01	0	+0.46	+0.46	0	+0.46
M	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(11 to 21	200-yr	29.14	29.14	29.13	29.17	-0.01	+0.04	+0.03	-0.01	+0.03
ft.)	500-yr	29.72	29.72	29.72	30.09	0	+0.37	+0.37	0	+0.37
Z	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(2 ft. to	200-yr	2.94	2.93	2.99	3.95	+0.06	+0.96	+1.02	+0.05	+1.01
HG	500-yr	17.60	17.63	18.07	18.10	+0.44	+0.03	+0.47	+0.47	+0.50
Upper	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Roberts	200-yr	12.78	12.77	12.77	12.39	0	-0.38	-0.38	-0.01	-0.39
(6 to 13 ft.)	500-yr	16.79	16.78	16.52	16.60	-0.26	+0.08	-0.18	-0.27	-0.19

[1] Elevations in hydraulic model are referenced to NGVD29 vertical datum and have been converted to NAVD88 vertical datum for this report by adding 2.4 ft. as determined by Carlson, Barbee and Gibson, Inc.

Table 6. Impact on Maximum Inundation Areas in FLOODPLAIN (Levees Fail When Water Reaches Top of Levee)										
		Max. Inundation Area (acres)				**Change (acres)**				
									Cumulative	
Storage Area Name	**Flood Event**	**Base [1]**	**Existing [2]**	**No Action [3]**	**With Project [4]**	**Existing to No Action [3]-[2]**	**No Action to With Project [4]-[3]**	**Existing to With Project [4]-[2]**	**Base to No Action [3]-[1]**	**Base to With Action [4]-[1]**
A1	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	2680	2680	2680	2680	0	0	0	0	0
	500-yr	2764	2764	2764	2775	0	+11	+11	0	+11
A2	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	1917	1917	1917	1917	0	0	0	0	0
	500-yr	1937	1937	1937	1939	0	+2	+2	0	+2
96	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	500-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
B	100-yr	3,161	3,161	3,161	3,116	0	-45	-45	0	-45
	200-yr	3,971	3,971	3,971	3,962	0	-9	-9	0	-9
	500-yr	4,248	4,248	4,251	4,347	+3	+96	+99	+3	+99
C	100-yr	2,634	2,634	2,634	2,617	0	-17	-17	0	-17
	200-yr	2,952	2,952	2,951	2,948	-1	-3	-4	-1	-4
	500-yr	3,057	3,057	3,060	3,098	+3	+38	+41	+3	+41
D	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	2,174	2,175	2,180	2,184	+5	+4	+9	+6	+10
	500-yr	2,229	2,229	2,230	2,230	+1	0	+1	+1	+1
E	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	709	709	710	704	+1	-6	-5	+1	-5
	500-yr	731	731	731	731	0	0	0	0	0
F	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	491	491	492	506	+1	+14	+15	+1	+15
	500-yr	579	580	585	585	+5	0	+5	+6	+6
G	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	6,798	6,797	6,800	6,834	+3	+34	+37	+2	+36
	500-yr	6,937	6,937	6,996	7,008	+59	+12	+71	+59	+71
K	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	396	398	392	404	-6	+12	+6	-4	+8
	500-yr	395	398	393	405	-5	+12	+7	-2	+10
L	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	432	432	432	432	0	0	0	0	0
	500-yr	433	433	433	434	0	+1	+1	0	+1
M	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	198	198	198	198	0	0	0	0	0
	500-yr	198	198	198	198	0	0	0	0	0
Z	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	66	65	67	198	+2	+131	+133	+1	+132
	500-yr	6,437	6,440	6,505	6,508	+65	+3	+68	+68	+71
Upper Roberts	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	{1}	{1}	{1}	{1}	{1}	{1}	{1}	{1}	{1}
	500-yr	{1}	{1}	{1}	{1}	{1}	{1}	{1}	{1}	{1}

{1} Elevation-area curve not developed for Storage Area Upper Roberts.

Table 7. Sensitivity Analysis – Impact on Maximum Water Surface Elevations in RIVER (Levees Overtop Without Failing)										
		Max. Water Surface Elevation (ft. NAVD88[1])				Change (ft.)				
									Cumulative	
Index Point	Flood Event	Base [1]	Existing [2]	No Action [3]	With Project [4]	Existing to No Action [3]-[2]	No Action to With Project [4]-[3]	Existing to With Project [4]-[2]	Base to No Action [3]-[1]	Base to With Action [4]-[1]
SJR1 (RM 63.24)	50-yr	28.98	28.98	28.98	28.91	0	-0.07	-0.07	0	-0.07
	100-yr	34.50	34.50	34.50	34.46	0	-0.04	-0.04	0	-0.04
	200-yr	35.38	35.38	35.38	35.38	0	0	0	0	0
	500-yr	35.83	35.83	35.83	35.83	0	0	0	0	0
SJR2 (RM 57.81)	50-yr	24.35	24.35	24.35	24.21	0	-0.14	-0.14	0	-0.14
	100-yr	29.49	29.49	29.49	29.43	0	-0.06	-0.06	0	-0.06
	200-yr	32.57	32.57	32.58	32.56	+0.01	-0.02	-0.01	+0.01	-0.01
	500-yr	34.35	34.35	34.35	34.35	0	0	0	0	0
SJR3 (RM 47.80)	50-yr	15.89	15.89	15.89	15.83	0	-0.06	-0.06	0	-0.06
	100-yr	18.99	18.99	18.99	18.97	0	-0.02	-0.02	0	-0.02
	200-yr	20.96	20.97	21.04	21.04	+0.07	0	+0.07	+0.08	+0.08
	500-yr	21.58	21.58	21.59	21.59	+0.01	0	+0.01	+0.01	+0.01
PC1 (Sta. 267.9)	50-yr	21.53	21.53	21.53	21.51	0	-0.02	-0.02	0	-0.02
	100-yr	25.63	25.63	25.63	25.58	0	-0.05	-0.05	0	-0.05
	200-yr	28.36	28.44	28.50	28.82	+0.06	+0.32	+0.38	+0.14	+0.46
	500-yr	30.71	30.72	30.73	30.67	+0.01	-0.06	-0.05	+0.02	-0.04
PC2 (Sta. 239.3)	50-yr	18.47	18.47	18.47	18.17	0	-0.3	-0.3	0	-0.3
	100-yr	21.35	21.35	21.36	21.08	+0.01	-0.28	-0.27	+0.01	-0.27
	200-yr	23.92	24.31	25.33	26.05	+1.02	+0.72	+1.74	+1.41	+2.13
	500-yr	26.09	26.24	26.70	27.56	+0.46	+0.86	+1.32	+0.61	+1.47
PC3 (Sta. 115.7)	50-yr	15.80	15.80	15.80	15.48	0	-0.32	-0.32	0	-0.32
	100-yr	19.00	19.00	19.00	18.81	0	-0.19	-0.19	0	-0.19
	200-yr	22.51	22.23	24.11	23.09	+1.88	-1.02	+0.86	+1.60	+0.58
	500-yr	24.94	24.93	26.00	25.59	+1.07	-0.41	+0.66	+1.06	+0.65
OR1 (Sta. 142.0)	50-yr	17.15	17.15	17.15	17.09	0	-0.06	-0.06	0	-0.06
	100-yr	21.31	21.31	21.31	21.32	0	+0.01	+0.01	0	+0.01
	200-yr	23.56	23.43	23.85	23.72	+0.42	-0.13	+0.29	+0.29	+0.16
	500-yr	24.66	24.66	24.63	24.59	-0.03	-0.04	-0.07	-0.03	-0.07
OR2 (Sta. -70.4)	50-yr	13.13	13.13	13.13	13.15	0	+0.02	+0.02	0	+0.02
	100-yr	16.36	16.36	16.36	16.43	0	+0.07	+0.07	0	+0.07
	200-yr	19.80	19.45	20.50	19.93	+1.05	-0.57	+0.48	+0.70	+0.13
	500-yr	22.82	22.83	22.84	22.88	+0.01	+0.04	+0.05	+0.02	+0.06
OR3 (Sta. -314.3)	50-yr	11.16	11.16	11.16	11.18	0	+0.02	+0.02	0	+0.02
	100-yr	13.81	13.81	13.81	13.86	0	+0.05	+0.05	0	+0.05
	200-yr	16.74	16.45	17.33	16.86	+0.88	-0.47	+0.41	+0.59	+0.12
	500-yr	21.25	21.32	21.80	22.18	+0.48	+0.38	+0.86	+0.55	+0.93
MR1 (RM 26.251)	50-yr	14.25	14.25	14.25	14.22	0	-0.03	-0.03	0	-0.03
	100-yr	17.53	17.53	17.53	17.54	0	+0.01	+0.01	0	+0.01
	200-yr	19.09	19.02	19.24	19.14	+0.22	-0.1	+0.12	+0.15	+0.05
	500-yr	19.71	19.71	19.69	19.66	-0.02	-0.03	-0.05	-0.02	-0.05
SS1 (Sta. 146.8)	50-yr	12.91	12.91	12.91	12.93	0	+0.02	+0.02	0	+0.02
	100-yr	16.10	16.10	16.10	16.17	0	+0.07	+0.07	0	+0.07
	200-yr	19.51	19.17	20.22	19.64	+1.05	-0.58	+0.47	+0.71	+0.13
	500-yr	22.52	22.53	22.54	22.58	+0.01	+0.04	+0.05	+0.02	+0.06
GLC1 (Sta. 23.6)	50-yr	11.60	11.60	11.60	11.62	0	+0.02	+0.02	0	+0.02
	100-yr	14.09	14.09	14.09	14.14	0	+0.05	+0.05	0	+0.05
	200-yr	16.85	16.57	17.42	16.96	+0.85	-0.46	+0.39	+0.57	+0.11
	500-yr	19.37	19.38	19.39	19.42	+0.01	+0.03	+0.04	+0.02	+0.05

[1] Elevations in hydraulic model are referenced to NGVD29 vertical datum and have been converted to NAVD88 vertical datum for this report by adding 2.4 ft. as determined by Carlson, Barbee and Gibson, Inc.

Table 8. Sensitivity Analysis – Impact on Maximum Water Surface Elevation in FLOODPLAIN (Levees Overtop Without Failing)

		Max. Water Surface Elevation (ft. NAVD88[1])				Change (ft.)				
									Cumulative	
Storage Area Name (approx. ground elevation range)	Flood Event	Base [1]	Existing [2]	No Action [3]	With Project [4]	Existing to No Action [3]-[2]	No Action to With Project [4]-[3]	Existing to With Project [4]-[2]	Base to No Action [3]-[1]	Base to With Action [4]-[1]
A1	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(22 ft. to	200-yr	36.63	36.63	36.63	36.63	0	0	0	0	0
HG)	500-yr	37.60	37.60	37.60	37.60	0	0	0	0	0
A2	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(17 ft. to	200-yr	36.62	36.62	36.62	36.62	0	0	0	0	0
HG)	500-yr	37.57	37.57	37.57	37.57	0	0	0	0	0
96	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(19 ft. to	200-yr	34.50	34.50	34.50	34.50	0	0	0	0	0
HG)	500-yr	35.38	35.38	35.38	35.38	0	0	0	0	0
B	100-yr	13.45	13.45	13.45	12.66	0	-0.79	-0.79	0	-0.79
(12 ft. to	200-yr	32.64	32.64	32.64	32.63	0	-0.01	-0.01	0	-0.01
HG)	500-yr	34.49	34.49	34.49	34.49	0	0	0	0	0
C	100-yr	19.33	19.33	19.32	17.95	-0.01	-1.37	-1.38	-0.01	-1.38
(12 ft. to	200-yr	32.63	32.63	32.63	32.62	0	-0.01	-0.01	0	-0.01
HG)	500-yr	34.46	34.46	34.47	34.46	+0.01	-0.01	0	+0.01	0
D	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(16 ft. to	200-yr	21.98	22.38	22.51	24.2	+0.13	+1.69	+1.82	+0.53	+2.22
HG)	500-yr	29.46	29.46	29.47	29.51	+0.01	+0.04	+0.05	+0.01	+0.05
E	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(12 ft. to	200-yr	21.23	21.75	22.38	24.77	+0.63	+2.39	+3.02	+1.15	+3.54
HG)	500-yr	29.06	29.08	29.13	29.20	+0.05	+0.07	+0.12	+0.07	+0.14
F	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(12 ft. to	200-yr	17.44	17.67	17.94	19	+0.27	+1.06	+1.33	+0.50	+1.56
HG)	500-yr	25.41	25.49	25.65	25.84	+0.16	+0.19	+0.35	+0.24	+0.43
G	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(7 ft. to	200-yr	13.25	13.80	14.17	17.09	+0.37	+2.92	+3.29	+0.92	+3.84
HG)	500-yr	25.31	25.35	25.58	25.78	+0.23	+0.20	+0.43	+0.27	+0.47
K	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(11 to 19	200-yr	27.03	27.46	25.26	28.84	-2.2	+3.58	+1.38	-1.77	+1.81
ft.)	500-yr	27.36	27.77	26.85	29.83	-0.92	+2.98	+2.06	-0.51	+2.47
L	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(11 to 19	200-yr	28.88	28.94	28.87	29.51	-0.07	+0.64	+0.57	-0.01	+0.63
ft.)	500-yr	31.26	31.26	31.27	31.68	+0.01	+0.41	+0.42	+0.01	+0.42
M	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(11 to 21	200-yr	29.14	29.18	29.14	29.6	-0.04	+0.46	+0.42	0	+0.46
ft.)	500-yr	31.42	31.43	31.43	31.76	0	+0.33	+0.33	+0.01	+0.34
Z	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(2 ft. to	200-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
HG	500-yr	21.36	21.43	21.89	22.25	+0.46	+0.36	+0.82	+0.53	+0.89
Upper	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Roberts	200-yr	8.17	8.10	8.88	8.49	+0.78	-0.39	+0.39	+0.71	+0.32
(6 to 13 ft.)	500-yr	12.19	12.11	12.28	12.00	+0.17	-0.28	-0.11	+0.09	-0.19

[1] Elevations in hydraulic model are referenced to NGVD29 vertical datum and have been converted to NAVD88 vertical datum for this report by adding 2.4 ft. as determined by Carlson, Barbee and Gibson, Inc.

Table 9. Sensitivity Analysis - Impact on Maximum Inundation Areas in FLOODPLAIN (Levees Overtop Without Failing)

		Max. Inundation Area (acres)				Change (acres)				
									Cumulative	
Storage Area Name	**Flood Event**	**Base [1]**	**Existing [2]**	**No Action [3]**	**With Project [4]**	**Existing to No Action [3]-[2]**	**No Action to With Project [4]-[3]**	**Existing to With Project [4]-[2]**	**Base to No Action [3]-[1]**	**Base to With Action [4]-[1]**
A1	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	3,115	3,115	3,115	3,115	0	0	0	0	0
	500-yr	3,378	3,378	3,378	3,378	0	0	0	0	0
A2	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	2,017	2,017	2,017	2,017	0	0	0	0	0
	500-yr	2,077	2,077	2,077	2,077	0	0	0	0	0
96	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	1,422	1,422	1,422	1,422	0	0	0	0	0
	500-yr	1,486	1,486	1,486	1,486	0	0	0	0	0
B	100-yr	27	27	27	7	0	-20	-20	0	-20
	200-yr	4,716	4,716	4,716	4,714	0	-2	-2	0	-2
	500-yr	5,182	5,182	5,182	5,182	0	0	0	0	0
C	100-yr	936	936	933	621	-3	-312	-315	-3	-315
	200-yr	3,252	3,252	3,252	3,251	0	-1	-1	0	-1
	500-yr	3,484	3,484	3,485	3,484	+1	-1	0	+1	0
D	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	1,815	1,949	1,961	2,042	+12	+81	+93	+146	+227
	500-yr	2,263	2,263	2,263	2,265	0	+2	+2	0	+2
E	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	669	676	685	703	+9	+18	+27	+16	+34
	500-yr	737	737	737	738	0	+1	+1	0	+1
F	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	344	353	364	406	+11	+42	+53	+20	+62
	500-yr	622	624	628	634	+4	+6	+10	+6	+12
G	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	4,533	4,787	4,958	6,307	+171	+1349	+1520	+425	+1774
	500-yr	7,240	7,245	7,270	7,292	+25	+22	+47	+30	+52
K	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	398	401	392	405	-9	+13	+4	-6	+7
	500-yr	400	402	397	407	-5	+10	+5	-3	+7
L	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	432	432	432	433	0	+1	+1	0	+1
	500-yr	439	439	439	440	0	+1	+1	0	+1
M	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	197	197	197	198	0	+1	+1	0	+1
	500-yr	198	198	198	198	0	0	0	0	0
Z	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	500-yr	7,021	7,034	7,115	7,176	+81	+61	+142	+94	+155
Upper Roberts	100-yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	200-yr	{1}	{1}	{1}	{1}	{1}	{1}	{1}	{1}	{1}
	500-yr	{1}	{1}	{1}	{1}	{1}	{1}	{1}	{1}	{1}

{1} Elevation-area curve not developed for Storage Area Upper Roberts.

In the 50-year flood event, which is closest in size to the system design flood event[1], the "With Project" scenario shows a reduction in the maximum WSE of up to 0.14 ft. in the San Joaquin River and a reduction of up to 0.35 ft. in Paradise Cut. In Old River and Grant Line Canal, the "With Project" scenario shows a WSE increase of up to 0.02 ft. No levees are overtopped in the 50-year flood event simulation so there are no impacts in the floodplains.

In the 100-year flood event, the "With Project" scenario shows a reduction in the maximum WSE of up to 0.03 ft. in the San Joaquin River and a reduction of up to 0.27 ft. in Paradise Cut. In Old River and Grant Line Canal, the "With Project" scenario shows a WSE increase of up to 0.08 ft. In the 100-year flood event simulation, the only levee overtopping occurs on the right bank of the San Joaquin River primarily opposite of Paradise Cut resulting in some inundation of Storage Areas B and C. The slight decrease water surface elevation in the "With Project" scenario translates to a slight decrease in the depth and extent of inundation in Storage Areas B and C.

In the 200-year flood event, the "With Project" scenario shows a reduction in the maximum WSE of up to 0.03 ft. in the San Joaquin River and an increase of up to 1.55 ft. in the Paradise Cut. In the 200-year flood event simulations, there is significant levee overtopping throughout the system. The impacts to floodplain depths and areas are shown in Tables 5 and 6, respectively. As shown in Table 5, the project has minimal impact on the maximum water surface elevation in the floodplain with the exception of Storage Areas E (-0.66 ft.), F (+0.37 ft.), G (+0.39 ft.), K (+1.47 ft.) and Z (+0.76 ft.). However, with the exception of Storage Area Z, these water surface elevation changes have corresponding inundation area changes ranging from approximately -1% to +3%. In Storage Area Z, the inundation area increases from 74 acres to 450 acres. The maximum depth of flooding increases from approximately 0.5 ft. in the Existing scenario to just over 1 ft. in the With Project scenario for 200-yr flood event. To put the Storage Area Z inundation area into perspective, in the 500-year flood event simulation the inundation area is approximately 6,800 acres, with a maximum depth of approximately 16 ft., for both scenarios.

In the 500-year flood event, the "With Project" scenario shows an increase in the maximum WSE of up to 0.32 ft. in the San Joaquin River and an increase of up to 1.08 ft. in the Paradise Cut. In the 500-year flood event simulations, there is significant levee overtopping throughout the system. The impacts to floodplain depths and areas are shown in Tables 5 and 6, respectively. As shown in Table 5, the project has minimal impact on the maximum water surface elevation in the floodplain with the exception of Storage Areas B (+0.31 ft.), C (+0.32 ft.), G (+0.65 ft.), K (+1.78 ft.), L (+0.46 ft.), M (+0.37 ft.) and Z (+0.45 ft.). However, for all of these storage areas the change in inundation area is less than 2.3%.

It is important to note that in the more frequent large flood events, 100-year and smaller, the project either reduced or did not change water surface elevations in the San Joaquin River, Paradise Cut, and upper Old River with increases of less than a tenth of a foot west of Stewart Tract. It is in the much less frequent events, which are significantly larger than the San Joaquin River Flood Control System design flood (approximately 1 in 50 AEP, or 50-year), where the proposed project results in increased water surface elevations. It is also important to note that the proposed project would not have increased water surface elevations in the channels or

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[1] The system design flow in the San Joaquin River above Paradise Weir is 52,000 cfs (USACE 1955). The 50-year flood event peak flow is 47,400 cfs.

floodplains for any of the floods that have occurred within the period of record, which includes over 100 years of recorded flood data.

The results of the risk-based hydraulic impact analysis performed by David Ford Consulting Engineers (Ford 2010) are summarized in Tables 10, 11, and 12. The risk analysis computed impacts of the "With Project" and "No Action" scenarios on the Conditional Annual Exceedance Probability (C-AEP) and on the Conditional Conditional Non-exceedance Probability, or Conditional Assurance (C-A). The maximum changes in C-AEP occur at index points PC2 and PC3 as shown in Table 10. The maximum changes in C-A also occur at index points PC2 and PC3 as shown in Tables 11 and 12. All of the risk-based impact analyses are based on the no levee failure scenario described in Attachment A.

Table 10. Change in Conditional Annual Exceedance Probability (C-AEP)

Index Point	**Existing to No Action**	**Existing to With Proj.**	**Cumulative – Base to No Action**	**Cumulative - Base to With Project**
SJR1	0.0000	-0.0003	0.0000	-0.0003
SJR2	0.0000	-0.0003	0.0000	-0.0003
SJR3	0.0001	0.0001	0.0001	0.0001
PC1	0.0000	0.0002	0.0000	0.0002
PC2	0.0012	0.0020	0.0015	0.0023
PC3	0.0015	0.0007	0.0014	0.0006
OR1	0.0000	-0.0001	0.0000	-0.0001
OR2	0.0008	0.0003	0.0006	0.0001
OR3	0.0005	0.0002	0.0004	0.0001
MR1	0.0002	0.0002	0.0001	0.0001
SS1	0.0002	0.0002	0.0002	0.0002
GLC1	-0.0001[1]	0.0001[1]	-0.0001[1]	0.0001[1]

[1] Computed C-AEP is beyond the 0.002 exceedance probability, so differences exceed precision of models.

Table 11. Change in Conditional Assurance (C-A)1 from Existing Condition								
Index Point	**p=0.10**		**p=0.01**		**p=0.004**		**p=0.002**	
	Existing to No Action	**Existing to With Project**	**Existing to No Action**	**Existing to With Project**	**Existing to No Action**	**Existing to With Project**	**Existing to No Action**	**Existing to With Project**
SJR1	0.0000	0.0000	0.0000	0.0336	0.0000	0.0060	0.0000	0.0028
SJR2	0.0000	0.0000	0.0000	0.0345	0.0000	0.0109	-0.0002	0.0057
SJR3	0.0000	0.0000	-0.0007	-0.0011	-0.0189	-0.0215	-0.0032	-0.0044
PC1	0.0000	0.0000	0.0000	0.0010	-0.0034	-0.0123	0.0000	-0.0001
PC2	0.0000	0.0000	0.0000	0.0000	-0.3366	-0.5251	-0.1009	-0.1492
PC3	0.0000	0.0000	0.0000	0.0000	-0.4103	-0.1787	-0.2675	-0.1715
OR1	0.0000	0.0000	0.0000	0.0079	0.0000	0.0015	0.0000	-0.0004
OR2	0.0000	0.0000	-0.0014	-0.0006	-0.1886	-0.0876	-0.0088	-0.0046
OR3	0.0000	0.0000	-0.0001	-0.0001	-0.1765	-0.0733	-0.0491	-0.0302
MR1	0.0000	0.0000	-0.0169	-0.0216	-0.0107	-0.0045	-0.0002	0.0004
SS1	0.0000	0.0000	0.0000	0.0000	-0.0785	-0.0383	-0.0425	-0.0387
GLC1	0.0000	0.0000	0.0000	0.0000	-0.0013	-0.0015	0.0405	-0.0015
[1] C-A can also be referred to as Conditional Conditional Non-exceedance Probability (C-CNP)								

Table 12. Change in Conditional Assurance (C-A)1 from Base Condition for Cumulative Analysis								
Index Point	**p=0.10**		**p=0.01**		**p=0.004**		**p=0.002**	
	Base to No Action	**Base to With Project**	**Base to No Action**	**Base to With Project**	**Base to No Action**	**Base to With Project**	**Base to No Action**	**Base to With Project**
SJR1	0.0000	0.0000	0.0000	0.0336	0.0000	0.0060	0.0000	0.0028
SJR2	0.0000	0.0000	0.0000	0.0345	0.0000	0.0109	-0.0002	0.0057
SJR3	0.0000	0.0000	-0.0009	-0.0013	-0.0221	-0.0247	-0.0039	-0.0051
PC1	0.0000	0.0000	0.0004	0.0014	-0.0039	-0.0128	-0.0001	-0.0002
PC2	0.0000	0.0000	0.0000	0.0000	-0.4420	-0.6305	-0.1277	-0.1760
PC3	0.0000	0.0000	0.0000	0.0000	-0.3789	-0.1473	-0.2667	-0.1707
OR1	0.0000	0.0000	-0.0001	0.0078	-0.0002	0.0013	-0.0001	-0.0005
OR2	0.0000	0.0000	-0.0013	-0.0005	-0.1201	-0.0191	-0.0044	-0.0002
OR3	0.0000	0.0000	-0.0001	-0.0001	-0.1378	-0.0346	-0.0358	-0.0169
MR1	0.0000	0.0000	-0.0114	-0.0161	-0.0040	0.0022	0.0001	0.0007
SS1	0.0000	0.0000	0.0000	0.0000	-0.0659	-0.0257	-0.0383	-0.0345
GLC1	0.0000	0.0000	0.0000	0.0000	-0.0013	-0.0015	0.0240	-0.0180
[1] C-A can also be referred to as Conditional Conditional Non-exceedance Probability (C-CNP)								

8. Determination of Significance of Impacts

To determine whether an increase in stage is significant, the following factors have been taken into consideration:

- How much of the change in stage is associated with restoring the design flow split and does the modification result in a flow split that exceeds the 1955 design?
- What is the change in stage for the design flood event?
- What are the changes in stage for events that exceed the design event?
- Are adjacent areas urban or non-urban?
- Are the adjacent agricultural areas that experience increases in stage in the river channel already flooded due to upstream levees overtopping? If the adjacent agricultural areas are flooded due to upstream levee overtopping, what is the change in floodplain depth with the proposed project?
- Does the duration of flooding change as a result of the proposed project?

The following is an analysis of the impacts of the proposed project based on an evaluation of the factors cited above.

How much of the change in stage is associated with restoring the federal levee system design flow in Paradise Cut. The design flow in the Paradise Cut is 15,000 cfs, 28.8% of the upstream design flow of 52,000 cfs in the San Joaquin River. Under existing conditions, with the design flow of 52,000 cfs in the San Joaquin River, the computed flow into Paradise Cut is 13,400 cfs, 25.8% of the San Joaquin River flow. The hydraulic computations indicate that the proposed project would increase the flow into Paradise Cut to 13,900 cfs, 26.7% of the San Joaquin River flow. This increase in flow in Paradise Cut partially restores the design flow split. The proposed project would have a positive effect on restoring the design flow condition.

What is the change in stage for the design flood event? The proposed project generally results in a decrease in flood stages for the design event for the surrounding river system. There are very small stage increases (0.02 ft.) downstream of the Paradise Cut along the agricultural areas on Old River and Grant Line Canal. The proposed project lowers the stage at the San Joaquin River at Mossdale Bridge gage (Index Point SJR2) by 0.14 ft.

What are the changes in stage for events that exceed the design event? Tables 4 and 5 summarize the change in flood stage for the flood control system.

Are adjacent areas urban or non-urban? The nearby urban areas are downstream along the San Joaquin River (Lathrop and Stockton) and southwest of the Project (Tracy). The proposed project has very small effects on the downstream urban areas which are protected with urban levees (slight decrease to no change in the maximum water surface elevation up through the 200-year flood event and increase of 0.28 ft. in the 500-year flood event at Index Point SJR3). The analysis shows a small area within the Tracy city limits in inundated in the 200-year flood event, with an increase of 0.39 ft. due to the proposed project (see Figure 11), however this impacted area is zoned as Commercial and Industrial. The remaining adjacent and downstream areas are in agriculture.

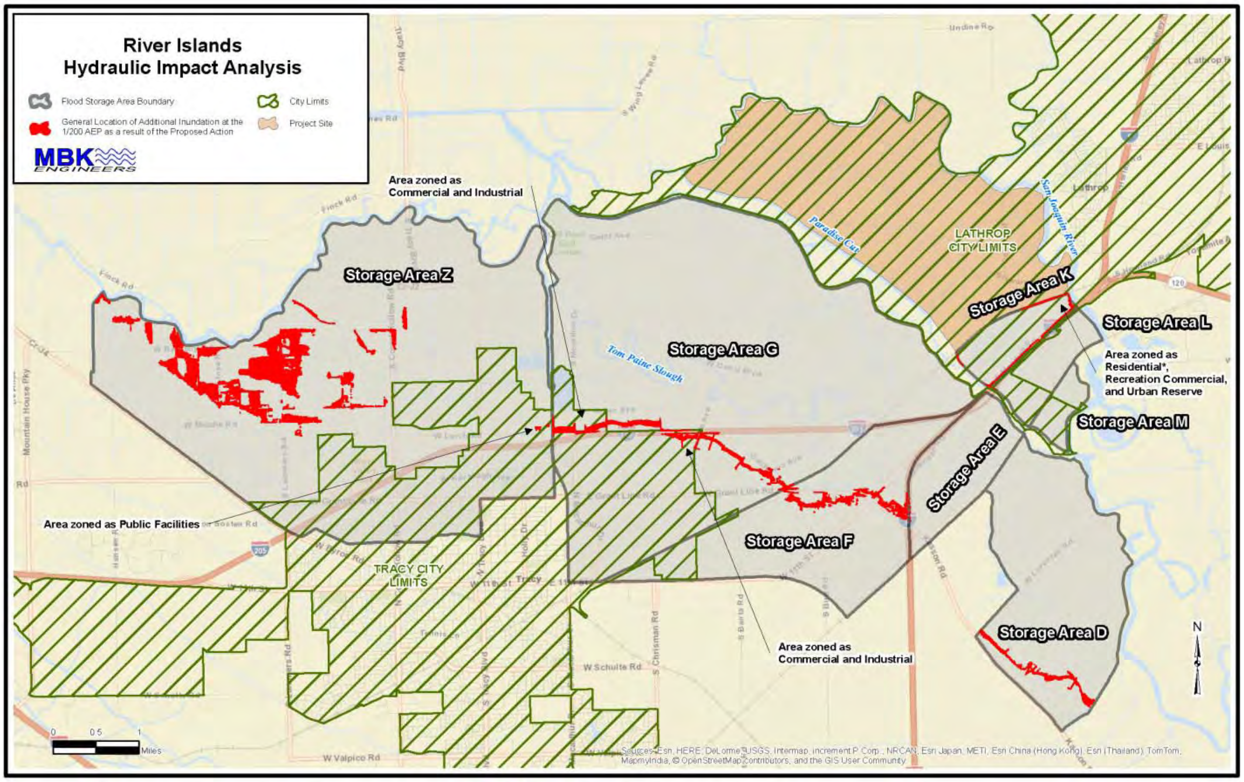

Figure 11. Project impacts within city limits, 200-year flood event

Are the adjacent agricultural areas that experience increases in stage in the river channel already flooded due to upstream levees failing? If the adjacent agricultural areas are flooded due to upstream levee failures, what is the change in floodplain depth with the proposed project? Yes, the floodplains on both sides of the river adjacent to these impact locations are already flooded due to upstream levee failures in the 200-year and 500-year flood event simulations. Tables 5 and 6 show how the maximum water surface elevation and area in the adjacent floodplains change with the proposed project. In storage area E the ground elevation ranges from about 12 ft. (NAVD88) to the flood elevation, so the 200-year flood depth ranges from 0 to 13.5 ft. for Existing and 0 to 12.8 for With Project and the 500-year flood depth ranges from 0 to 16.3 ft. for both Existing and With Project. The maximum inundated area decreases 5 acres (0.7%) in the 200-year flood and in unchanged in the 500-year flood. In storage area G the ground elevation ranges from about 7 ft. (NAVD88) to the flood elevation, so the 200-year flood depth ranges from 0 to 14.1 ft. for Existing and 0 to 14.5 for With Project and the 500-year flood depth ranges from 0 to 15.6 ft. for Existing and 0 to 16.2 for With Project. The maximum inundated area increases 37 acres (0.5%) in the 200-year flood and 71 acres (1.0%) in the 500-year flood. In storage area K the ground elevation ranges from about 11 to 19 ft. (NAVD88), so the 200-year flood depth ranges from 8.1 to 16.1 ft. for Existing and 9.5 to 17.5 for With Project and the 500-year flood depth ranges from 8.0 to 16.0 ft. for Existing and 9.8 to 17.8 for With Project. The maximum inundated area increases 6 acres (1.5%) in the 200-year flood and 7 acres (1.8%) in the 500-year flood. Damage to crops is not typically associated with changes in depth when depths exceed 1 foot as they are more sensitive to changes in duration and/or frequency of flooding. There are also isolated structures in the floodplain. Since these areas are already flooded, the changes in depth are at extremely rare events (increases in stage only occur at the 200 and 500 year events) and the change in flood depth is moderate as compared to the actual depth, the impacts are not significant. The area of inundation was only increases 60 acres out of over 7,000 acres inundated for the 200-year and 500-year floods.

Does the duration of flooding change as a result of the proposed project? The duration of flooding does not change as a result of the proposed project.

9. Summary/Conclusion

The proposed project will alter the flows in the surrounding levee system for the full range of flood events. These changes are generally beneficial for the frequent flood events (50 and 100 year), with increases in stage for the adjacent agricultural areas for the less frequent extreme flood events (200 and 500 year). The adjacent and downstream urban areas are not impacted by the proposed project. The adjacent urban areas and non-urban areas do not experience an increase in flood risk as a result of the proposed project as demonstrated in the Risk Analysis.

The January 1997 storm is the flood of record for this region, with the estimated recurrence interval of 100-year for the 1-day duration flood volume (USACE 2002). Levee performance in the California Central Valley for main-stem system levees has generally been that levees fail before they overtop. During the January 1997 flood event, the largest event in recorded history on the San Joaquin River, 14 levee breaches occurred upstream of the Stewart Tract. Therefore, the primary failure mechanism used in this analysis assumes that levees will fail when the water reaches an elevation equal to the top of the levee. Results from an analysis that assumed that levees would overtop without failing are also included to demonstrate the sensitivity of the levee performance assumption.

Taking into consideration the factors sighted in Section 8 of this memo and the Risk Analysis evaluation (Attachment C), the hydraulic impacts of the proposed project are less than significant. This finding is consistent with the fact that the proposed project would not have increased flood stages for any of the historic recorded floods (over 100 years of record) on the San Joaquin River.

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Attachment A

Proposed Ground Rules for Section 408 Risk Analysis of
Potential Hydraulic Impacts of River Islands at Lathrop Project

July 19, 2010

Proposed Ground Rules for Section 408 Risk Analysis of Potential Hydraulic Impacts of River Islands at Lathrop Project

1. Levee Performance

    a. Levees overtop without failing.

2. Evaluation Scenarios

    a. **Base Condition –** system prior to construction of the River Islands interior levees that form the Phase 1 protected area shown in Figure 1. In addition:

        i. If levees do not meet the minimum project standard they would be raised in the hydraulic model to meet the minimum authorized levee height (1955 Profile); and

        ii. Where existing top of levees heights exceed the authorized height, they are modeled as such.

    b. **Existing Condition –** Base Condition plus existing Phase 1 protected area, which was completed in 2006 (see Figure 1).

    c. **Modified Condition, Cumulative with no Federal Action (No Action) –** Base Condition plus FEMA certifiable interior levee constructed for entire project site (see Figure 2). The interior levee does not come in contact with Federal Project levee or required levee easements. This scenario represents the River Islands Project that would be constructed absent federal permits. Urban levees (Reclamation District 17) raised (if necessary) to have 3 feet of freeboard on 200-year flood event.

    d. **Modified Condition, With Project –** Base Condition plus addition of proposed River Islands Project and Paradise Cut Improvement Project (see Figure 3). Urban levees (Reclamation District 17) raised (if necessary) to have 3 feet of freeboard on 200-year flood event.

3. Hydrology

    a. Sacramento and San Joaquin River Basins Comprehensive Study San Joaquin River mainstem at Vernalis storm centering.

4. Risk Analysis Procedures

a. System input flow-frequency curves derived using the same procedures as in the HEC Section 408 risk analysis demonstration project (June 2009) will be used. These curves represent the summation of regulated flow hydrographs at hydraulic model boundary conditions upstream of a given Index Point.

b. Inflow-Outflow relationships derived using the same procedures as in the demonstration project will be used. These relationships will be used to account for system routing and loss of flow due to spills over levees. This relationship translates the system input flow to a regulated flow at each of the Index Points.

c. Flow-discharge Transform Functions at Index Points will be based on an infinite levee scenario (no spills). This is a maximum flow versus maximum stage relationship.

d. The inflow-outflow relationship should be based on sensitivity analysis of Manning’s n-value roughness coefficients and levee overtopping weir flow coefficients. The Manning’s n-value uncertainty range will be determined recognizing model calibration variability at the index points. The levee overtopping weir coefficient is not a calibrated parameter so its uncertainty range will be based on the typical coefficient range for broad crested weirs of 2.6 to 3.1 as defined in the HEC-RAS Hydraulic Reference Manual, CPD-69, March 2008 (Table 8-1).

5. Analysis of Conditional Annual Exceedance Probability

a. The procedures being utilized will not produce a level of protection evaluation for each index point in the system. This is because of the necessity to make simplifying assumptions concerning levee performance and hydrologic inputs. The assumption of no levee failures will result in AEPs that are conditioned on that assumption and will thereby overestimate the level of protection provided throughout the system. Therefore for this analysis a Conditional Annual Exceedance Probability (C-AEP) will be calculated for each index point. All of the factors governing the “Conditional” aspect of the AEP will be documented.

b. “Conditional” Conditional Non-Exceedance Probabilities (C-CNP) shall be reported, too.

c. The target levee elevations used to compute Without Project Condition C-AEP and C-CNPs shall be consistent with the levee elevations used to establish the Base Condition (see item 2.a).

d. For Index Points controlled by backwater such that stage-discharge relationships do not exist, the analysis will be based on stage-frequency and not flow-frequency methodology. In these same areas the C-AEPs and C-CNPs will be based on the authorized levee elevation as shown on the 1955 Design flood profiles.

6. Index Point Locations

a. A list of index points is provided in Table 1. A map showing the index point locations is shown in Figure 4.

Table 1. Index Points

Reach	Location [1]	Index Point ID	Channel Invert Elev. (ft. NGVD29)	Fed Project Design Top of Levee, 1955 Profile (ft. NGVD29)	Top of Levee Elevation (ft. NGVD29)	Top of Levee Elevation Source
San Joaquin River						
Vernalis to Paradise Cut	63.24	SJR1	-19	32.1	31.8	CA Levee Database [2]
Paradise Cut to Old River	57.81	SJR2	-14	26.8	25.8	CA Levee Database [2]
Old River to model boundary	47.80	SJR3	-15	18.1	18.4	CA Levee Database [2]
Paradise Cut						
San Joaquin R. to Old R.	267.9	PC1	7	23.8	23.9	CA Levee Database [2]
San Joaquin R. to Old R.	239.3	PC2	-1	22.9	21.6	CA Levee Database [2]
San Joaquin R. to Old R.	115.7	PC3	-5	19.8	22.2	CA Levee Database [2]
Old River						
San Joaquin R. to Middle R.	142.0	OR1	-8	19.6	19.6	CA Levee Database [2]
Middle R. to Paradise Cut	172.06	OR2	-20	14.8	17.5	CA Levee Database [2]
Paradise Cut to model boundary	-100.5	OR3	-8	na	15.6	DWR bathymetry survey, 1997
Middle River						
Old R. to model boundary	26.251	MR1	-4	na	15.6	Comprehensive Study topo
Salmon Slough						
All	146.81	SS1	-14	14.4	19.4	CA Levee Database [2]
Grant Line Canal						
All	23.6	GLC1	-13	na	18.1	DWR bathymetry survey, 1997

[1] Hydraulic model cross-section ID. San Joaquin River and Middle River are referenced to Comp Study River Mile. Paradise Cut, Old River and Grant Line Canal are based on individual reach stationing on 100 foot increments.
[2] Converted from vertical datum NAVD88 to NGVD29 based on relationship of 0 ft. NGVD29 = 2.4 ft. NAVD88 as per Carlson, Barbee, Gibson.

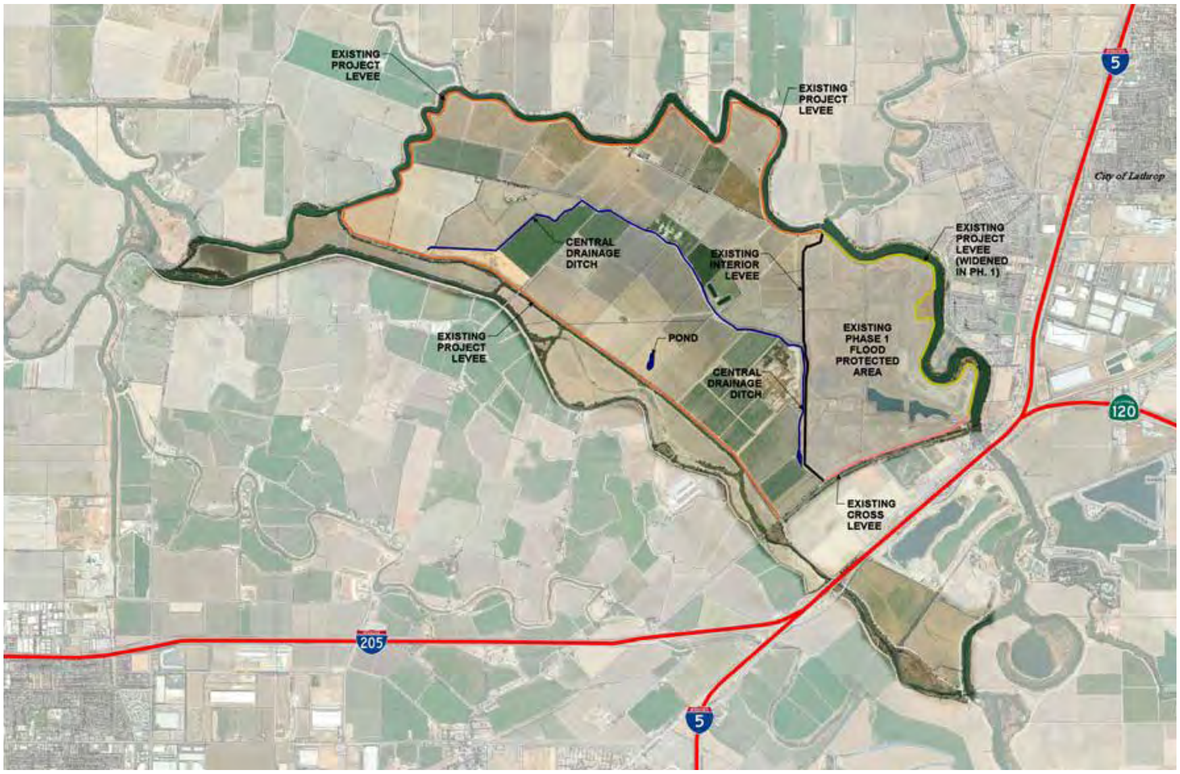

Figure 1. Existing Condition Scenario

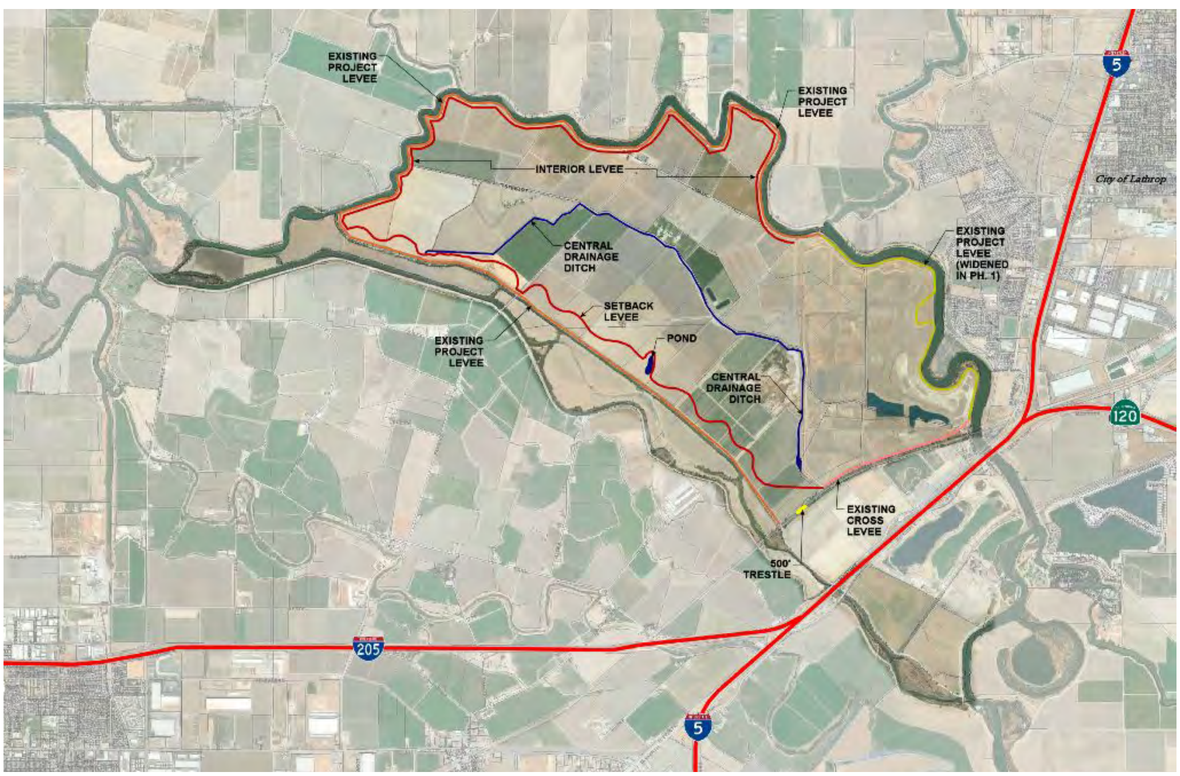

Figure 2. No Action Scenario

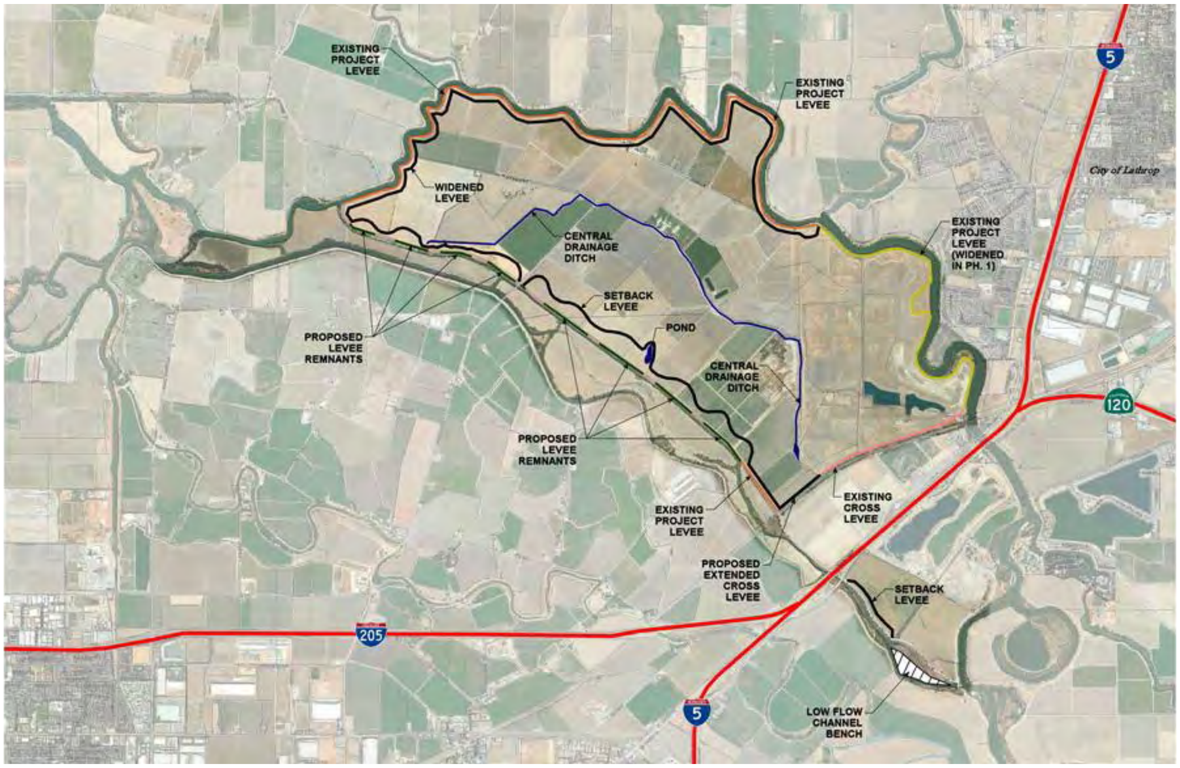

Figure 3. With Project Scenario

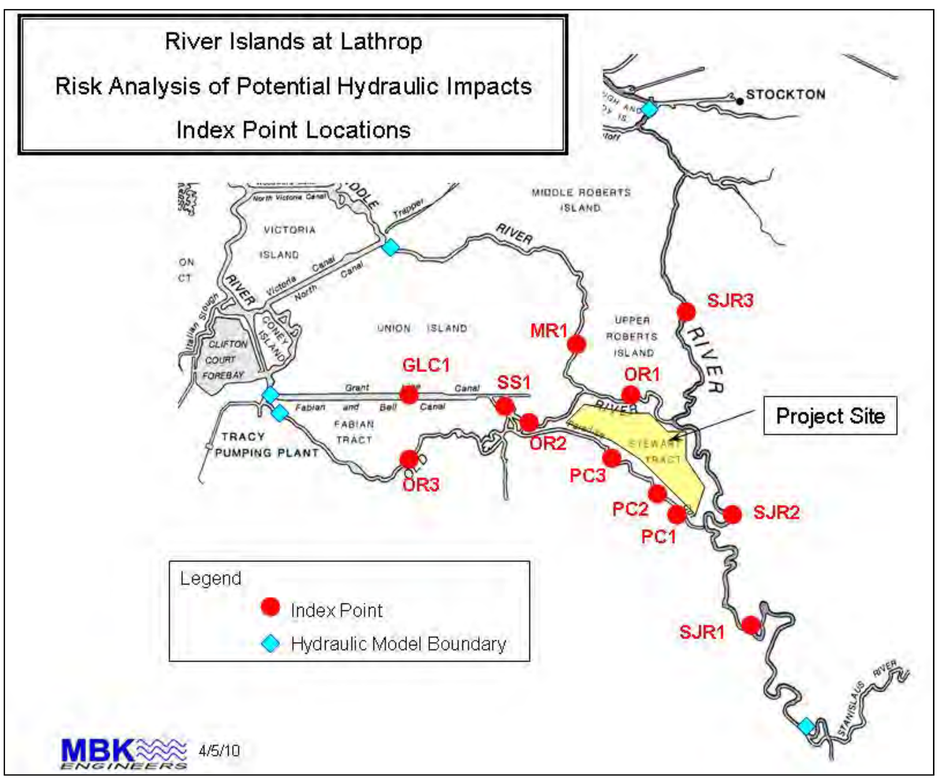

Figure 4.

Attachment B

River Islands at Lathrop, Hydraulic Analysis in Support of
Risk Based Hydraulic Impact Analysis

River Islands at Lathrop

Hydraulic Analysis in Support of Risk Based Hydraulic Impact Analysis

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Appendix F. Quality Control Certification

1. Introduction

A process for using risk analysis for determining the potential hydraulic impacts of the River Islands at Lathrop Project was developed in cooperation with the U.S. Army Corps of Engineers (USACE). This procedure is outlined in the document "Proposed Ground Rules for Section 408 Risk Analysis of Potential Impacts of the River Islands at Lathrop Project" which is provided in Appendix A. This procedure will be referred to herein as the Ground Rules. The procedure was based on a similar process developed and used for the Natomas Levee Improvement Program being undertaken by the Sacramento Area Flood Control Agency, which relied heavily on a demonstration of a process for risk analysis performed for USACE by WEST Consultants (WEST 2009).

This report documents the hydraulic analysis outlined in the Ground Rules. The hydraulic analysis was used to produce the Inflow-Outflow Relationships as per Section 4b of the Ground Rules and the Flow-Discharge Transform Functions as per Section 4c of the Ground Rules.

The Risk Analysis utilizes the hydraulic uncertainty described herein along with the hydrologic uncertainty to calculate an annual probability of levee overtopping under the study scenarios specified in the Ground Rules. This calculation is thought to provide a more complete view of the risks of a proposed project than a less complex deterministic analysis that would only address changes in water surface elevation for a particular flood event.

2. Hydraulic Simulation Model

A HEC-RAS computer simulation model of the lower San Joaquin River (LSJR Model) was used to perform hydraulic analyses. HEC-RAS is a computer program developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center that performs one-dimensional steady and unsteady hydraulic calculations for a full network of natural and constructed channels. Version 4.1 of HEC-RAS was used for this analysis. The LSJR Model was calibrated using the January 1997 flood event and the February 1998 high flow event. The development, calibration and verification of the model are described in detail in the MBK Engineers report "Lower San Joaquin River (LSJR) HEC-RAS Hydraulic Computer Simulation Model Development, Calibration and Verification", dated January 27, 2006 (MBK 2006a).

The LSJR Model study area includes the San Joaquin River from Vernalis to the Stockton Deep Water Channel, Old River from the San Joaquin River to the west end of Fabian Tract near Clifton Court Forebay, Middle River from Old River to Highway 4, and the entirety of Paradise Cut, Salmon Slough and Grant Line Canal. A schematic of the LSJR Model river reaches is provided in Figure 1.

The upstream boundary condition for the LSJR Model is the San Joaquin River basin flow at the latitude of Vernalis. The downstream boundary condition is the river stage at the following locations:

- San Joaquin River at Stockton Deep Water Ship Channel
- Middle River at Victoria Canal
- Grant Line Canal at Old River
- Old River near Delta Mendota Canal above Barrier

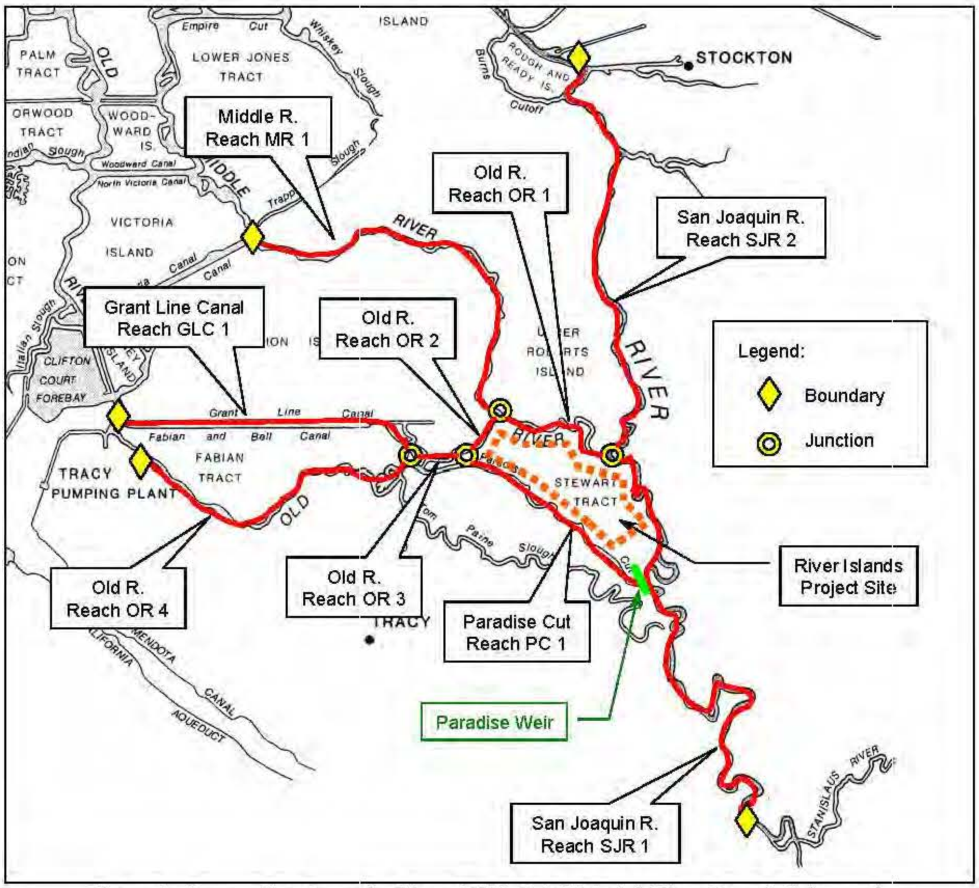

Figure 1. Lower San Joaquin River HEC-RAS Model River Reach Schematic

3. Hydrology

The hydraulic analysis used flows computed by the USACE for the Sacramento and San Joaquin River Basin Comprehensive Study (Comp Study) (USACE 2002) using a UNET model of the San Joaquin River basin. UNET is the predecessor of the unsteady flow routine in HEC-RAS. The flows used for this analysis were from San Joaquin River UNET model simulations that assumed that levees would overtop without failing.

The Comp Study hydrology was developed for a number of storm centerings that were designed to stress the flood control system at specific locations. As specified in Section 3a of the Ground Rules, the San Joaquin River mainstem at Vernalis storm centering was used for this analysis.

The hydrologic data set contains flow data for the following flood frequencies: 2-year (50%), 10-year (10%), 25-year (4%), 50-year (2%), 100-year (1%), 200-year (0.5%) and 500-year

(0.2%). The 200-year and 500-year inflow data sets include flow that enters the LSJR Model study area by way of the floodplain on that east side of the San Joaquin.

4. Index Points

The Flow-Stage Transform Functions and Inflow-Outflow Relationships are developed for specified locations referred to as Index Points. Each Index Point represents a river reach. The location of most of the Index Points is the location in the representative reach with the least amount of levee freeboard, that is, the location of the low point in the levee crown relative to the river stage. Additional Index Points, namely PC2 and PC3, were added because they represent locations with greater deterministic water surface elevation impacts. A total of twelve Index Points have been defined for this project as summarized in Table 1 and shown in Figure 2.

Table 1. Index Points

Index Point I.D.	Reach	Location [1]	Design Top of Levee Elevation [2] (ft. NAVD88)	Existing Top of Levee Elevation (ft. NAVD88)
	San Joaquin River			
SJR1	Vernalis to Paradise Cut (RM 69.8 to RM 58.4)	63.24	34.5	34.2 [3]
SJR2	Paradise Cut to Old River (RM 58.4 to RM 53.3)	57.81	29.2	28.2 [3]
SJR3	Old River to model boundary (RM 53.3 to RM 39.7)	47.80	20.5	20.8 [3]
	Paradise Cut			
PC1	All	267.9	26.2	26.3 [3]
PC2	All	239.3	25.3	24.0 [3]
PC3	All	115.7	22.2	24.6 [3]
	Old River			
OR1	San Joaquin R. to Middle R. (Sta. 301.4 to Sta. 85.5)	142.0	22.0	22.0 [3]
OR2	Middle R. to Paradise Cut (Sta. 85.5 to Sta. -70.4)	-70.4	17.2	19.9 [3]
OR3	Paradise Cut to model boundary (Sta. -70.4 to Sta. -588)	-314.3	na [6]	18.0 [4]
	Middle River			
MR1	All	26.251	na [6]	18.0 [5]
	Salmon Slough			
SS1	All	146.8	16.8	21.8 [3]
	Grant Line Canal			
GLC1	All	23.6	na [6]	20.5 [4]

[1] Hydraulic model cross-section ID. San Joaquin River and Middle River are referenced to Comp Study River Mile. Paradise Cut, Old River and Grant Line Canal/Salmon Slough are based on individual reach stationing on 100 foot increments.

[2] From San Joaquin River Flood Control Project Design Memorandum No. 1 (1955 profiles). Converted from vertical datum NGVD 1929: 0 ft. NGVD 1929 = 2.4 ft. NAVD 1988 (Carlson, Barbee and Gibson survey).

[3] Source: California Levee Database.

[4] Source: DWR bathymetry survey, 1997. Converted from vertical datum NGVD 1929: 0 ft. NGVD 1929 = 2.4 ft. NAVD 1988 (Carlson, Barbee and Gibson survey).

[5] Source: Comp Study topography. Converted from vertical datum NGVD 1929: 0 ft. NGVD 1929 = 2.4 ft. NAVD 1988 (Carlson, Barbee and Gibson survey).

[6] Not a Federal Project levee.

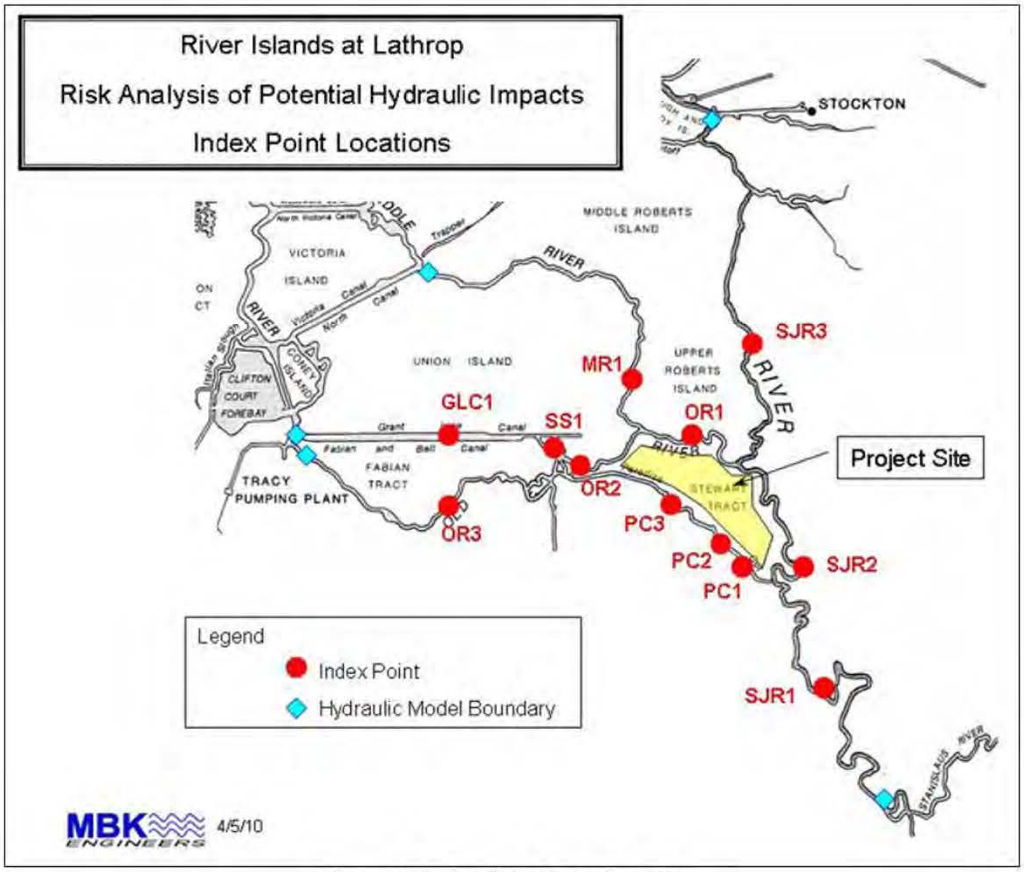

Figure 2. Index Point Location Map

5. Hydraulic Uncertainty

The calibrated hydraulic model computes a "best estimate" of flows and stages, but there is a potential range of flows and stages due to uncertainty in the hydraulic parameters that the model uses. In order to test the sensitivity of the model results to these parameters, an uncertainty analysis was performed as per Section 4d of the Ground Rules. The parameters used in hydraulic modeling that have the most uncertainty are the Manning's roughness coefficients (n-values) and the weir coefficients for levee overflow weirs (weir C). In order to quantify the hydraulic uncertainty related to these hydraulic parameters, the following simulations were made:

Hydraulic Uncertainty Simulation	n-value (change from best estimate value)	Levee weir C (best estimate C=2.8)
HU1	+20%	2.6
HU2	-20%	2.6
HU3	+20%	3.1
HU4	-20%	3.1

The 20% variation in n-values was arrived at from sensitivity simulations of the model calibration. Simulations of the calibration model were made with n-values varied plus and minus 10% and 20%. Review of the results of the sensitivity analyses indicated that 20% is a conservative variation for n-value uncertainty, as illustrated by the maximum water surface profiles plots provided in Appendix B. The weir C range is based on the "typical range" for broad crested weirs from Table 8-1 in the HEC-RAS Hydraulic Reference Manual (USACE 2010).

The hydraulic uncertainty range is defined by the maximum and minimum values computed by the hydraulic uncertainty simulations. Hydraulic uncertainty ranges were computed for the Flow-Stage Transform Functions (see Section 7) and Index Point Outflow (see Section 8.2).

6. Study Scenarios

The analysis was performed for four scenarios as specified in Section 2 of the Ground Rules:

1) Base Condition ("Base"): System prior to construction of the River Islands interior levees that form the Phase 1 protected area shown in Figure 3.
2) Existing Condition ("Existing"): Base Condition plus existing Phase 1 protected area as shown in Figure 3. The Phase 1 protected area, which covers about 25% of the development area, is protected by levees completed in 2006 and accredited by FEMA.
3) Modified Condition, Cumulative with No Federal Action ("No Action"): This scenario evaluates hydraulic impacts for flood protection which could be built without triggering a Federal action. This scenario consists of a FEMA accredited interior levee that does not come in contact with Federal Project levee or any waters of the U.S., as shown in Figure 4. Urban levees are assumed to have a minimum of three feet of freeboard on the 200-year flood event.
4) Modified Condition, Cumulative With Project ("With Project"): This scenario includes the improvements for River Islands as described in "Lower San Joaquin River HEC-RAS Model, Modeling of River Islands at Lathrop Post-Project Conditions" dated May 10, 2006 (MBK 2006b), with the following changes. The proposed "back-bays" on Old River, designated as OR1 through OR7 in MBK 2006b, are no longer part of the "With Project" condition. The "With Project" alternative is shown in Figure 5. Urban levees are assumed to have a minimum of three feet of freeboard on the 200-year flood event.

In all scenarios it is assumed that all of the San Joaquin River Flood Control Project (SJRFCP) levees are in compliance with minimum design freeboard requirements. That is, if existing top of levee elevation data indicated that a levee is freeboard deficient relative to the SJRFCP design flood plane (1955 Profile), the hydraulic model was modified to increase the top of levee to meet the minimum authorized height.

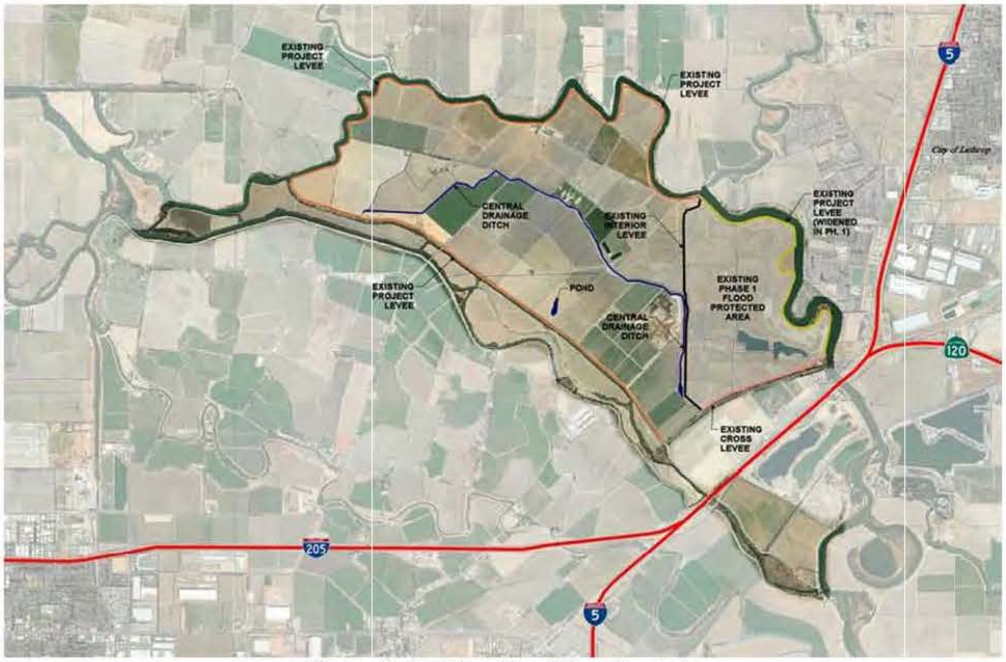

Figure 3. Existing Condition Scenario

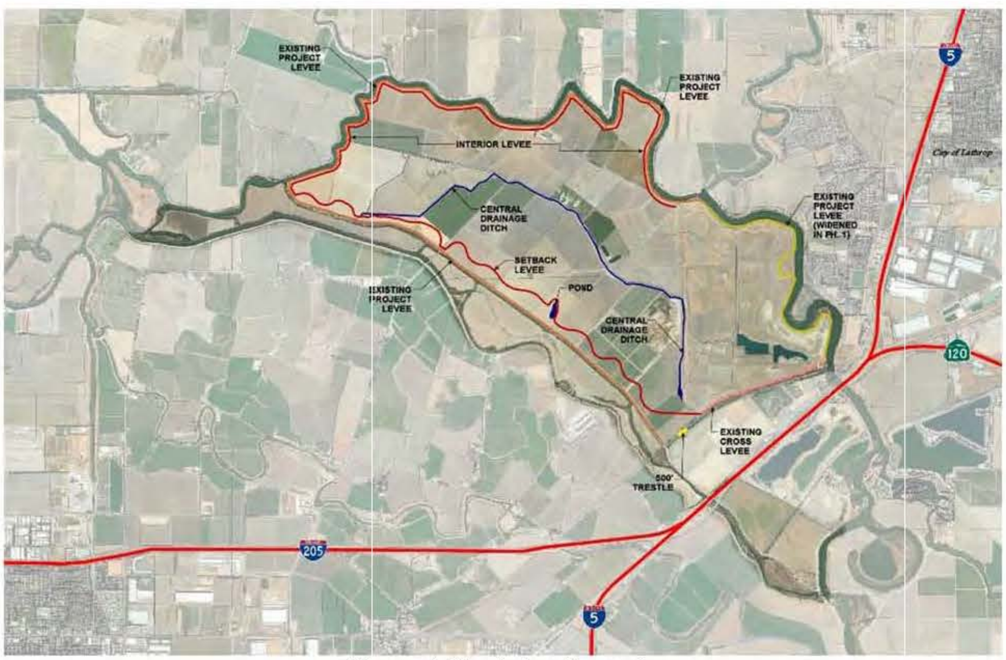

Figure 4. No Action Scenario

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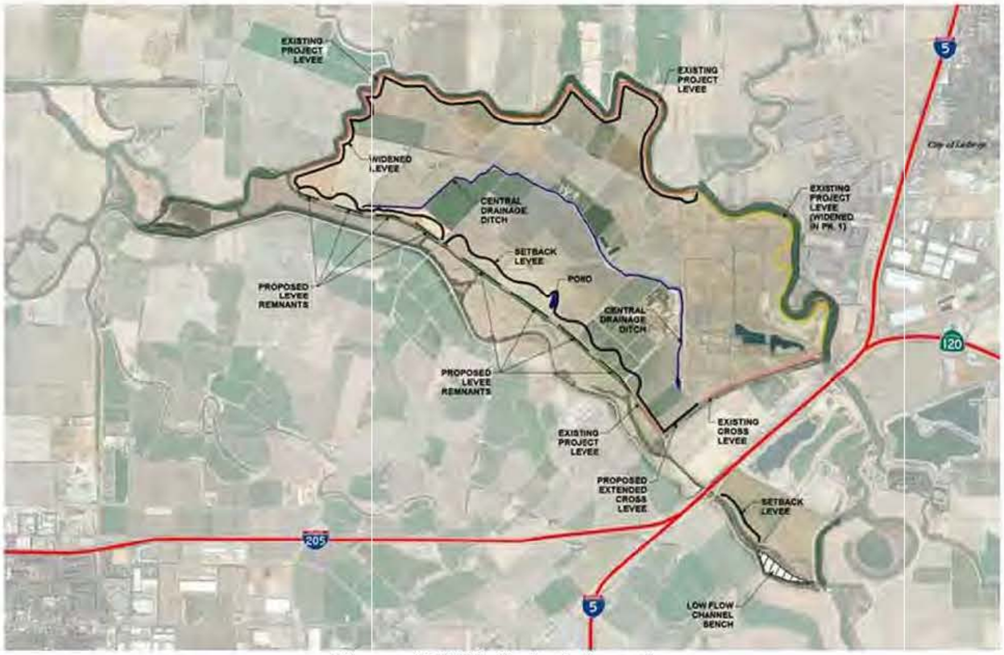

Figure 5. With Project Scenario

7. Flow-Stage Transform Functions

The Flow-Stage Transform Function for a given Index Point is defined by a set of maximum stages and flows computed by the hydraulic model at that Index Point. As specified in the Ground Rules the hydraulic analysis used for this purpose assumes "infinite levees". The purpose of this is to ensure that the Flow-Stage Transform Function extends above the top of the levee.

Hydraulic model simulations were run with the seven flood events described in Section 3: 2-, 10-, 25-, 50-, 100-, 200- and 500-year. The maximum flow and stage computed for each flood event defines a point on the Flow-Stage Transform Function. The Flow-Stage Transform Function was extended below the 2-year flood maximums through the use of rating curves derived from the hydraulic model simulations. In spite of the "infinite levees" assumption the Flow-Stage Transform Functions for Index Point GLC1 did not extend above the top of levee for the Best Estimate and Hydraulic Uncertainty Bound 2 scenarios. These functions were extrapolated above the top of levee based on the slope of the function between the 200-year and 500-year points. Flow-Stage Transform Functions were not developed for the Paradise Cut Index Points (PC1, PC2 and PC3) because reliable Inflow-Outflow Relationships do not exist due to backwater conditions caused by floodplain flows returning to the river channel. An alternative method based on Stage-Frequency relationships was employed as described in Section 9 of this report.

The final Flow-Stage Transform Function data points are tabulated in Tables 2 and 3. Plots of the final Flow-Stage Transform Functions with hydraulic uncertainty bounds are provided in Appendix C.

Table 2. Flow-Stage Transform Functions: Base, Existing and No Action.

	Best Estimate		Hydraulic Uncertainty Bound 1		Hydraulic Uncertainty Bound 2	
Index Point	Flow (cfs)	Stage (ft. NAVD88)	Flow (cfs)	Stage (ft. NAVD88)	Flow (cfs)	Stage (ft. NAVD88)
SJR1	0	2.4	0	2.4	0	2.4
(RM63.24)	11,260	17.0	11,260	17.7	11,280	16.2
Top of Levee	17,300	20.1	17,300	20.8	17,300	19.4
= 34.2 ft.	35,100	26.1	35,100	26.9	35,100	25.2
NAVD88	42,300	27.8	42,300	28.7	42,300	26.9
	47,500	29.0	47,500	29.9	47,500	28.0
	77,100	34.6	77,300	35.6	77,400	33.4
	122,200	41.1	122,300	42.4	122,900	39.7
	163,300	46.6	163,100	48.2	163,600	45.0
SJR2	0	2.4	0	2.4	0	2.4
(RM57.81)	10,970	14.2	11,020	14.8	10,970	13.6
Top of Levee	15,800	16.7	15,300	17.2	16,400	16.2
= 28.2 ft.	27,900	21.7	27,200	22.4	28,600	20.9
NAVD88	32,500	23.3	31,700	24.0	33,400	22.5
	35,700	24.4	34,900	25.1	36,700	23.5
	54,300	29.7	53,100	30.6	55,700	28.8
	82,400	36.3	81,000	37.5	84,600	35.1
	107,900	41.8	105,800	43.0	110,800	40.6
SJR3	0	2.4	0	2.4	0	2.4
(RM47.80)	4,560	10.1	4,670	10.3	4,470	9.9
Top of Levee	7,000	11.1	6,900	11.4	7,200	10.9
= 20.8 ft.	12,600	14.1	12,400	14.6	12,900	13.6
NAVD88	14,600	15.2	14,200	15.7	14,900	14.6
	15,800	15.9	15,400	16.5	16,200	15.3
	22,500	19.1	22,400	20.1	22,700	18.2
	34,200	24.0	34,100	25.1	34,300	22.7
	44,900	27.8	44,600	29.1	45,100	26.4
OR1	0	2.4	0	2.4	0	2.4
(Sta. 142.0)	6,250	10.0	6,250	10.3	6,290	9.8
Top of Levee	8,800	11.5	8,400	11.9	9,200	11.1
=22.0 ft.	15,200	15.0	14,900	15.6	15,700	14.5
NAVD88	17,900	16.3	17,500	16.9	18,400	15.6
	19,900	17.2	19,500	17.8	20,500	16.5
	31,700	21.5	30,600	22.2	32,900	20.7
	48,000	26.5	46,500	27.4	50,100	25.6
	62,900	30.4	61,000	31.5	65,500	29.3

Table 2. Flow-Stage Transform Functions: Base, Existing and No Action.

Index Point	Best Estimate Flow (cfs)	Best Estimate Stage (ft. NAVD88)	Hydraulic Uncertainty Bound 1 Flow (cfs)	Hydraulic Uncertainty Bound 1 Stage (ft. NAVD88)	Hydraulic Uncertainty Bound 2 Flow (cfs)	Hydraulic Uncertainty Bound 2 Stage (ft. NAVD88)
OR2	0	2.4	0	2.4	0	2.4
(Sta. -70.4)	5,710	8.9	5,720	9.0	5,750	8.8
Top of Levee	9,400	9.4	9,500	9.5	9,300	9.2
=19.9 ft.	20,500	11.5	20,800	11.9	20,300	11.0
NAVD88	25,300	12.4	25,600	12.9	24,900	11.9
	28,900	13.1	29,200	13.7	28,400	12.6
	49,400	16.5	49,200	17.2	49,500	15.8
	78,900	20.6	78,900	21.5	79,000	19.6
	106,000	23.8	105,800	24.8	106,000	22.7
OR3	0	2.4	0	2.4	0	2.4
(Sta. -314.3)	1,280	8.7	1,280	8.7	1,290	8.7
Top of Levee	2,100	8.9	2,200	8.9	2,100	8.8
=18.0 ft.	4,800	9.9	4,900	10.1	4,700	9.7
NAVD88	6,200	10.5	6,400	10.9	6,000	10.2
	7,300	11.2	7,500	11.6	7,100	10.8
	13,600	13.9	13,600	14.5	13,500	13.4
	22,900	17.4	23,000	18.2	22,900	16.6
	31,700	20.3	31,600	21.2	31,700	19.3
MR1	0	2.4	0	2.4	0	2.4
(RM 26.251)	520	9.2	530	9.3	520	9.1
Top of Levee	900	10.0	910	10.3	890	9.8
=18.0 ft.	1,940	12.5	1,950	13.0	1,940	12.1
NAVD88	2,390	13.5	2,390	14.0	2,380	13.0
	2,720	14.2	2,730	14.8	2,720	13.7
	4,840	17.8	4,790	18.4	4,880	17.1
	8,230	22.0	8,180	22.8	8,300	21.1
	11,440	25.3	11,450	26.3	11,610	24.3
SS1	0	2.4	0	2.4	0	2.4
(Sta. 146.8)	4,430	8.9	4,440	8.9	4,450	8.8
Top of Levee	7,260	9.3	7,320	9.4	7,150	9.1
=21.8 ft.	15,730	11.3	15,830	11.7	15,540	10.9
NAVD88	19,100	12.2	19,240	12.7	18,950	11.7
	21,560	12.9	21,720	13.5	21,360	12.4
	35,800	16.2	35,600	16.9	35,930	15.5
	55,950	20.3	55,890	21.2	56,000	19.3
	74,210	23.5	74,090	24.5	74,160	22.3
GLC1	0	2.4	0	2.4	0	2.4
(Sta. 23.6)	4,430	8.8	4,440	8.8	4,450	8.7
Top of Levee	7,260	9.0	7,320	9.1	7,150	8.9
=20.5 ft.	15,730	10.3	15,830	10.6	15,540	10.1
NAVD88	19,100	11.0	19,240	11.4	18,950	10.7
	21,560	11.6	21,720	12.0	21,360	11.2
	35,790	14.2	35,590	14.7	35,920	13.6
	55,940	17.5	55,880	18.3	55,990	16.6
	74,660	20.2	74,380	21.2	75,070	19.3
	83,900	21.6			93,800	21.9

Table 3. Flow-Stage Transform Functions, With Project.

Index Point	Best Estimate		Hydraulic Uncertainty Bound 1		Hydraulic Uncertainty Bound 2	
	Flow (cfs)	Stage (ft. NAVD88)	Flow (cfs)	Stage (ft. NAVD88)	Flow (cfs)	Stage (ft. NAVD88)
SJR1	0	2.4	0	2.4	0	2.4
(RM63.24)	11,260	17.0	11,260	17.7	11,280	16.2
Top of Levee	17,300	20.1	17,300	20.8	17,300	19.4
= 34.2 ft.	35,100	26.0	35,100	26.8	35,100	25.1
NAVD88	42,300	27.8	42,300	28.6	42,300	26.8
	47,500	28.9	47,500	29.8	47,500	27.9
	77,100	34.5	77,000	35.6	77,400	33.4
	122,200	41.0	122,200	42.3	123,100	39.6
	163,400	46.5	163,100	48.1	163,500	44.9
SJR2	0	2.4	0	2.4	0	2.4
(RM57.81)	10,990	14.2	11,040	14.8	10,980	13.7
Top of Levee	15,800	16.7	15,200	17.1	16,400	16.2
= 28.2 ft.	27,400	21.5	26,700	22.2	28,100	20.8
NAVD88	32,000	23.1	31,200	23.9	32,800	22.3
	35,200	24.2	34,400	25.0	36,200	23.4
	53,700	29.6	52,400	30.4	55,100	28.7
	81,600	36.1	80,300	37.3	83,900	35.0
	107,000	41.6	104,800	42.9	110,100	40.5
SJR3	0	2.4	0	2.4	0	2.4
(RM47.80)	4,570	10.1	4,680	10.3	4,480	9.9
Top of Levee	7,000	11.1	6,800	11.4	7,200	10.9
= 20.8 ft.	12,500	14.0	12,200	14.5	12,700	13.5
NAVD88	14,400	15.1	14,100	15.6	14,800	14.5
	15,700	15.8	15,300	16.4	16,100	15.3
	22,400	19.1	22,300	20.0	22,600	18.2
	34,100	23.9	33,900	25.1	34,200	22.7
	44,700	27.7	44,400	29.1	45,000	26.3
OR1	0	2.4	0	2.4	0	2.4
(Sta. 142.0)	6,250	10.0	6,260	10.3	6,290	9.8
Top of Levee	8,700	11.5	8,300	11.9	9,200	11.1
=22.0 ft.	14,900	15.0	14,500	15.5	15,400	14.4
NAVD88	17,600	16.2	17,200	16.8	18,000	15.6
	19,600	17.1	19,100	17.7	20,100	16.4
	31,200	21.4	30,000	22.1	32,500	20.7
	47,400	26.5	45,800	27.4	49,600	25.5
	62,100	30.4	60,100	31.4	64,900	29.3
OR2	0	2.4	0	2.4	0	2.4
(Sta. -70.4)	5,710	8.9	5,740	9.0	5,740	8.8
Top of Levee	9,400	9.4	9,500	9.5	9,300	9.2
=19.9 ft.	20,700	11.5	20,900	11.9	20,400	11.1
NAVD88	25,400	12.4	25,800	12.9	25,100	11.9
	29,000	13.2	29,300	13.7	28,600	12.6
	49,600	16.5	49,400	17.2	49,600	15.8
	79,000	20.6	79,000	21.5	79,000	19.6
	106,100	23.8	105,900	24.8	106,000	22.7

Table 3. Flow-Stage Transform Functions, With Project.

	Best Estimate		Hydraulic Uncertainty Bound 1		Hydraulic Uncertainty Bound 2	
Index Point	Flow (cfs)	Stage (ft. NAVD88)	Flow (cfs)	Stage (ft. NAVD88)	Flow (cfs)	Stage (ft. NAVD88)
OR3	0	2.4	0	2.4	0	2.4
(Sta. -314.3)	1,280	8.7	1,290	8.7	1,280	8.7
Top of Levee	2,100	8.9	2,200	8.9	2,100	8.8
=18.0 ft.	4,800	9.9	5,000	10.1	4,800	9.7
NAVD88	6,200	10.6	6,400	10.9	6,000	10.2
	7,300	11.2	7,500	11.6	7,100	10.8
	13,600	13.9	13,700	14.5	13,600	13.4
	23,000	17.4	23,000	18.2	22,900	16.6
	31,700	20.3	31,700	21.2	31,800	19.3
MR1	0	2.4	0	2.4	0	2.4
(RM 26.251)	520	9.2	530	9.3	520	9.1
Top of Levee	900	10.0	910	10.3	890	9.8
=18.0 ft.	1,930	12.5	1,940	13.0	1,940	12.1
NAVD88	2,370	13.5	2,380	14.0	2,370	13.0
	2,710	14.2	2,710	14.7	2,700	13.7
	4,820	17.8	4,770	18.4	4,860	17.1
	8,200	22.0	8,150	22.8	8,290	21.1
	11,430	25.2	11,440	26.3	11,600	24.3
SS1	0	2.4	0	2.4	0	2.4
(Sta. 146.8)	4,430	8.9	4,450	8.9	4,450	8.8
Top of Levee	7,260	9.3	7,360	9.4	7,150	9.1
=21.8 ft.	15,850	11.3	15,940	11.7	15,670	10.9
NAVD88	19,200	12.2	19,340	12.7	19,060	11.7
	21,650	12.9	21,810	13.5	21,460	12.4
	35,910	16.3	35,710	17.0	36,000	15.5
	56,010	20.3	55,970	21.2	56,040	19.3
	74,270	23.5	74,150	24.6	74,170	22.3
GLC1	0	2.4	0	2.4	0	2.4
(Sta. 23.6)	4,430	8.8	4,450	8.8	4,450	8.7
Top of Levee	7,260	9.0	7,360	9.1	7,150	8.9
=20.5 ft.	15,850	10.3	15,940	10.6	15,670	10.1
NAVD88	19,200	11.0	19,340	11.4	19,060	10.7
	21,650	11.6	21,810	12.0	21,460	11.2
	35,910	14.2	35,700	14.8	36,000	13.6
	56,000	17.5	55,960	18.3	56,030	16.6
	73,750	20.1	73,150	21.0	74,400	19.2
	82,500	21.4			92,400	21.7

8. Inflow-Outflow Relationships

Inflow-Outflow Relationships were developed for each of the Index Points except for those on Paradise Cut due to backwater affects as noted earlier. The Inflow-Outflow Relationship defines the relationship of the system inflow above a given Index Point and the resultant flow at that Index Point for each study scenario.

8.1 Inflow

The "Inflow" for a given Index Point is the maximum flow from a summation of all of the hydraulic model inflow hydrographs upstream of that Index Point. The LSJR model has a single upstream boundary (Figure 1). The "Inflow" for all index points is therefore defined as the peak flow of the inflow hydrographs. The "Inflow" for each flood frequency is listed in Table 4. Inflow hydrographs are shown in Figure 6.

Table 4. Inflows.

Flood Frequency (years)	Peak Flow (cfs)
2	17,320
10	35,110
25	42,310
50	47,660
100	78,100
200	144,390
500	223,990

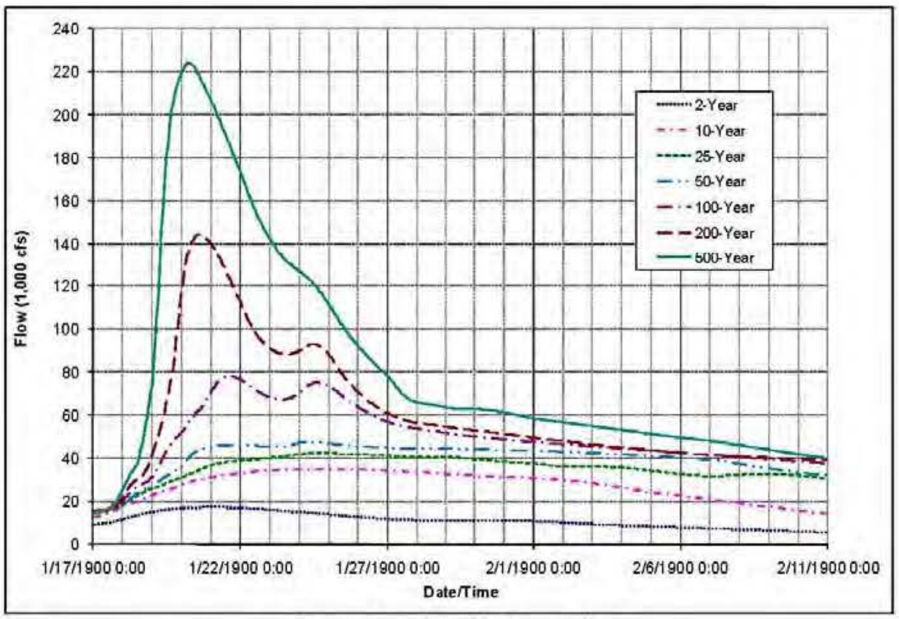

Figure 6. Inflow Hydrographs

8.2 Outflow

The "Outflow" for a given Index Point is the maximum flow computed by the hydraulic model at that Index Point. Outflows were computed for each of the scenarios described in Section 6. The hydraulic simulations assumed that levees would overtop without failing, as specified in Section 1a of the Ground Rules.

The Inflow-Outflow Relationships are provided in Table 5. Plots of the Inflow-Outflow Relationships are provided in Appendix D. The hydraulic uncertainty bounds shown are the result of the hydraulic uncertainty simulations described in Section 5.

9. Stage-Frequency Functions

The peak flows at Index Points PC1, PC2 and PC3 are affected by backwater conditions in the 200-year and 500-year simulations due to floodplain flows returning to the Paradise Cut channel. This condition leads to inconsistencies between the Inflow-Outflow Relationship and the Flow-Stage Transform Functions since the Flow-Stage Transform Functions are based on infinite levee conditions which would not account for the effects of the return flows. For these Index Points stage-frequency functions were developed and are provided in Table 6. Plots of the stage-frequency functions are provided in Appendix E.

10. Deterministic Impact Results

The computed maximum water surface elevations and flows at each of the Index Points are provided in Table 7 and Table 8, respectively. This data is not part of the risk analysis but is provided for information only.

Table 5. Inflow-Outflow Relationships.

Index Point	Fre-quency	Inflow (cfs)	Outflow (cfs)											
			Base			Existing			No Action			With Project		
			HU – Min.	Best Est.	HU – Max.	HU – Min.	Best Est.	HU – Max.	HU – Min.	Best Est.	HU – Max.	HU – Min.	Best Est.	HU – Max.
SJR1 (RM 63.24)	2-yr	17,320	17,280	17,300	17,310	17,280	17,300	17,310	17,280	17,300	17,310	17,290	17,300	17,310
	10-yr	35,110	35,080	35,090	35,090	35,080	35,090	35,090	35,080	35,090	35,090	35,080	35,090	35,090
	25-yr	42,310	42,250	42,260	42,270	42,250	42,260	42,270	42,250	42,260	42,270	42,250	42,260	42,270
	50-yr	47,660	47,440	47,470	47,490	47,440	47,470	47,490	47,440	47,470	47,490	47,450	47,470	47,490
	100-yr	78,100	72,340	77,330	77,500	72,340	77,330	77,500	72,340	77,330	77,500	72,400	77,300	77,310
	200-yr	144,390	78,370	91,950	110,230	78,370	91,950	110,230	78,370	91,950	110,230	78,440	92,000	110,270
	500-yr	223,990	82,780	97,680	118,810	82,780	97,680	118,810	82,780	97,680	118,810	82,860	97,750	118,860
SJR2 (RM 57.81)	2-Yr	17,320	15,020	15,750	16,970	15,020	15,750	16,970	15,020	15,750	16,970	14,740	15,750	16,970
	10-Yr	35,110	26,640	27,870	29,450	26,640	27,870	29,450	26,640	27,870	29,450	26,160	27,370	28,930
	25-Yr	42,310	31,050	32,490	34,320	31,050	32,490	34,320	31,050	32,490	34,320	30,550	31,990	33,800
	50-Yr	47,660	34,170	35,740	37,780	34,170	35,740	37,780	34,170	35,740	37,780	33,630	35,240	37,260
	100-Yr	78,100	47,560	54,830	57,190	47,560	54,830	57,190	47,560	54,830	57,190	47,010	54,120	56,650
	200-Yr	144,390	49,320	59,700	75,070	49,320	59,700	75,070	49,320	59,700	75,070	48,790	59,180	74,640
	500-Yr	223,990	50,600	61,810	77,570	50,600	61,810	77,570	50,630	61,810	77,570	50,150	61,410	77,180
SJR3 (RM 47.80)	2-Yr	17,320	6,820	7,000	7,280	6,820	7,000	7,280	6,820	7,000	7,280	6,730	7,010	7,290
	10-Yr	35,110	12,120	12,630	13,160	12,120	12,630	13,160	12,120	12,630	13,160	11,980	12,470	12,990
	25-Yr	42,310	13,900	14,560	15,300	13,900	14,560	15,300	13,900	14,560	15,300	13,770	14,420	15,140
	50-Yr	47,660	15,070	15,780	16,700	15,070	15,780	16,700	15,070	15,780	16,700	14,940	15,660	16,550
	100-Yr	78,100	19,550	22,180	23,130	19,550	22,180	23,130	19,550	22,180	23,120	19,560	22,140	23,020
	200-Yr	144,390	23,410	26,680	29,720	23,430	26,710	29,750	23,560	26,870	29,900	23,550	26,880	29,900
	500-Yr	223,990	24,180	28,150	32,540	24,190	28,150	32,540	24,190	28,190	32,630	24,200	28,190	32,600
OR1 (Sta 142.0)	2-Yr	17,320	8,200	8,750	9,690	8,200	8,750	9,690	8,200	8,750	9,690	8,000	8,740	9,680
	10-Yr	35,110	14,520	15,250	16,290	14,520	15,250	16,290	14,520	15,250	16,290	14,170	14,890	15,930
	25-Yr	42,310	17,140	17,930	19,020	17,140	17,930	19,020	17,140	17,930	19,020	16,770	17,560	18,650
	50-Yr	47,660	19,070	19,940	21,070	19,070	19,940	21,070	19,070	19,940	21,070	18,660	19,560	20,690
	100-Yr	78,100	25,980	31,220	34,010	25,980	31,220	34,010	25,980	31,220	34,010	25,720	30,910	33,560
	200-Yr	144,390	30,760	36,930	45,330	30,760	36,930	45,320	30,760	36,930	45,320	30,470	36,640	45,030
	500-Yr	223,990	31,530	38,240	48,080	31,530	38,240	48,070	31,540	38,240	48,070	31,260	38,030	47,880

Table 5. Inflow-Outflow Relationships.

Index Point	Fre-quency	Inflow (cfs)	Outflow (cfs)											
			Base			Existing			No Action			With Project		
			HU – Min.	Best Est.	HU – Max.	HU – Min.	Best Est.	HU – Max.	HU – Min.	Best Est.	HU – Max.	HU – Min.	Best Est.	HU – Max.
OR2	2-Yr	17,320	9,160	9,400	9,530	9,160	9,400	9,530	9,160	9,400	9,530	9,160	9,400	9,630
(Sta.	10-Yr	35,110	19,980	20,510	21,010	19,980	20,510	21,010	19,980	20,510	21,010	20,150	20,680	21,150
-70.4)	25-Yr	42,310	24,580	25,290	25,920	24,580	25,290	25,920	24,580	25,290	25,920	24,740	25,430	26,060
	50-Yr	47,660	27,990	28,850	29,510	27,990	28,850	29,510	27,990	28,850	29,510	28,140	28,990	29,650
	100-Yr	78,100	42,360	48,540	49,140	42,360	48,540	49,140	42,360	48,540	49,140	42,980	48,970	49,240
	200-Yr	144,390	67,490	73,130	73,130	66,020	70,510	71,470	69,010	78,630	82,000	64,630	74,040	80,860
	500-Yr	223,990	99,170	108,700	113,160	99,100	108,970	114,530	100,910	109,850	116,370	101,800	111,450	117,340
OR3	2-Yr	17,320	2,080	2,140	2,170	2,080	2,140	2,170	2,080	2,140	2,170	2,080	2,130	2,190
(Sta.	10-Yr	35,110	4,670	4,780	5,070	4,670	4,780	5,070	4,670	4,780	5,070	4,710	4,820	5,120
-314.3)	25-Yr	42,310	5,780	6,190	6,550	5,780	6,190	6,550	5,780	6,190	6,550	5,830	6,230	6,590
	50-Yr	47,660	6,830	7,290	7,650	6,830	7,290	7,650	6,830	7,290	7,650	6,870	7,330	7,690
	100-Yr	78,100	11,580	13,330	13,330	11,580	13,330	13,330	11,580	13,330	13,330	11,770	13,460	13,460
	200-Yr	144,390	19,330	21,010	21,010	18,910	20,180	20,400	19,690	22,800	23,810	18,450	21,330	23,440
	500-Yr	223,990	22,950	27,510	32,550	22,920	27,530	32,620	23,040	27,610	32,890	23,070	27,740	33,040
MR1	2-Yr	17,320	870	900	930	870	900	930	870	900	930	870	900	920
(RM	10-Yr	35,110	1,940	1,940	1,950	1,940	1,940	1,950	1,940	1,940	1,950	1,930	1,930	1,940
26.251)	25-Yr	42,310	2,380	2,390	2,400	2,380	2,390	2,400	2,380	2,390	2,400	2,370	2,370	2,380
	50-Yr	47,660	2,720	2,720	2,740	2,720	2,720	2,740	2,720	2,720	2,740	2,700	2,710	2,720
	100-Yr	78,100	4,120	4,820	4,900	4,120	4,820	4,900	4,120	4,820	4,900	4,150	4,830	4,880
	200-Yr	144,390	5,700	6,530	7,220	5,640	6,410	7,320	5,770	6,830	7,790	5,580	6,640	7,740
	500-Yr	223,990	6,670	7,960	9,470	6,670	7,960	9,470	6,640	7,920	9,480	6,580	7,850	9,490
SS1	2-Yr	17,320	7,080	7,260	7,360	7,080	7,260	7,360	7,080	7,260	7,360	7,080	7,260	7,430
(Sta.	10-Yr	35,110	15,310	15,730	15,930	15,310	15,730	15,930	15,310	15,730	15,930	15,440	15,850	16,040
146.8)	25-Yr	42,310	18,790	19,100	19,370	18,790	19,100	19,370	18,790	19,100	19,370	18,910	19,200	19,470
	50-Yr	47,660	21,160	21,560	21,850	21,160	21,560	21,850	21,160	21,560	21,850	21,270	21,650	21,950
	100-Yr	78,100	30,780	35,200	35,790	30,780	35,200	35,790	30,780	35,200	35,790	31,210	35,490	35,860
	200-Yr	144,390	47,960	51,880	51,880	46,990	50,120	50,930	48,830	55,590	57,990	46,000	52,550	57,220
	500-Yr	223,990	59,650	67,210	74,910	59,530	67,270	74,970	60,000	67,470	75,400	60,150	67,800	75,630

Table 5. Inflow-Outflow Relationships.

			Outflow (cfs)											
			Base			Existing			No Action			With Project		
Index Point	**Fre-quency**	**Inflow (cfs)**	**HU – Min.**	**Best Est.**	**HU – Max.**	**HU – Min.**	**Best Est.**	**HU – Max.**	**HU – Min.**	**Best Est.**	**HU – Max.**	**HU – Min.**	**Best Est.**	**HU – Max.**
GLC1 (Sta. 23.6)	2-Yr	17,320	7,080	7,260	7,360	7,080	7,260	7,360	7,080	7,260	7,360	7,080	7,260	7,430
	10-Yr	35,110	15,310	15,730	15,930	15,310	15,730	15,930	15,310	15,730	15,930	15,440	15,850	16,040
	25-Yr	42,310	18,790	19,100	19,370	18,790	19,100	19,370	18,790	19,100	19,370	18,910	19,200	19,470
	50-Yr	47,660	21,160	21,560	21,850	21,160	21,560	21,850	21,160	21,560	21,850	21,270	21,650	21,940
	100-Yr	78,100	30,780	35,200	35,780	30,780	35,200	35,780	30,780	35,200	35,780	31,210	35,490	35,850
	200-Yr	144,390	47,940	51,850	51,850	46,970	50,090	50,910	48,820	55,570	57,960	45,990	52,530	57,200
	500-Yr	223,990	59,640	67,200	74,900	59,520	67,260	74,960	60,000	67,450	75,390	60,130	67,790	75,600

HU: Hydraulic Uncertainty

Table 6. Stage-Frequency Relationships for Index Points PC1, PC2 and PC3

		Maximum Water Surface Elevation (ft. NAVD88)											
		Base			Existing			No Action			With Project		
Index Point	Fre-quency	HU – Min.	Best Est.	HU – Max.	HU – Min.	Best Est.	HU – Max.	HU – Min.	Best Est.	HU – Max.	HU – Min.	Best Est.	HU – Max.
PC1 (Sta. 267.9)	2-yr	11.3	13.8	15.3	11.3	13.8	15.3	11.3	13.8	15.3	11.3	13.8	15.6
	10-yr	17.1	19.2	20.8	17.1	19.2	20.8	17.1	19.2	20.8	17.3	19.2	20.8
	25-yr	18.6	20.6	22.3	18.6	20.6	22.3	18.6	20.6	22.3	18.7	20.6	22.2
	50-yr	19.6	21.5	23.3	19.6	21.5	23.3	19.6	21.5	23.3	19.5	21.5	23.2
	100-yr	23.5	25.6	26.4	23.5	25.6	26.4	23.5	25.6	26.4	23.5	25.6	26.3
	200-yr	26.5	28.4	29.1	26.7	28.4	29.1	26.7	28.5	29.2	27.6	28.8	29.4
	500-yr	30.1	30.7	31.1	30.1	30.7	31.1	30.1	30.7	31.1	30.1	30.7	31.0
PC2 (Sta. 239.3)	2-yr	9.7	11.6	13.0	9.7	11.6	13.0	9.7	11.6	13.0	9.7	11.4	12.9
	10-yr	14.8	16.9	18.0	14.8	16.9	18.0	14.8	16.9	18.0	14.5	16.2	17.6
	25-yr	16.3	17.9	19.0	16.3	17.9	19.0	16.3	17.9	19.0	15.8	17.5	18.7
	50-yr	17.1	18.5	19.7	17.1	18.5	19.7	17.1	18.5	19.7	16.6	18.2	19.4
	100-yr	19.7	21.4	22.0	19.7	21.4	22.0	19.7	21.4	22.0	19.4	21.1	21.7
	200-yr	21.9	23.9	24.9	22.4	24.3	25.2	23.1	25.3	26.0	24.0	26.1	26.7
	500-yr	25.4	26.1	26.5	25.6	26.2	26.7	26.0	26.7	27.1	27.0	27.5	28.0
PC3 (Sta. 115.7)	2-yr	9.6	10.5	11.5	9.6	10.5	11.5	9.6	10.5	11.5	9.6	10.4	11.2
	10-yr	13.1	14.2	15.2	13.1	14.2	15.2	13.1	14.2	15.2	12.7	13.8	14.7
	25-yr	14.0	15.1	16.2	14.0	15.1	16.2	14.0	15.1	16.2	13.6	14.8	15.9
	50-yr	14.6	15.8	17.0	14.6	15.8	17.0	14.6	15.8	17.0	14.2	15.5	16.6
	100-yr	17.5	19.0	19.4	17.5	19.0	19.4	17.5	19.0	19.4	17.3	18.8	19.2
	200-yr	19.9	22.5	23.4	20.3	22.2	23.2	22.0	24.1	24.8	21.7	23.1	23.5
	500-yr	24.0	24.8	25.3	24.0	24.8	25.3	25.1	25.9	26.2	24.6	25.5	26.0

HU: Hydraulic Uncertainty

Table 7. Deterministic Hydraulic Impacts, Maximum Water Surface Elevation (Best Estimate Simulation)

		Max. Water Surface Elevation (ft. NAVD88)				Change (ft.)			
Index Point	**Fre-quency**	**Base**	**Existing**	**No Action**	**With Project**	**Existing to No Action**	**Existing to With Proj.**	**Cumul. – Base to No Action**	**Cumul.- Base to With Project**
SJR1 (RM 63.24)	2-yr	20.13	20.13	20.13	20.13	0	0	0	0
	10-yr	26.07	26.07	26.07	25.99	0	-0.08	0	-0.08
	25-yr	27.82	27.82	27.82	27.75	0	-0.07	0	-0.07
	50-yr	28.98	28.98	28.98	28.91	0	-0.07	0	-0.07
	100-yr	34.50	34.50	34.50	34.46	0	-0.04	0	-0.04
	200-yr	35.38	35.38	35.38	35.38	0	0	0	0
	500-yr	35.83	35.83	35.83	35.83	0	0	0	0
SJR2 (RM 57.81)	2-yr	16.71	16.71	16.71	16.71	0	0	0	0
	10-yr	21.66	21.66	21.66	21.5	0	-0.16	0	-0.16
	25-yr	23.26	23.26	23.26	23.12	0	-0.14	0	-0.14
	50-yr	24.35	24.35	24.35	24.21	0	-0.14	0	-0.14
	100-yr	29.49	29.49	29.49	29.43	0	-0.06	0	-0.06
	200-yr	32.57	32.57	32.58	32.57	+0.01	0	+0.01	0
	500-yr	34.35	34.35	34.35	34.35	0	0	0	0
SJR3 (RM 47.80)	2-yr	11.15	11.15	11.15	11.15	0	0	0	0
	10-yr	14.12	14.12	14.12	14.04	0	-0.08	0	-0.08
	25-yr	15.18	15.18	15.18	15.11	0	-0.07	0	-0.07
	50-yr	15.89	15.89	15.89	15.83	0	-0.06	0	-0.06
	100-yr	18.99	18.99	18.99	18.97	0	-0.02	0	-0.02
	200-yr	20.96	20.97	21.04	21.04	+0.07	+0.07	+0.08	+0.08
	500-yr	21.57	21.57	21.59	21.59	+0.02	+0.02	+0.02	+0.02
PC1 (Sta. 267.9)	2-yr	13.78	13.78	13.78	13.75	0	-0.03	0	-0.03
	10-yr	19.21	19.21	19.21	19.19	0	-0.02	0	-0.02
	25-yr	20.62	20.62	20.62	20.61	0	-0.01	0	-0.01
	50-yr	21.53	21.53	21.53	21.51	0	-0.02	0	-0.02
	100-yr	25.63	25.63	25.63	25.58	0	-0.05	0	-0.05
	200-yr	28.36	28.44	28.50	28.82	+0.06	+0.38	+0.14	+0.46
	500-yr	30.71	30.72	30.73	30.66	+0.01	-0.06	+0.02	-0.05
PC2 (Sta. 239.3)	2-yr	11.60	11.60	11.60	11.42	0	-0.18	0	-0.18
	10-yr	16.87	16.87	16.87	16.21	0	-0.66	0	-0.66
	25-yr	17.87	17.87	17.87	17.48	0	-0.39	0	-0.39
	50-yr	18.47	18.47	18.47	18.17	0	-0.30	0	-0.30
	100-yr	21.36	21.36	21.36	21.08	0	-0.28	0	-0.28
	200-yr	23.92	24.31	25.33	26.05	+1.02	+1.74	+1.41	+2.13
	500-yr	26.06	26.22	26.67	27.54	+0.45	+1.32	+0.61	+1.48
PC3 (Sta. 115.7)	2-yr	10.50	10.50	10.50	10.36	0	-0.14	0	-0.14
	10-yr	14.22	14.22	14.22	13.78	0	-0.44	0	-0.44
	25-yr	15.14	15.14	15.14	14.78	0	-0.36	0	-0.36
	50-yr	15.80	15.80	15.80	15.48	0	-0.32	0	-0.32
	100-yr	19.00	19.00	19.00	18.81	0	-0.19	0	-0.19
	200-yr	22.51	22.23	24.11	23.09	+1.88	+0.86	+1.60	+0.58
	500-yr	24.85	24.83	25.95	25.50	+1.12	+0.67	+1.10	+0.65

Table 7. Deterministic Hydraulic Impacts, Maximum Water Surface Elevation (Best Estimate Simulation)

		Max. Water Surface Elevation (ft. NAVD88)				Change (ft.)			
Index Point	**Fre-quency**	**Base**	**Existing**	**No Action**	**With Project**	**Existing to No Action**	**Existing to With Proj.**	**Cumul. – Base to No Action**	**Cumul.- Base to With Project**
OR1 (Sta. 142.0)	2-yr	11.49	11.49	11.49	11.49	0	0	0	0
	10-yr	15.03	15.03	15.03	14.97	0	-0.06	0	-0.06
	25-yr	16.27	16.27	16.27	16.21	0	-0.06	0	-0.06
	50-yr	17.15	17.15	17.15	17.09	0	-0.06	0	-0.06
	100-yr	21.31	21.31	21.31	21.32	0	+0.01	0	+0.01
	200-yr	23.56	23.43	23.85	23.72	+0.42	+0.29	+0.29	+0.16
	500-yr	24.61	24.61	24.60	24.56	-0.01	-0.05	-0.01	-0.05
OR2 (Sta. -70.4)	2-yr	9.35	9.35	9.35	9.35	0	0	0	0
	10-yr	11.46	11.46	11.46	11.49	0	+0.03	0	+0.03
	25-yr	12.40	12.40	12.40	12.43	0	+0.03	0	+0.03
	50-yr	13.13	13.13	13.13	13.15	0	+0.02	0	+0.02
	100-yr	16.36	16.36	16.36	16.43	0	+0.07	0	+0.07
	200-yr	19.80	19.45	20.50	19.93	+1.05	+0.48	+0.70	+0.13
	500-yr	22.60	22.61	22.64	22.70	+0.03	+0.09	+0.04	+0.10
OR3 (Sta. -314.3)	2-yr	8.85	8.85	8.85	8.85	0	0	0	0
	10-yr	9.85	9.85	9.85	9.86	0	+0.01	0	+0.01
	25-yr	10.54	10.54	10.54	10.56	0	+0.02	0	+0.02
	50-yr	11.17	11.17	11.17	11.18	0	+0.01	0	+0.01
	100-yr	13.81	13.81	13.81	13.86	0	+0.05	0	+0.05
	200-yr	16.74	16.45	17.34	16.86	+0.89	+0.41	+0.60	+0.12
	500-yr	18.53	18.53	18.55	18.58	+0.02	+0.05	+0.02	+0.05
MR1 (RM 26.251)	2-yr	10.01	10.01	10.01	10.01	0	0	0	0
	10-yr	12.54	12.54	12.54	12.52	0	-0.02	0	-0.02
	25-yr	13.53	13.53	13.53	13.50	0	-0.03	0	-0.03
	50-yr	14.25	14.25	14.25	14.22	0	-0.03	0	-0.03
	100-yr	17.53	17.53	17.53	17.54	0	+0.01	0	+0.01
	200-yr	19.09	19.02	19.24	19.14	+0.22	+0.12	+0.15	+0.05
	500-yr	19.68	19.68	19.67	19.65	-0.01	-0.03	-0.01	-0.03
SS1 (Sta. 146.8)	2-yr	9.29	9.29	9.29	9.29	0	0	0	0
	10-yr	11.27	11.27	11.27	11.3	0	+0.03	0	+0.03
	25-yr	12.19	12.19	12.19	12.22	0	+0.03	0	+0.03
	50-yr	12.91	12.91	12.91	12.93	0	+0.02	0	+0.02
	100-yr	16.11	16.11	16.11	16.17	0	+0.06	0	+0.06
	200-yr	19.52	19.17	20.22	19.65	+1.05	+0.48	+0.70	+0.13
	500-yr	22.30	22.31	22.35	22.40	+0.04	+0.09	+0.05	+0.10
GLC1 (Sta. 23.6)	2-yr	9.00	9.00	9.00	9.00	0	0	0	0
	10-yr	10.32	10.32	10.32	10.34	0	+0.02	0	+0.02
	25-yr	11.01	11.01	11.01	11.03	0	+0.02	0	+0.02
	50-yr	11.60	11.60	11.60	11.62	0	+0.02	0	+0.02
	100-yr	14.09	14.09	14.09	14.14	0	+0.05	0	+0.05
	200-yr	16.85	16.57	17.42	16.96	+0.85	+0.39	+0.57	+0.11
	500-yr	19.19	19.19	19.22	19.27	+0.03	+0.08	+0.03	+0.08

Table 8. Deterministic Hydraulic Impacts, Maximum Flow
(Best Estimate Simulation)

		Maximum Flow (cfs)				Change (%)			
Index Point	Frequency	Base	Existing	No Action	With Project	Existing to No Action	Existing to With Proj.	Cumul. – Base to No Action	Cumul.- Base to With Project
SJR1 (RM 63.24)	2-yr	17,300	17,300	17,300	17,300	0%	0%	0%	0%
	10-yr	35,090	35,090	35,090	35,090	0%	0%	0%	0%
	25-yr	42,260	42,260	42,260	42,260	0%	0%	0%	0%
	50-yr	47,470	47,470	47,470	47,470	0%	0%	0%	0%
	100-yr	77,330	77,330	77,330	77,300	0%	0%	0%	0%
	200-yr	91,950	91,950	91,950	92,000	0%	+0.1%	0%	+0.1%
	500-yr	97,680	97,680	97,680	97,750	0%	+0.1%	0%	+0.1%
SJR2 (RM 57.81)	2-yr	15,750	15,750	15,750	15,750	0%	0%	0%	0%
	10-yr	27,870	27,870	27,870	27,370	0%	-1.8%	0%	-1.8%
	25-yr	32,490	32,490	32,490	31,990	0%	-1.5%	0%	-1.5%
	50-yr	35,740	35,740	35,740	35,240	0%	-1.4%	0%	-1.4%
	100-yr	54,830	54,830	54,830	54,120	0%	-1.3%	0%	-1.3%
	200-yr	59,700	59,700	59,700	59,180	0%	-0.9%	0%	-0.9%
	500-yr	61,810	61,810	61,810	61,410	0%	-0.6%	0%	-0.6%
SJR3 (RM 47.80)	2-yr	7,000	7,000	7,000	7,010	0%	+0.1%	0%	+0.1%
	10-yr	12,630	12,630	12,630	12,470	0%	-1.3%	0%	-1.3%
	25-yr	14,560	14,560	14,560	14,420	0%	-1.0%	0%	-1.0%
	50-yr	15,780	15,780	15,780	15,660	0%	-0.8%	0%	-0.8%
	100-yr	22,180	22,180	22,180	22,140	0%	-0.2%	0%	-0.2%
	200-yr	26,680	26,710	26,870	26,880	+0.6%	+0.6%	+0.7%	+0.7%
	500-yr	28,150	28,150	28,190	28,190	+0.1%	+0.1%	+0.1%	+0.1%
PC1 (Sta. 267.9)	2-yr	1,560	1,560	1,560	1,560	0%	0%	0%	0%
	10-yr	7,210	7,210	7,210	7,720	0%	+7.1%	0%	+7.1%
	25-yr	9,760	9,760	9,760	10,250	0%	+5.0%	0%	+5.0%
	50-yr	11,650	11,650	11,650	12,150	0%	+4.3%	0%	+4.3%
	100-yr	22,180	22,180	22,180	22,960	0%	+3.5%	0%	+3.5%
	200-yr	27,660	27,660	27,660	28,920	0%	+4.6%	0%	+4.6%
	500-yr	28,920	28,920	28,920	30,620	0%	+5.9%	0%	+5.9%
PC2 (Sta. 239.3)	2-yr	1,560	1,560	1,560	1,560	0%	0%	0%	0%
	10-yr	7,210	7,210	7,210	7,720	0%	+7.1%	0%	+7.1%
	25-yr	9,760	9,760	9,760	10,250	0%	+5.0%	0%	+5.0%
	50-yr	11,650	11,650	11,650	12,150	0%	+4.3%	0%	+4.3%
	100-yr	22,180	22,180	22,180	22,960	0%	+3.5%	0%	+3.5%
	200-yr	31,700	31,170	31,110	30,540	-0.2%	-2.0%	-1.9%	-3.7%
	500-yr	41,830	41,140	39,290	37,650	-4.5%	-8.5%	-6.1%	-10.0%
PC3 (Sta. 115.7)	2-yr	1,560	1,560	1,560	1,560	0%	0%	0%	0%
	10-yr	7,210	7,210	7,210	7,720	0%	+7.1%	0%	+7.1%
	25-yr	9,750	9,750	9,750	10,250	0%	+5.1%	0%	+5.1%
	50-yr	11,650	11,650	11,650	12,150	0%	+4.3%	0%	+4.3%
	100-yr	22,160	22,160	22,160	22,950	0%	+3.6%	0%	+3.6%
	200-yr	33,860	36,140	38,870	49,620	+7.6%	+37.3%	+14.8%	+46.5%
	500-yr	44,050	45,240	48,430	57,830	+7.1%	+27.8%	+9.9%	+31.3%

Table 8. Deterministic Hydraulic Impacts, Maximum Flow (Best Estimate Simulation)

		Maximum Flow (cfs)				Change (%)			
Index Point	Fre-quency	Base	Existing	No Action	With Project	Existing to No Action	Existing to With Proj.	Cumul. – Base to No Action	Cumul.- Base to With Project
OR1 (Sta. 142.0)	2-yr	8,750	8,750	8,750	8,740	0%	-0.1%	0%	-0.1%
	10-yr	15,250	15,250	15,250	14,890	0%	-2.4%	0%	-2.4%
	25-yr	17,930	17,930	17,930	17,560	0%	-2.1%	0%	-2.1%
	50-yr	19,940	19,940	19,940	19,560	0%	-1.9%	0%	-1.9%
	100-yr	31,220	31,220	31,220	30,910	0%	-1.0%	0%	-1.0%
	200-yr	36,930	36,930	36,930	36,640	0%	-0.8%	0%	-0.8%
	500-yr	38,240	38,240	38,240	38,030	0%	-0.5%	0%	-0.5%
OR2 (Sta. -70.4)	2-yr	9,400	9,400	9,400	9,400	0%	0%	0%	0%
	10-yr	20,510	20,510	20,510	20,680	0%	+0.8%	0%	+0.8%
	25-yr	25,290	25,290	25,290	25,430	0%	+0.6%	0%	+0.6%
	50-yr	28,850	28,850	28,850	28,990	0%	+0.5%	0%	+0.5%
	100-yr	48,540	48,540	48,540	48,970	0%	+0.9%	0%	+0.9%
	200-yr	73,130	70,510	78,630	74,040	+11.5%	+5.0%	+7.5%	+1.2%
	500-yr	108,700	108,970	109,850	111,450	+0.8%	+2.3%	+1.1%	+2.5%
OR3 (Sta. -314.3)	2-yr	2,140	2,140	2,140	2,130	0%	-0.5%	0%	-0.5%
	10-yr	4,780	4,780	4,780	4,820	0%	+0.8%	0%	+0.8%
	25-yr	6,190	6,190	6,190	6,230	0%	+0.6%	0%	+0.6%
	50-yr	7,290	7,290	7,290	7,330	0%	+0.5%	0%	+0.5%
	100-yr	13,330	13,330	13,330	13,460	0%	+1.0%	0%	+1.0%
	200-yr	21,010	20,180	22,800	21,330	+13.0%	+5.7%	+8.5%	+1.5%
	500-yr	27,510	27,530	27,610	27,740	+0.3%	+0.8%	+0.4%	+0.8%
MR1 (RM 26.251)	2-yr	900	900	900	900	0%	0%	0%	0%
	10-yr	1,940	1,940	1,940	1,930	0%	-0.5%	0%	-0.5%
	25-yr	2,390	2,390	2,390	2,370	0%	-0.8%	0%	-0.8%
	50-yr	2,720	2,720	2,720	2,710	0%	-0.4%	0%	-0.4%
	100-yr	4,820	4,820	4,820	4,830	0%	+0.2%	0%	+0.2%
	200-yr	6,530	6,410	6,830	6,640	+6.6%	+3.6%	+4.6%	+1.7%
	500-yr	7,960	7,960	7,920	7,850	-0.5%	-1.4%	-0.5%	-1.4%
SS1 (Sta. 146.8)	2-yr	7,260	7,260	7,260	7,260	0%	0%	0%	0%
	10-yr	15,730	15,730	15,730	15,850	0%	+0.8%	0%	+0.8%
	25-yr	19,100	19,100	19,100	19,200	0%	+0.5%	0%	+0.5%
	50-yr	21,560	21,560	21,560	21,650	0%	+0.4%	0%	+0.4%
	100-yr	35,200	35,200	35,200	35,490	0%	+0.8%	0%	+0.8%
	200-yr	51,880	50,120	55,590	52,550	+10.9%	+4.8%	+7.2%	+1.3%
	500-yr	67,210	67,270	67,470	67,800	+0.3%	+0.8%	+0.4%	+0.9%
GLC1 (Sta. 23.6)	2-yr	7,260	7,260	7,260	7,260	0%	0%	0%	0%
	10-yr	15,730	15,730	15,730	15,850	0%	+0.8%	0%	+0.8%
	25-yr	19,100	19,100	19,100	19,200	0%	+0.5%	0%	+0.5%
	50-yr	21,560	21,560	21,560	21,650	0%	+0.4%	0%	+0.4%
	100-yr	35,200	35,200	35,200	35,490	0%	+0.8%	0%	+0.8%
	200-yr	51,850	50,090	55,570	52,530	+10.9%	+4.9%	+7.2%	+1.3%
	500-yr	67,200	67,260	67,450	67,790	+0.3%	+0.8%	+0.4%	+0.9%

References

MBK Engineers. Lower San Joaquin River (LSJR) HEC-RAS Hydraulic Computer Simulation Model Development, Calibration and Verification. January 2006. (MBK 2006a)

MBK Engineers. Lower San Joaquin River HEC-RAS Model Modeling of River Islands at Lathrop Post-Project Conditions. May 2006. (MBK 2006b)

U.S. Army Corps of Engineers, Sacramento District. San Joaquin River Flood Protection Project, Design Memorandum No. 1. December 1955. (USACE 1955)

U.S. Army Corps of Engineers, Sacramento District. Sacramento and San Joaquin River Basins Comprehensive Study. December 2002. (USACE 2002)

U.S. Army Corps of Engineers, Hydrologic Engineering Center. HEC-RAS River Analysis System Hydraulic Reference Manual. January 2010. (USACE 2010)

WEST Consultants, Inc. Documentation and Demonstration of a Process for Risk Analysis of Proposed Modifications to Sacramento River Flood Control Project Levees. March 2009. (WEST 2009)

Appendix A

Proposed Ground Rules for Section 408 Risk Analysis of Potential Impacts of River Islands at Lathrop Project

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July 19, 2010

Proposed Ground Rules for Section 408 Risk Analysis of Potential Hydraulic Impacts of River Islands at Lathrop Project

1. Levee Performance

    a. Levees overtop without failing.

2. Evaluation Scenarios

    a. **Base Condition** – system prior to construction of the River Islands interior levees that form the Phase 1 protected area shown in Figure 1. In addition:

        i. If levees do not meet the minimum project standard they would be raised in the hydraulic model to meet the minimum authorized levee height (1955 Profile); and

        ii. Where existing top of levees heights exceed the authorized height, they are modeled as such.

    b. **Existing Condition** – Base Condition plus existing Phase 1 protected area, which was completed in 2006 (see Figure 1).

    c. **Modified Condition, Cumulative with no Federal Action (No Action)** – Base Condition plus FEMA certifiable interior levee constructed for entire project site (see Figure 2). The interior levee does not come in contact with Federal Project levee or required levee easements. This scenario represents the River Islands Project that would be constructed absent federal permits. Urban levees (Reclamation District 17) raised (if necessary) to have 3 feet of freeboard on 200-year flood event.

    d. **Modified Condition, With Project** – Base Condition plus addition of proposed River Islands Project and Paradise Cut Improvement Project (see Figure 3). Urban levees (Reclamation District 17) raised (if necessary) to have 3 feet of freeboard on 200-year flood event.

3. Hydrology

    a. Sacramento and San Joaquin River Basins Comprehensive Study San Joaquin River mainstem at Vernalis storm centering.

4. Risk Analysis Procedures

   a. System input flow-frequency curves derived using the same procedures as in the HEC Section 408 risk analysis demonstration project (June 2009) will be used. These curves represent the summation of regulated flow hydrographs at hydraulic model boundary conditions upstream of a given Index Point.

   b. Inflow-Outflow relationships derived using the same procedures as in the demonstration project will be used. These relationships will be used to account for system routing and loss of flow due to spills over levees. This relationship translates the system input flow to a regulated flow at each of the Index Points.

   c. Flow-discharge Transform Functions at Index Points will be based on an infinite levee scenario (no spills). This is a maximum flow versus maximum stage relationship.

   d. The inflow-outflow relationship should be based on sensitivity analysis of Manning's n-value roughness coefficients and levee overtopping weir flow coefficients. The Manning's n-value uncertainty range will be determined recognizing model calibration variability at the index points. The levee overtopping weir coefficient is not a calibrated parameter so its uncertainty range will be based on the typical coefficient range for broad crested weirs of 2.6 to 3.1 as defined in the HEC-RAS Hydraulic Reference Manual, CPD-69, March 2008 (Table 8-1).

5. Analysis of Conditional Annual Exceedance Probability

   a. The procedures being utilized will not produce a level of protection evaluation for each index point in the system. This is because of the necessity to make simplifying assumptions concerning levee performance and hydrologic inputs. The assumption of no levee failures will result in AEP's that are conditioned on that assumption and will thereby overestimate the level of protection provided throughout the system. Therefore for this analysis a Conditional Annual Exceedance Probability (C-AEP) will be calculated for each index point. All of the factors governing the "Conditional" aspect of the AEP will be documented.

   b. "Conditional" Conditional Non-Exceedance Probabilities (C-CNP) shall be reported, too.

c. The target levee elevations used to compute Without Project Condition C-AEP and C-CNP's shall be consistent with the levee elevations used to establish the Base Condition (see item 2.a).

d. For Index Points controlled by backwater such that stage-discharge relationships do not exist, the analysis will be based on stage-frequency and not flow-frequency methodology. In these same areas the C-AEP's and C-CNP's will be based on the authorized levee elevation as shown on the 1955 Design flood profiles.

6. Index Point Locations

a. A list of index points is provided in Table 1. A map showing the index point locations is shown in Figure 4.

Table 1. Index Points

Reach	Location [1]	Index Point ID	Channel Invert Elev. (ft. NGVD29)	Fed Project Design Top of Levee, 1955 Profile (ft. NGVD29)	Top of Levee Elevation (ft. NGVD29)	Top of Levee Elevation Source
San Joaquin River						
Vernalis to Paradise Cut	63.24	SJR1	-19	32.1	31.8	CA Levee Database [2]
Paradise Cut to Old River	57.81	SJR2	-14	26.8	25.8	CA Levee Database [2]
Old River to model boundary	47.80	SJR3	-15	18.1	18.4	CA Levee Database [2]
Paradise Cut						
San Joaquin R. to Old R.	267.9	PC1	7	23.8	23.9	CA Levee Database [2]
San Joaquin R. to Old R.	239.3	PC2	-1	22.9	21.6	CA Levee Database [2]
San Joaquin R. to Old R.	115.7	PC3	-5	19.8	22.2	CA Levee Database [2]
Old River						
San Joaquin R. to Middle R.	142.0	OR1	-8	19.6	19.6	CA Levee Database [2]
Middle R. to Paradise Cut	172.06	OR2	-20	14.8	17.5	CA Levee Database [2]
Paradise Cut to model boundary	-100.5	OR3	-8	na	15.6	DWR bathymetry survey, 1997
Middle River						
Old R. to model boundary	26.251	MR1	-4	na	15.6	Comprehensive Study topo
Salmon Slough						
All	146.81	SS1	-14	14.4	19.4	CA Levee Database [2]
Grant Line Canal						
All	23.6	GLC1	-13	na	18.1	DWR bathymetry survey, 1997

[1] Hydraulic model cross-section ID. San Joaquin River and Middle River are referenced to Comp Study River Mile. Paradise Cut, Old River and Grant Line Canal are based on individual reach stationing on 100 foot increments.
[2] Converted from vertical datum NAVD88 to NGVD29 based on relationship of 0 ft. NGVD29 = 2.4 ft. NAVD88 as per Carlson, Barbee, Gibson.

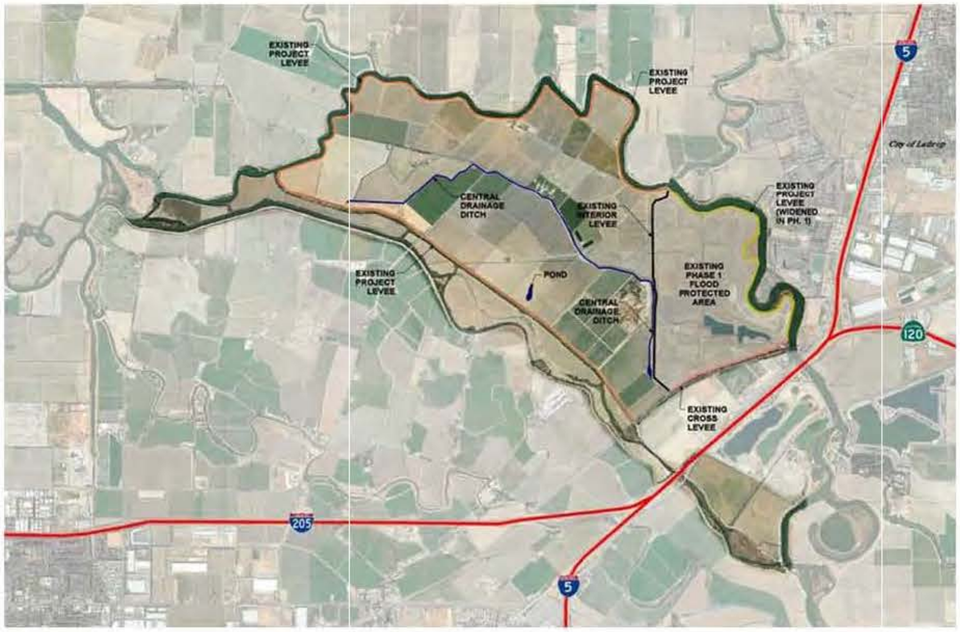

Figure 1. Existing Condition Scenario

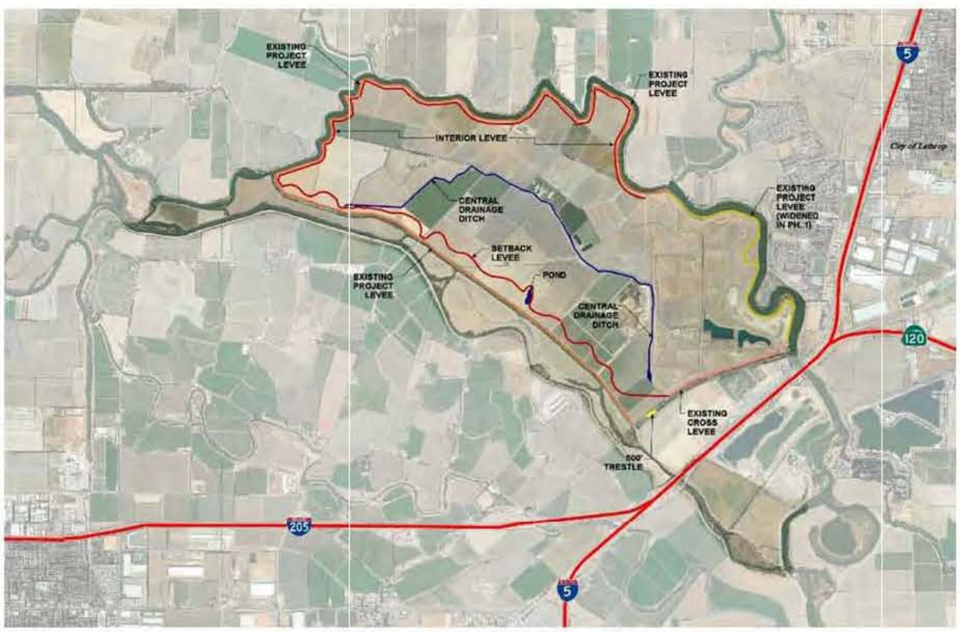

Figure 2. No Action Scenario

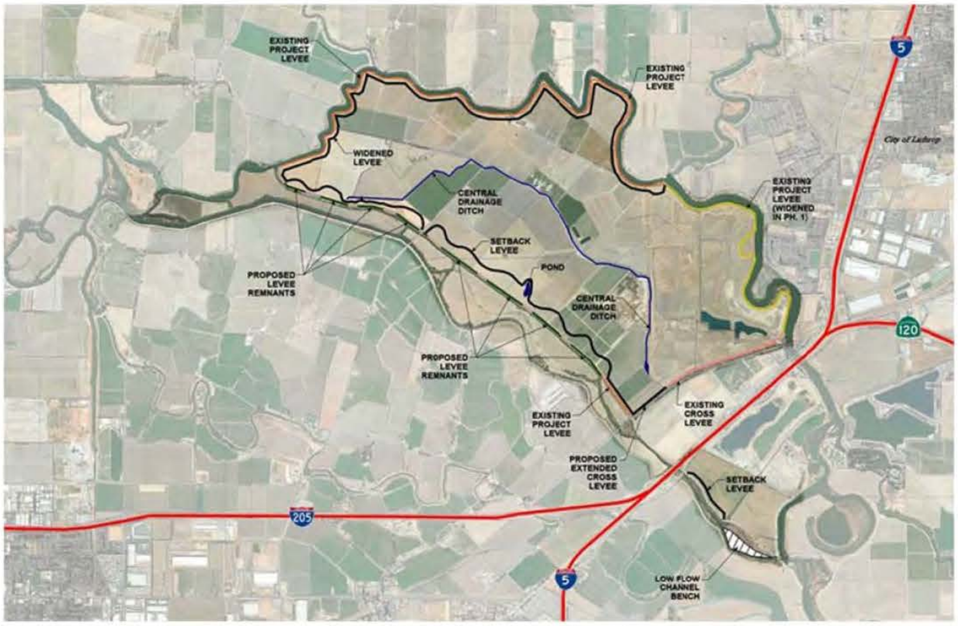

Figure 3. With Project Scenario

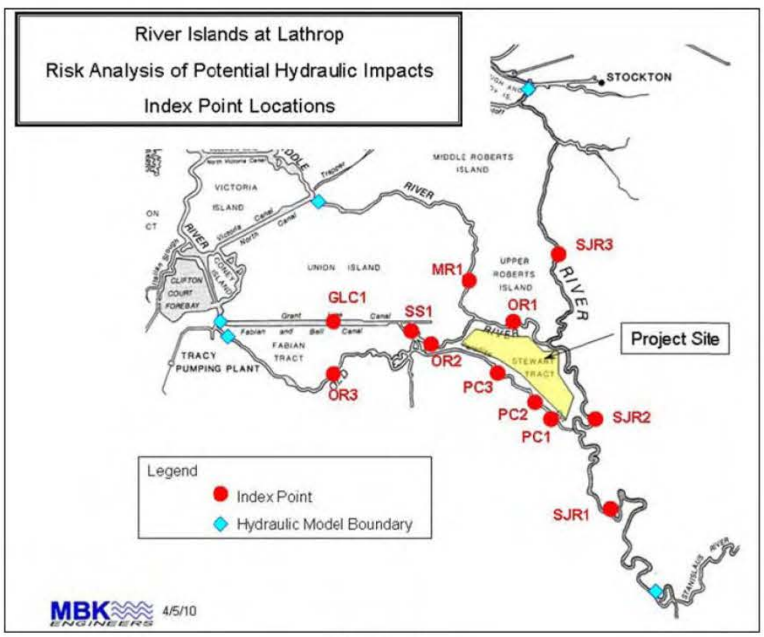

Figure 4.

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Appendix B

Calibration Sensitivity Profiles

Figure B-1.	Calibration Sensitivity Maximum Water Surface Profiles, San Joaquin River above Paradise Weir, January 1997 Event
Figure B-2.	Calibration Sensitivity Maximum Water Surface Profiles, San Joaquin River above Paradise Weir, January 1997 Event
Figure B-3.	Calibration Sensitivity Maximum Water Surface Profiles, Paradise Cut, January 1997 Event
Figure B-4.	Calibration Sensitivity Maximum Water Surface Profiles, Old River, January 1997 Event
Figure B-5.	Calibration Sensitivity Maximum Water Surface Profiles, Grant Line Canal, January 1997 Event
Figure B-6.	Calibration Sensitivity Maximum Water Surface Profiles, San Joaquin River above Paradise Weir, February 1998 Event
Figure B-7.	Calibration Sensitivity Maximum Water Surface Profiles, San Joaquin River below Paradise Weir, February 1998 Event
Figure B-8.	Calibration Sensitivity Maximum Water Surface Profiles, Old River, February 1998 Event
Figure B-9.	Calibration Sensitivity Maximum Water Surface Profiles, Grant Line Canal, February 1998 Event
Figure B-10.	Calibration Sensitivity Maximum Water Surface Profiles, Middle River, February 1998 Event

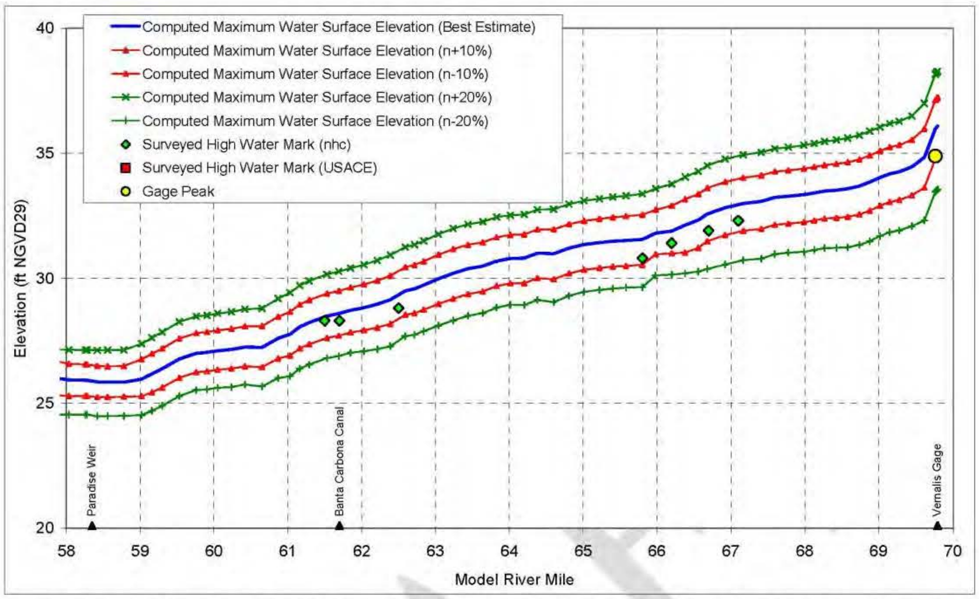

Figure B-1. Calibration Sensitivity Maximum Water Surface Profiles, San Joaquin River above Paradise Weir, January 1997 Event

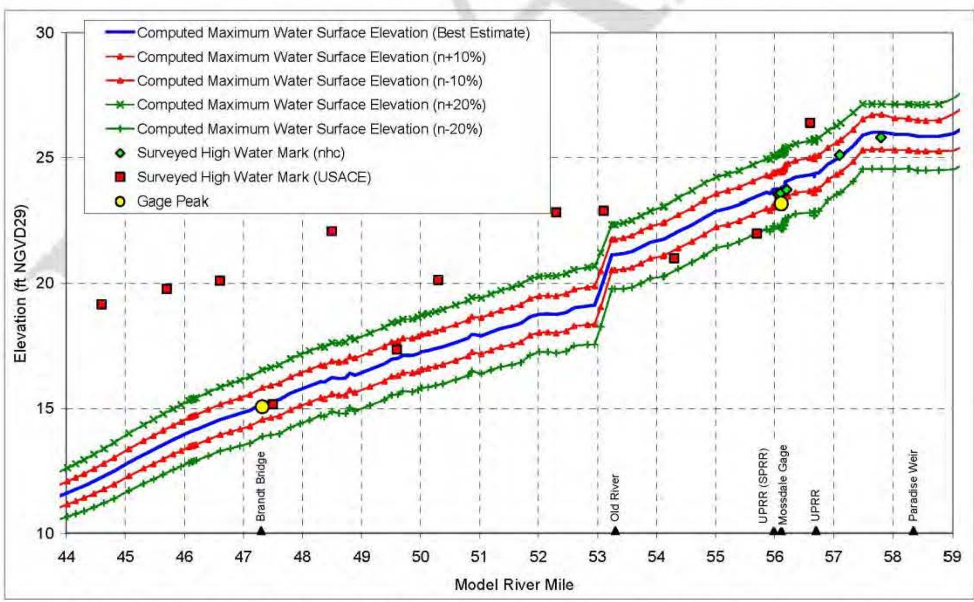

Figure B-2. Calibration Sensitivity Maximum Water Surface Profiles, San Joaquin River above Paradise Weir, January 1997 Event

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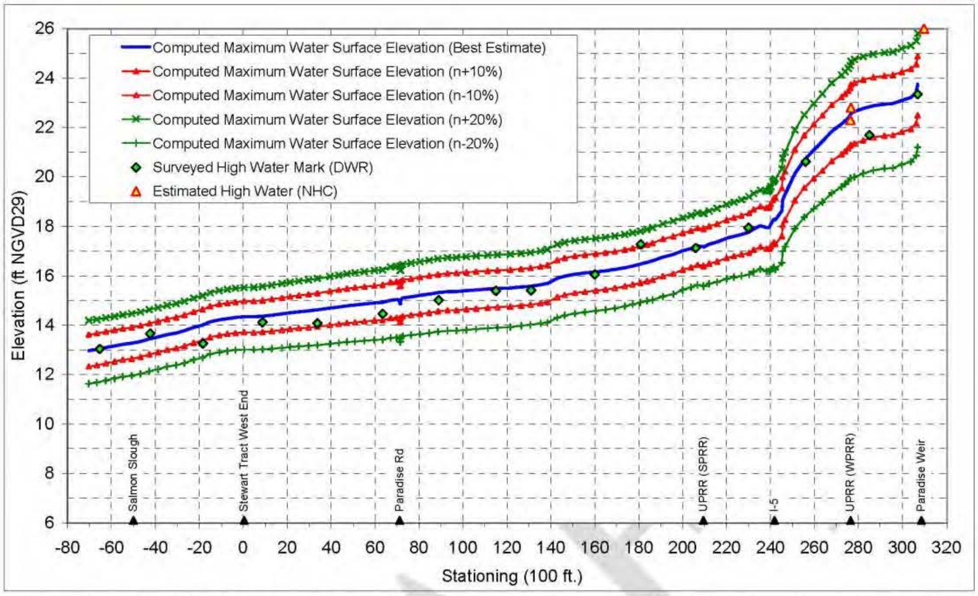

Figure B-3. Calibration Sensitivity Maximum Water Surface Profiles, Paradise Cut, January 1997 Event

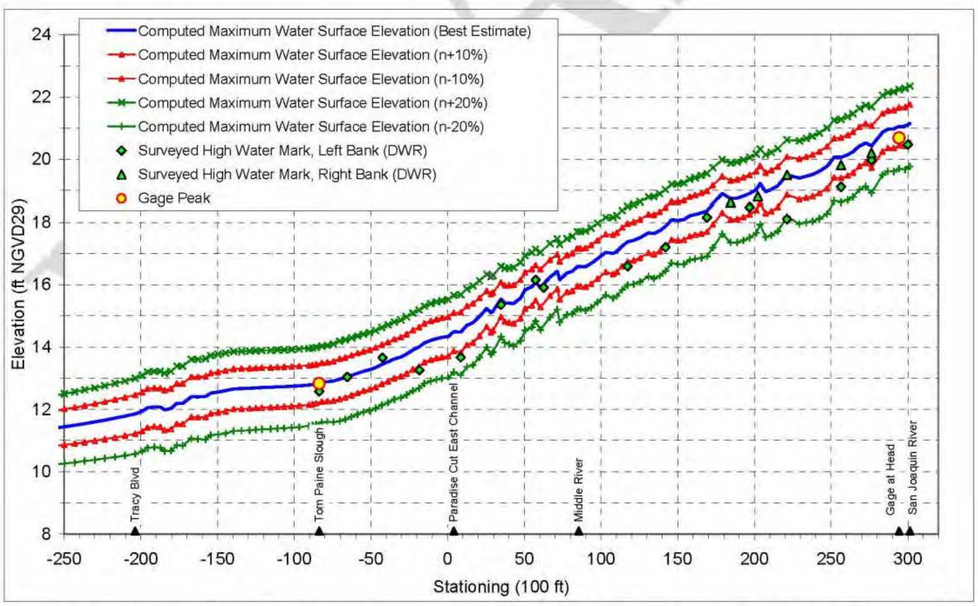

Figure B-4. Calibration Sensitivity Maximum Water Surface Profiles, Old River, January 1997 Event

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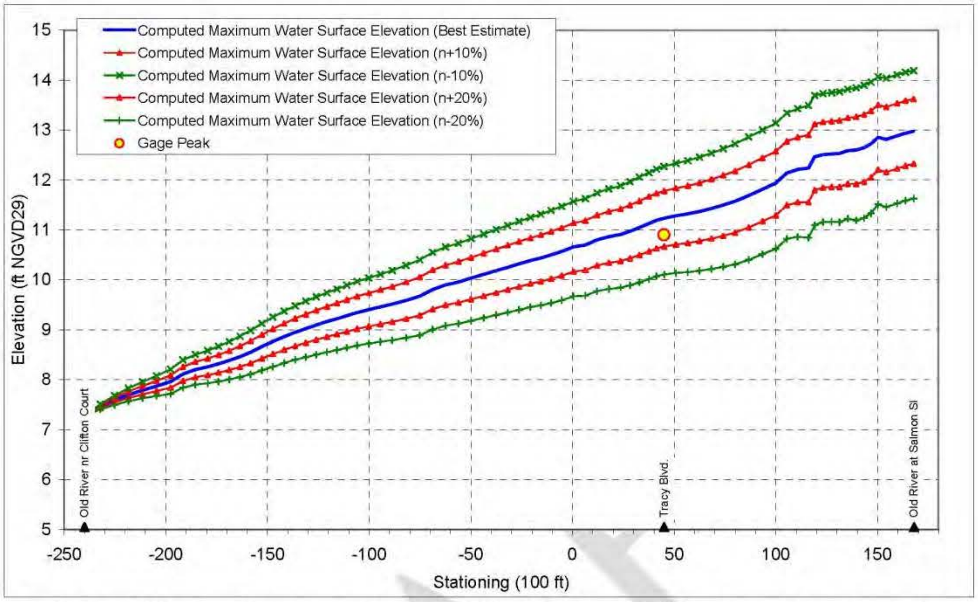

Figure B-5. Calibration Sensitivity Maximum Water Surface Profiles, Grant Line Canal, January 1997 Event

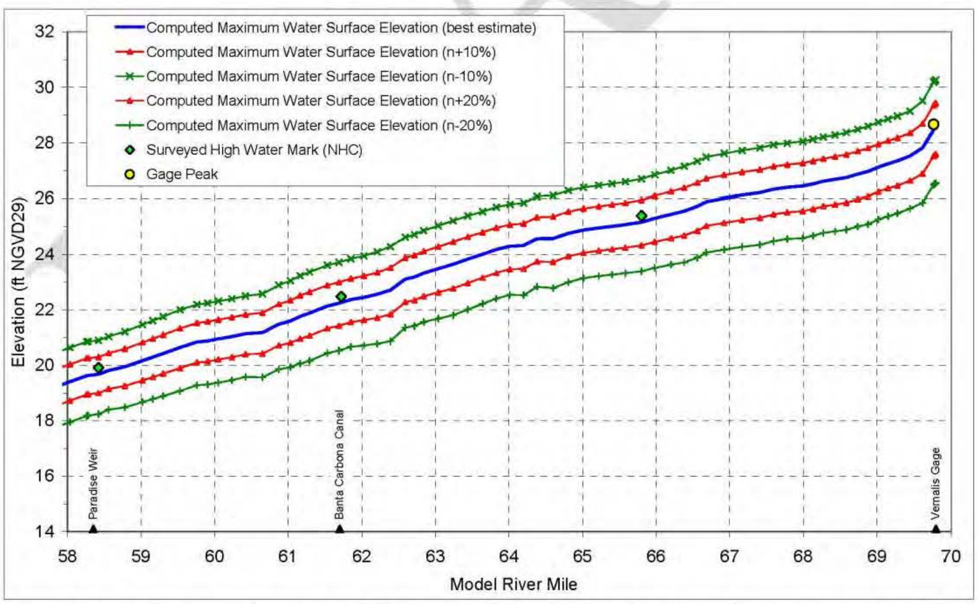

Figure B-6. Calibration Sensitivity Maximum Water Surface Profiles, San Joaquin River above Paradise Weir, February 1998 Event

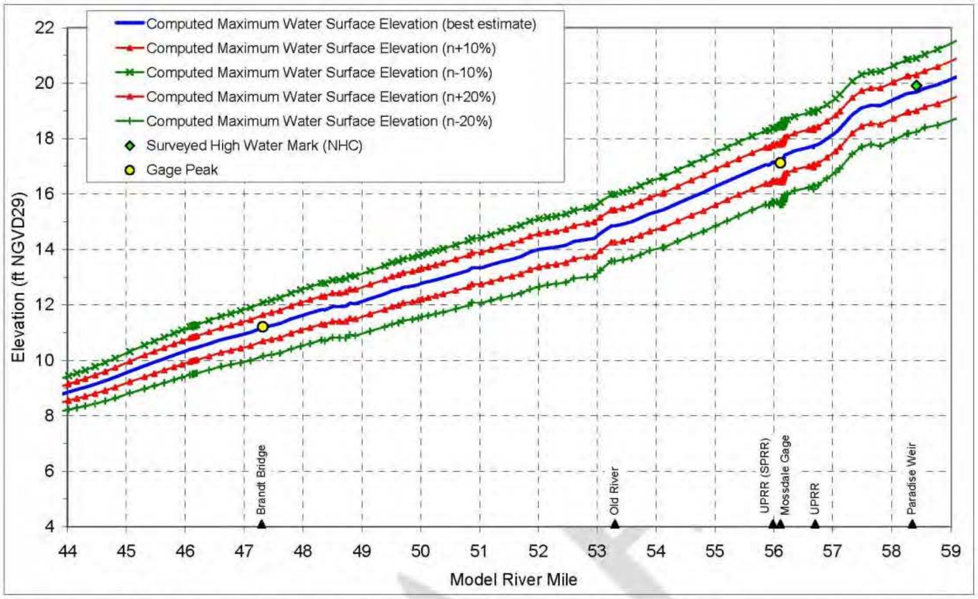

Figure B-7. Calibration Sensitivity Maximum Water Surface Profiles, San Joaquin River below Paradise Weir, February 1998 Event

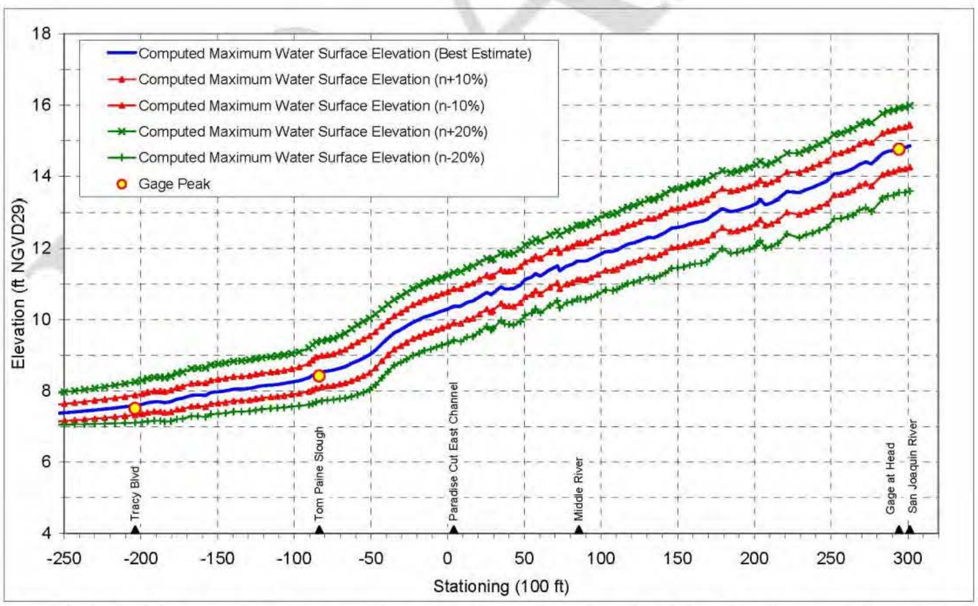

Figure B-8. Calibration Sensitivity Maximum Water Surface Profiles, Old River, February 1998 Event

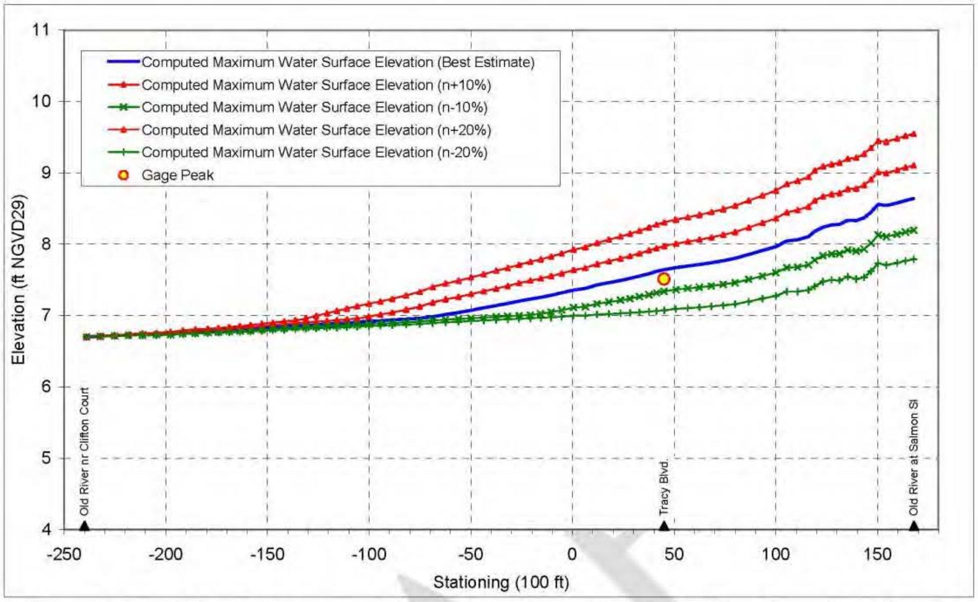

Figure B-9. Calibration Sensitivity Maximum Water Surface Profiles, Grant Line Canal, February 1998 Event

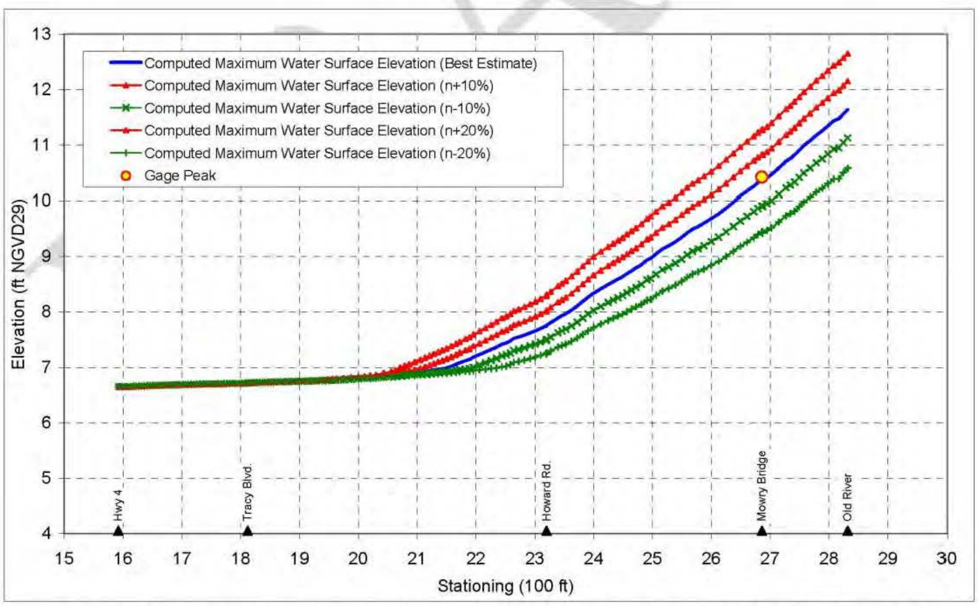

Figure B-10. Calibration Sensitivity Maximum Water Surface Profiles, Middle River, February 1998 Event

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Appendix C

Plots of Flow-Stage Transform Functions

Figure C-1. Flow-Stage Transform Function, Index Point SJR1 (RM 63.24)
Figure C-2. Flow-Stage Transform Function, Index Point SJR2 (RM 57.81)
Figure C-3. Flow-Stage Transform Function, Index Point SJR3 (RM 47.80)
Figure C-4. Flow-Stage Transform Function, Index Point OR1 (Sta. 142.0)
Figure C-5. Flow-Stage Transform Function, Index Point OR2 (Sta. -70.4)
Figure C-6. Flow-Stage Transform Function, Index Point OR3 (Sta. -314.3)
Figure C-7. Flow-Stage Transform Function, Index Point MR1 (RM 26.251)
Figure C-8. Flow-Stage Transform Function, Index Point SS1 (Sta. 146.8)
Figure C-9. Flow-Stage Transform Function, Index Point GLC1 (Sta. 23.6)

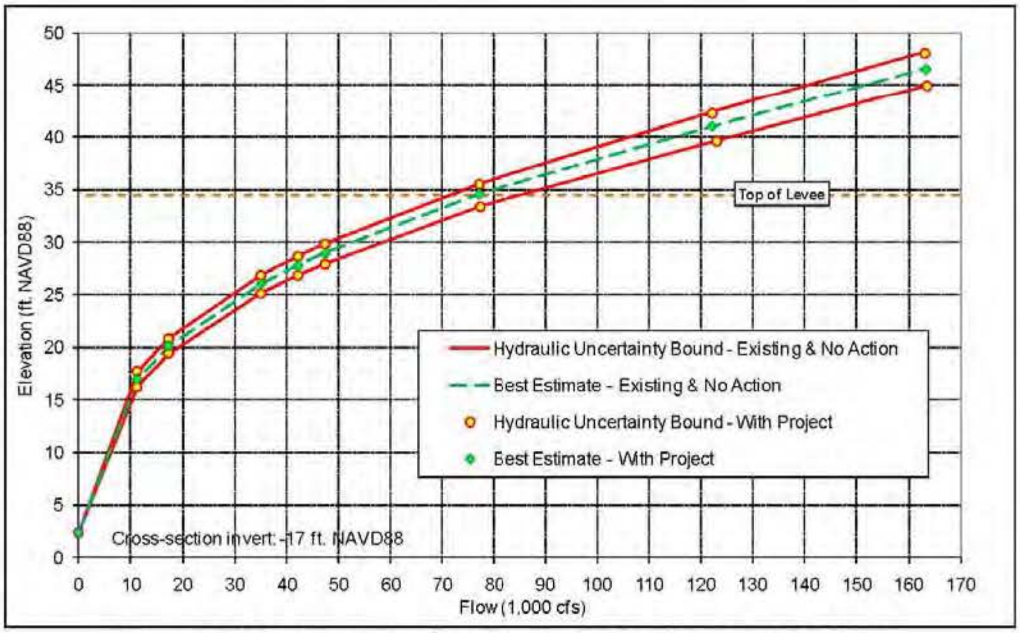

Figure C-1. Flow-Stage Transform Function, Index Point SJR1 (RM 63.24)

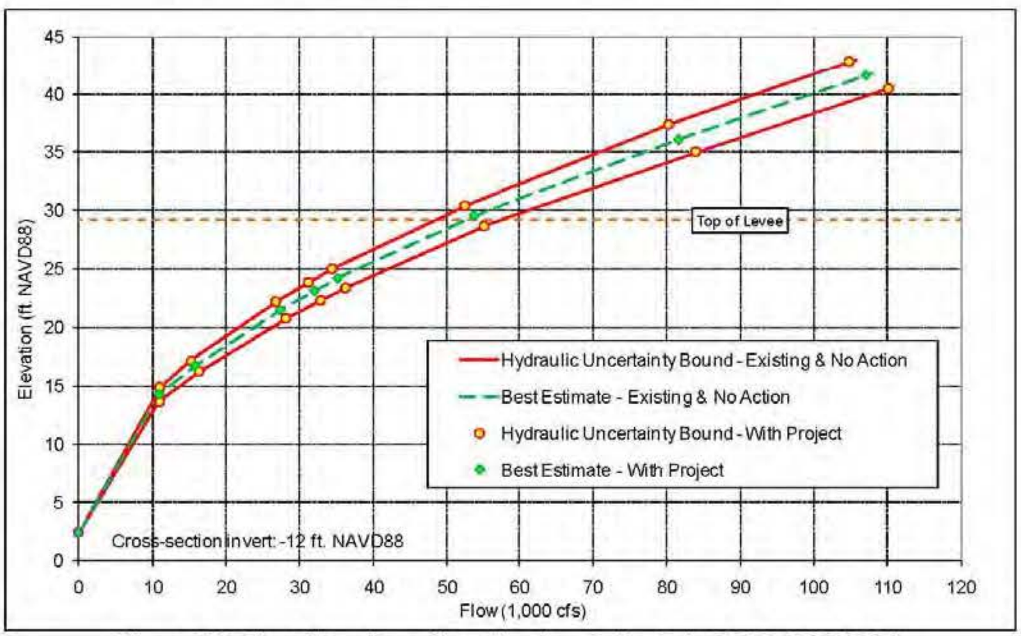

Figure C-2. Flow-Stage Transform Function, Index Point SJR2 (RM 57.81)

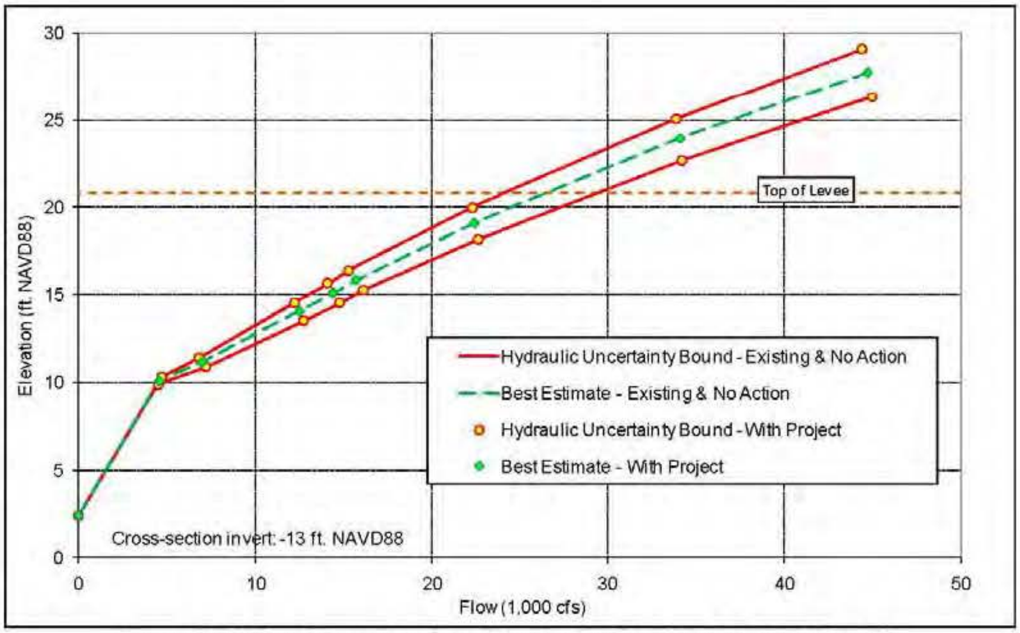

Figure C-3. Flow-Stage Transform Function, Index Point SJR3 (RM 47.80)

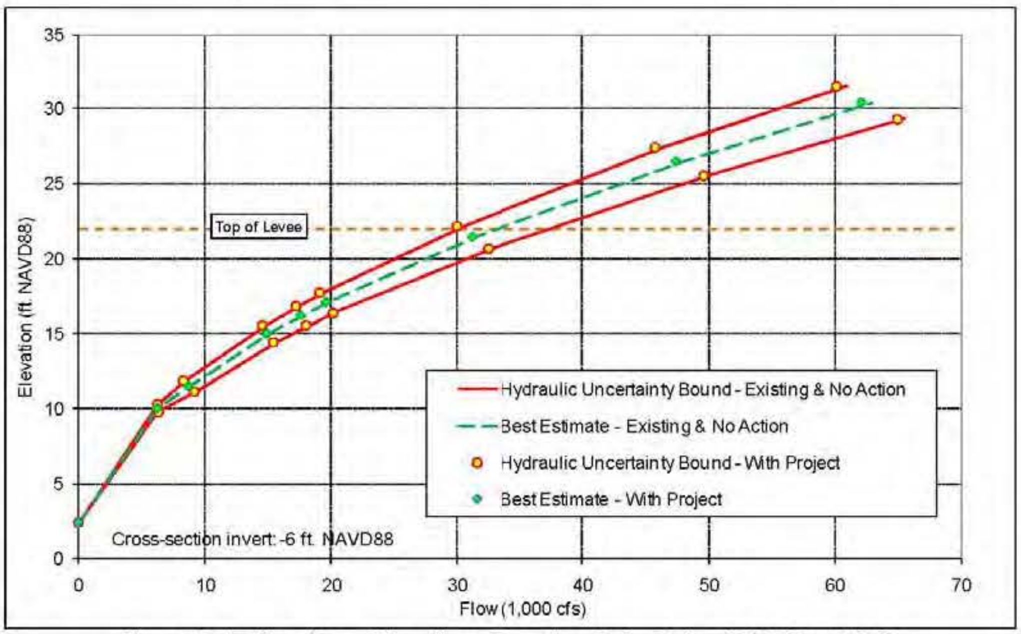

Figure C-4. Flow-Stage Transform Function, Index Point OR1 (Sta. 142.0)

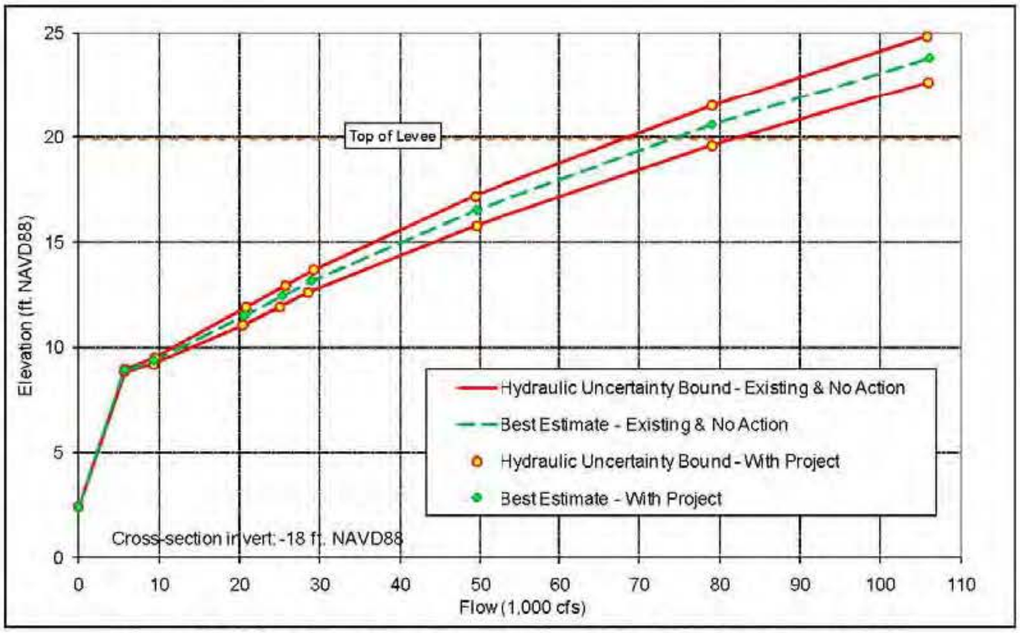

Figure C-5. Flow-Stage Transform Function, Index Point OR2 (Sta. -70.37)

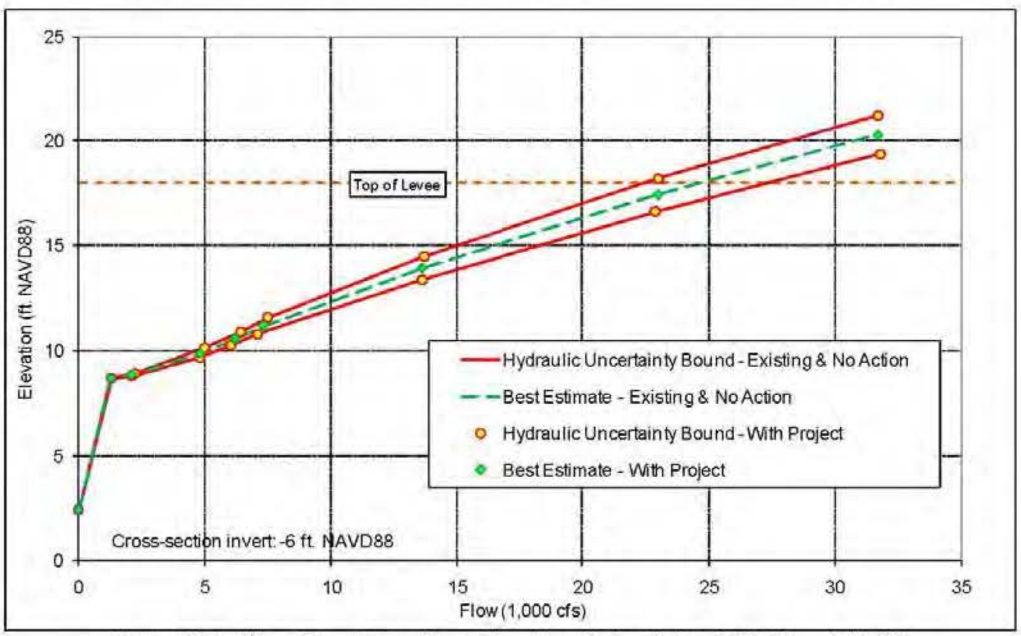

Figure C-6. Flow-Stage Transform Function, Index Point OR3 (Sta. -314.29)

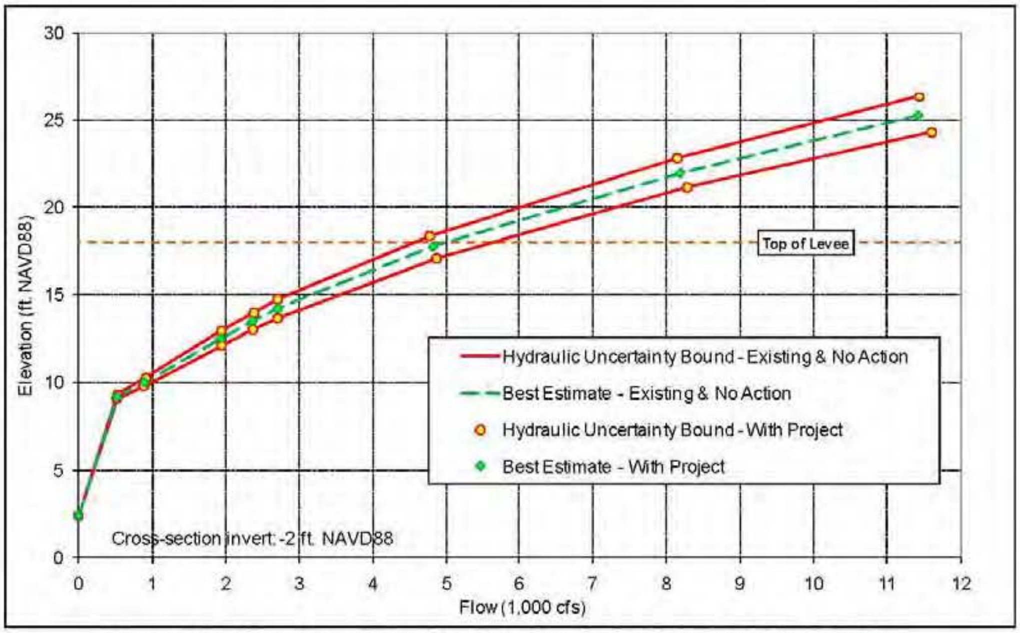

Figure C-7. Flow-Stage Transform Function, Index Point MR1 (RM 26.251)

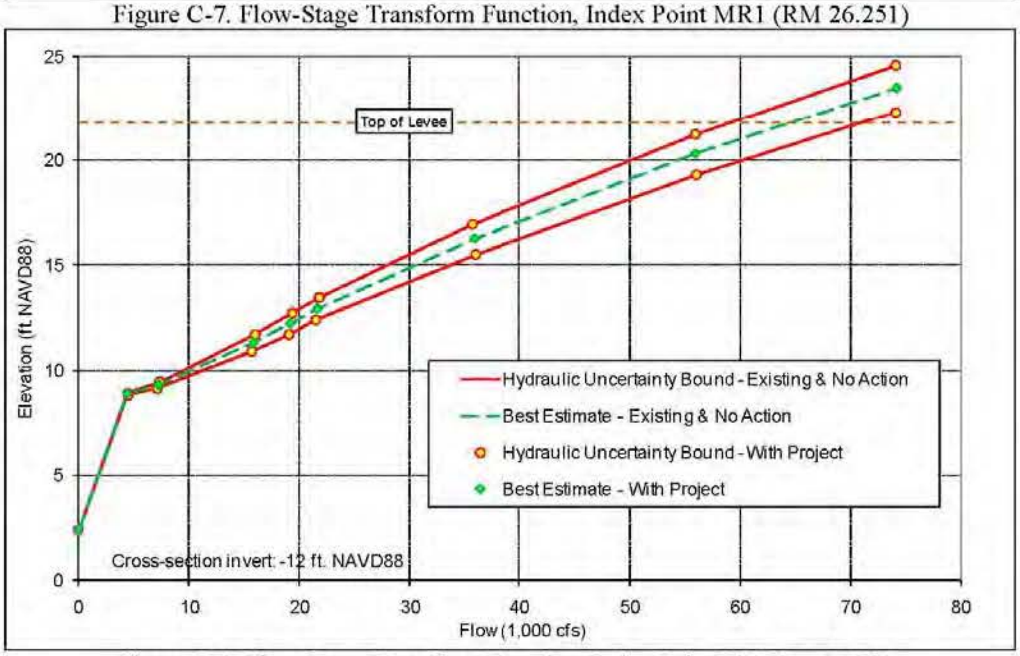

Figure C-8. Flow-Stage Transform Function, Index Point SS1 (Sta. 146.81)

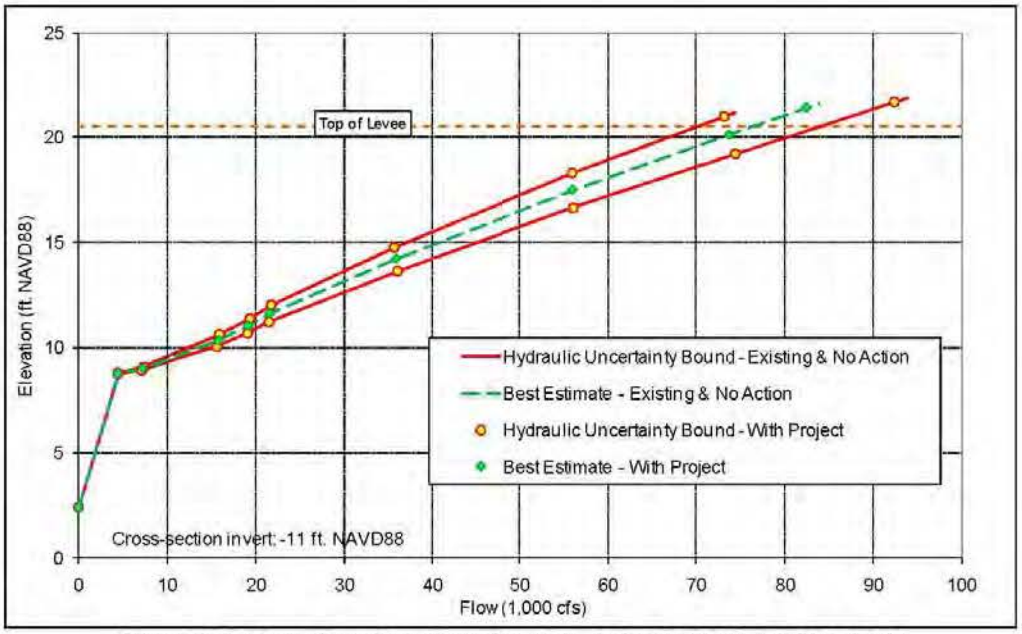

Figure C-9. Flow-Stage Transform Function, Index Point GLC1 (Sta. 23.6)

Appendix D

Plots of Inflow-Outflow Relationships

Figure D-1. Inflow-Outflow Relationship, Index Point SJR1 (RM 63.24)
Figure D-2. Inflow-Outflow Relationship, Index Point SJR2 (RM 57.81)
Figure D-3. Inflow-Outflow Relationship, Index Point SJR3 (RM 47.80)
Figure D-4. Inflow-Outflow Relationship, Index Point OR1 (Sta. 142.0)
Figure D-5. Inflow-Outflow Relationship, Index Point OR2 (Sta. -70.4)
Figure D-6. Inflow-Outflow Relationship, Index Point OR3 (Sta. -314.3)
Figure D-7. Inflow-Outflow Relationship, Index Point MR1 (RM 26.251)
Figure D-8. Inflow-Outflow Relationship, Index Point SS1 (Sta. 146.8)
Figure D-9. Inflow-Outflow Relationship, Index Point GLC1 (Sta. 23.6)

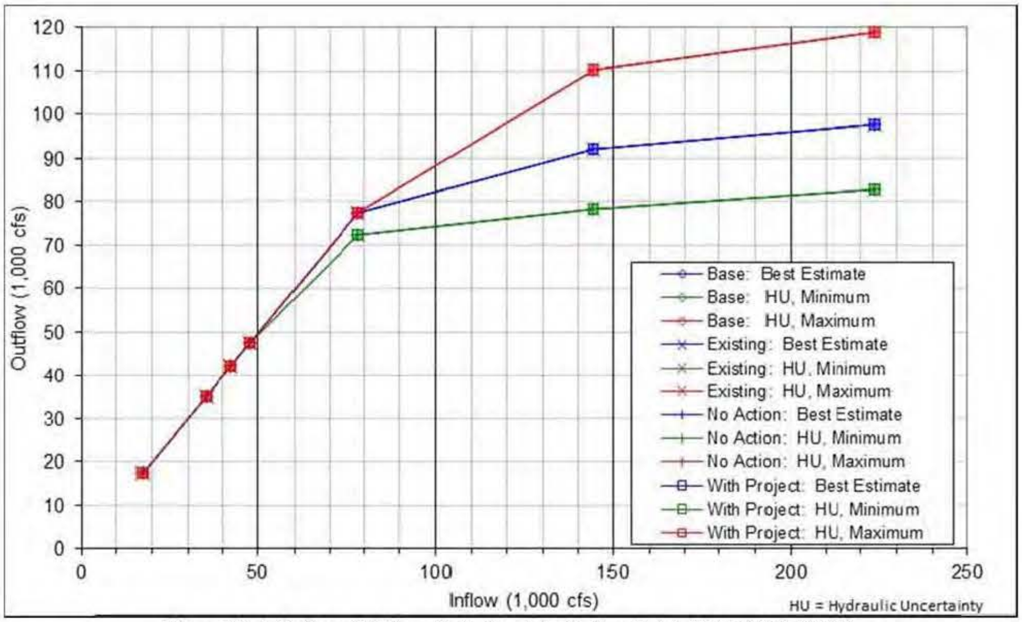

Figure D-1. Inflow-Outflow Relationship, Index Point SJR1 (RM 63.24)

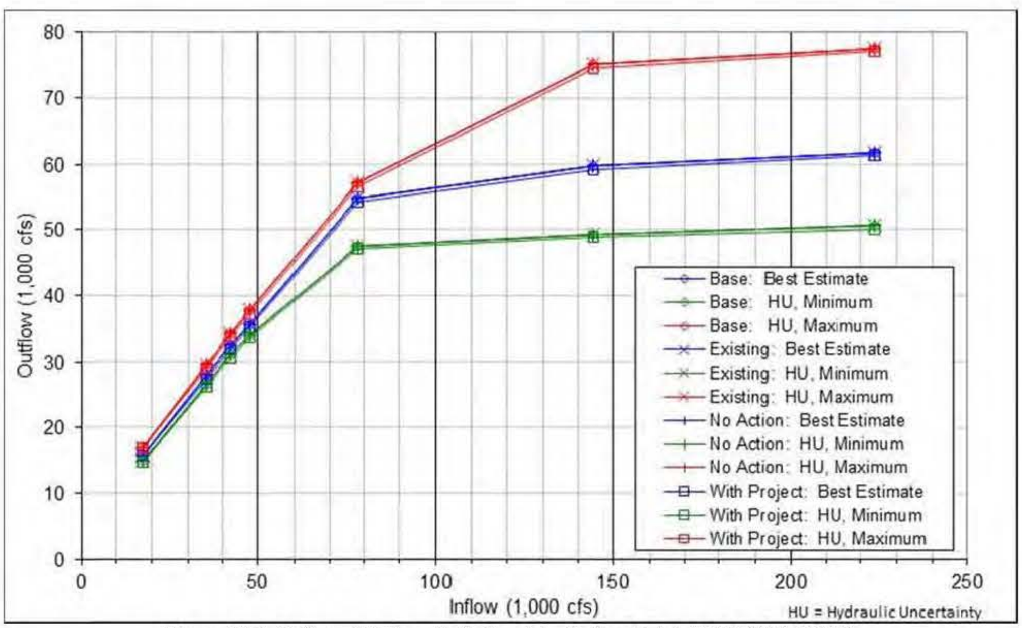

Figure D-2. Inflow-Outflow Relationship, Index Point SJR2 (RM 57.81)

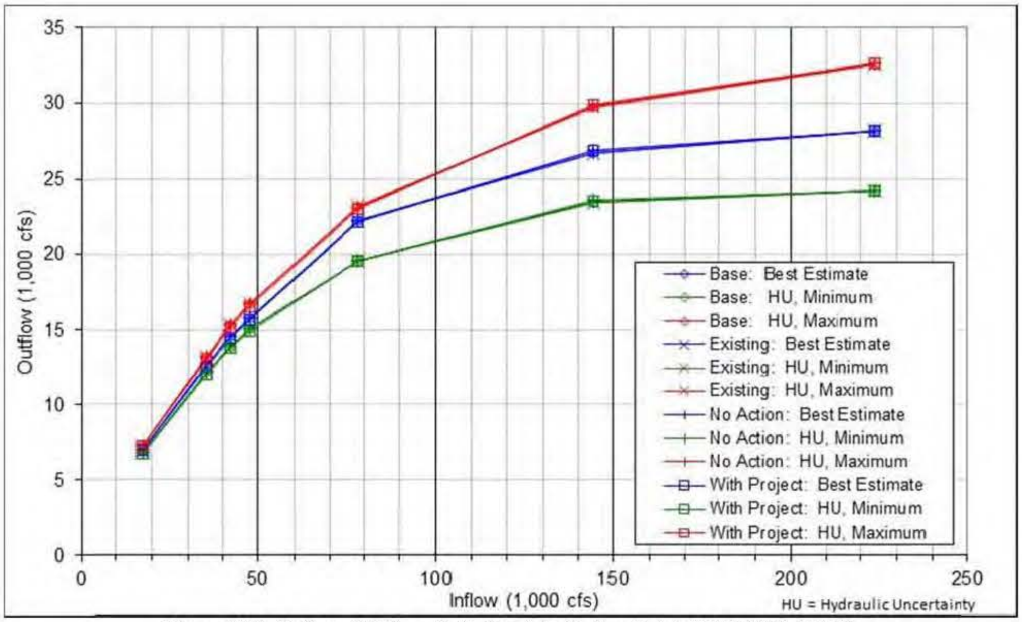

Figure D-3. Inflow-Outflow Relationship, Index Point SJR3 (RM 47.80)

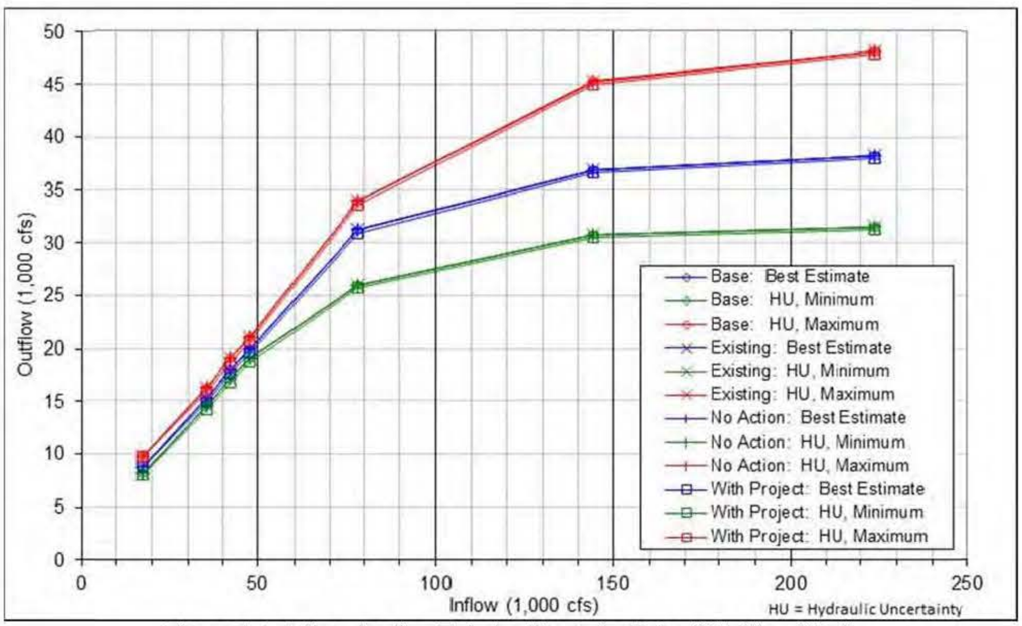

Figure D-4. Inflow-Outflow Relationship, Index Point OR1 (Sta. 142.0)

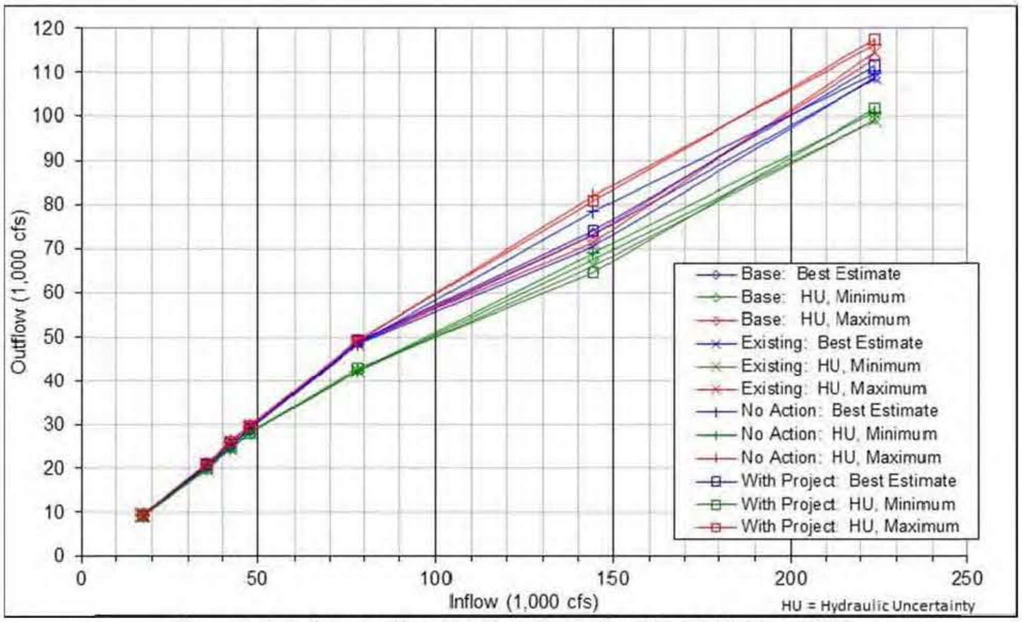

Figure D-5. Inflow-Outflow Relationship, Index Point OR2 (Sta. -70.4)

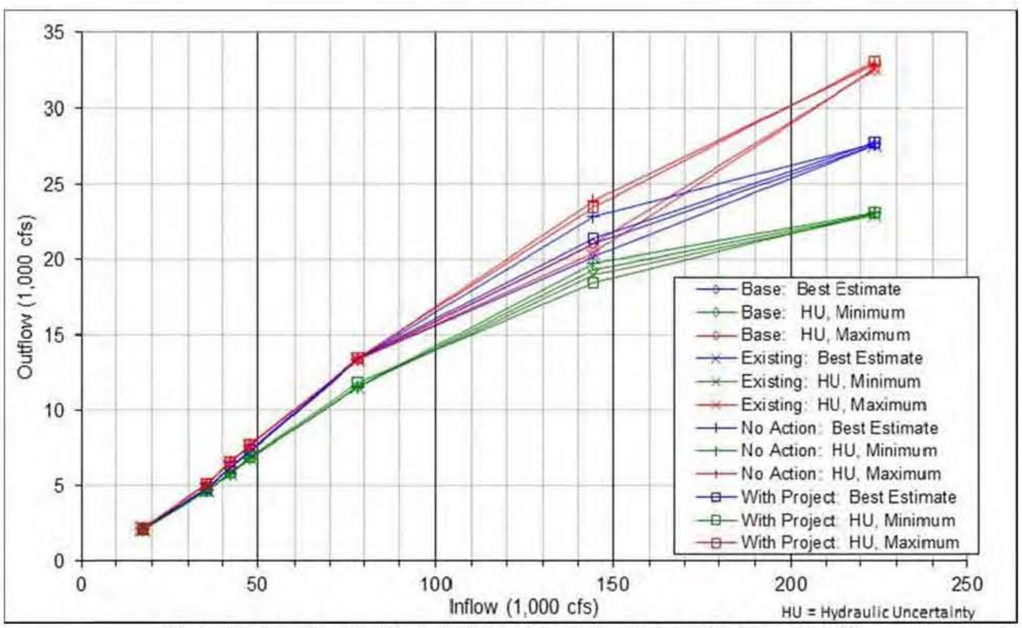

Figure D-6. Inflow-Outflow Relationship, Index Point OR3 (Sta. -314.3)

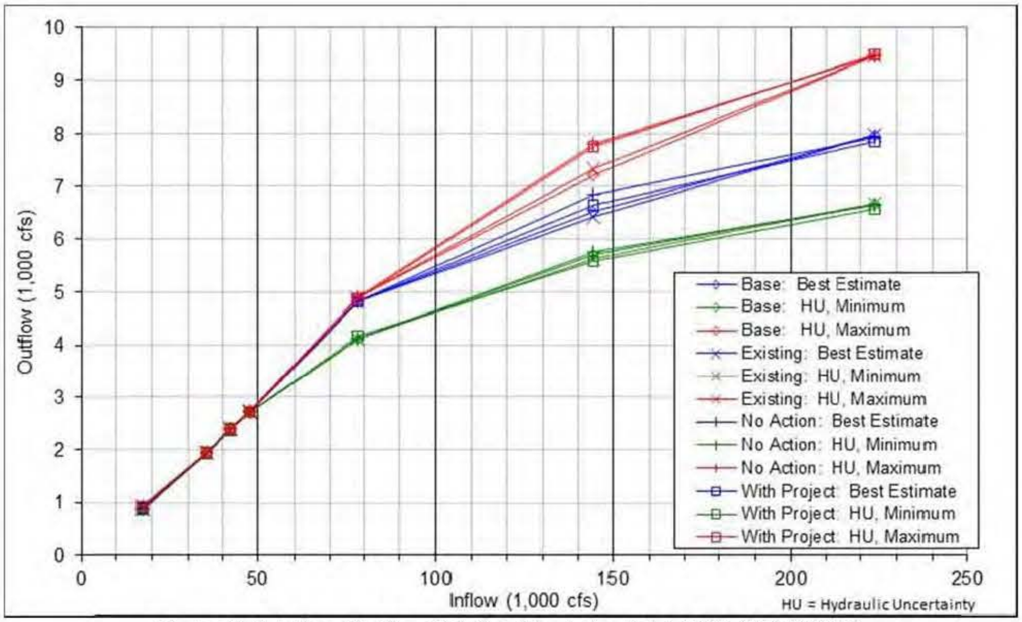

Figure D-7. Inflow-Outflow Relationship, Index Point MR1 (RM 26.251)

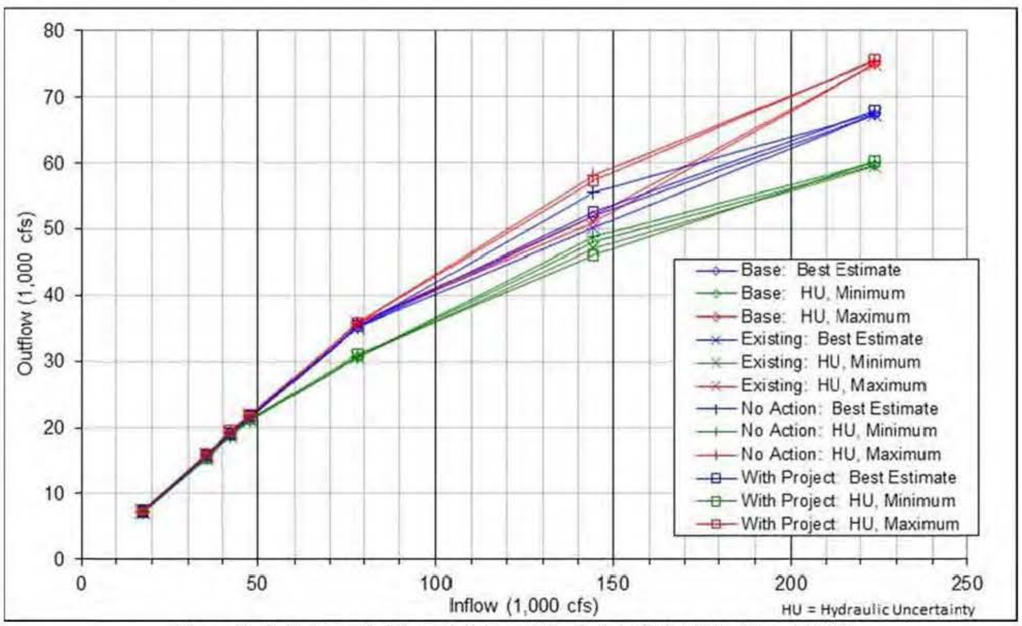

Figure D-8. Inflow-Outflow Relationship, Index Point SS1 (Sta. 146.8)

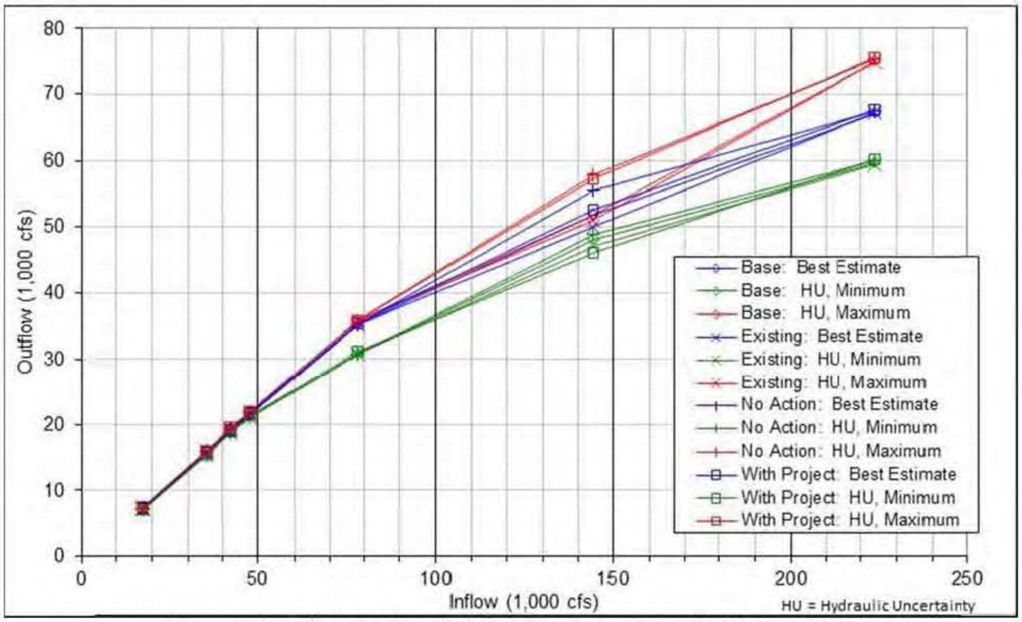

Figure D-9. Inflow-Outflow Relationship, Index Point GLC1 (Sta. 23.6)

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Appendix E

Plots of Stage-Frequency Relationships for PC1, PC2 and PC3

Figure E-1. Stage-Frequency Relationship, Index Point PC1 (Sta. 267.9)
Figure E-2. Stage-Frequency Relationship, Index Point PC2 (Sta. 239.3)
Figure E-3. Stage-Frequency Relationship, Index Point PC3 (Sta. 115.7)

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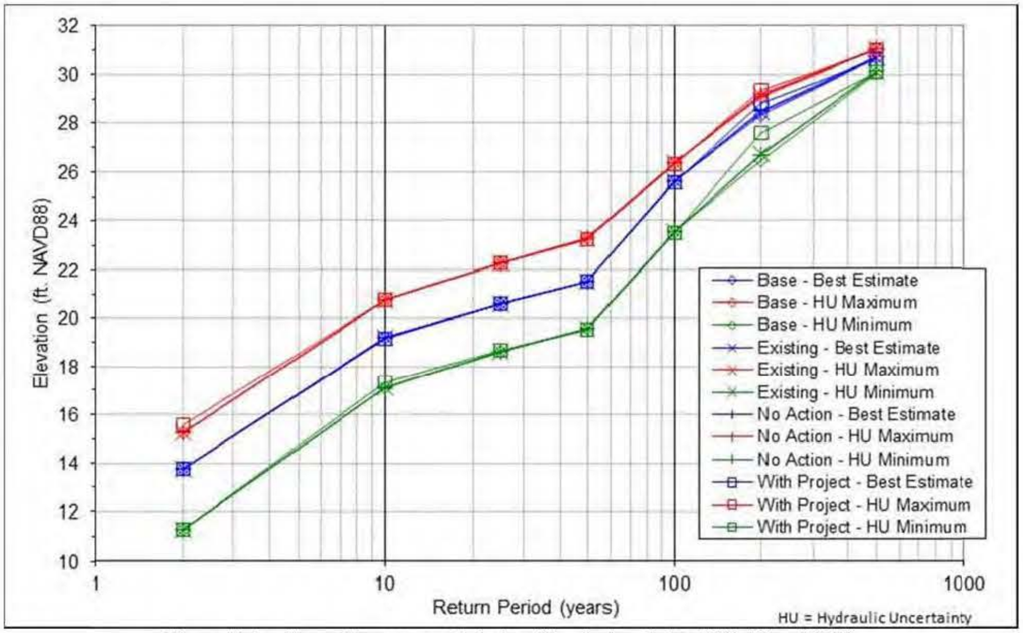

Figure E-1. Stage-Frequency Relationship, Index Point PC1 (Sta. 267.9)

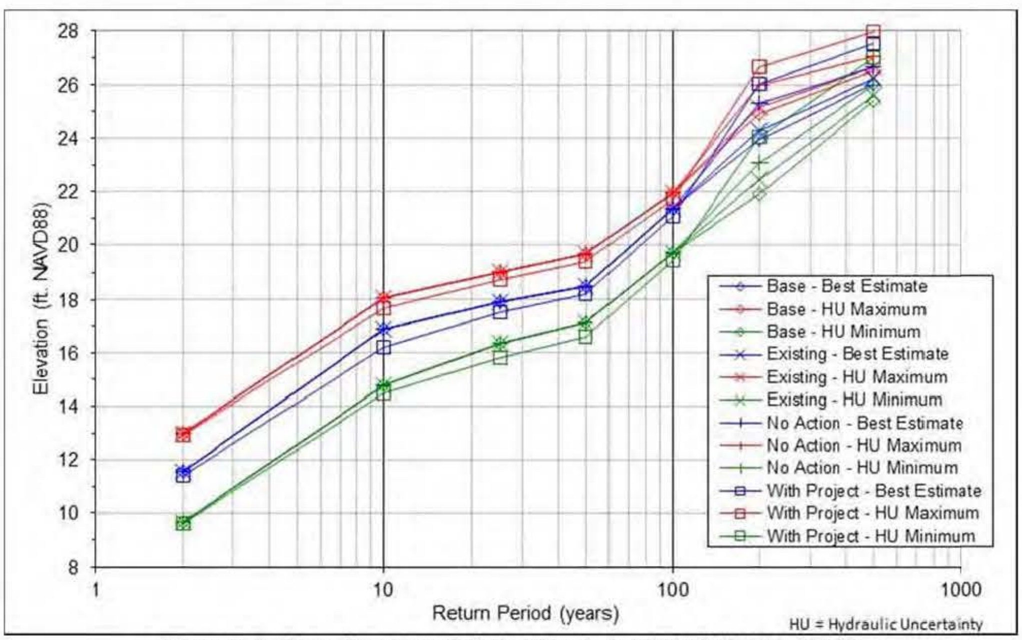

Figure E-2. Stage-Frequency Relationship, Index Point PC2 (Sta. 239.3)

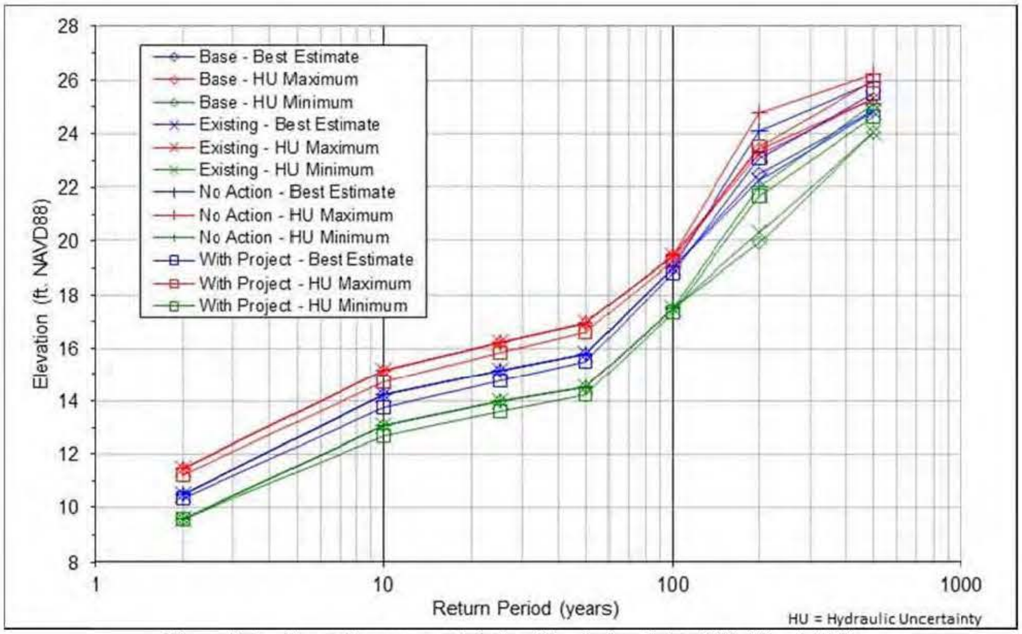

Figure E-3. Stage-Frequency Relationship, Index Point PC3 (Sta. 115.7)

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Appendix F

Quality Control Certification

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MBK ENGINEERS

Internal Quality Control Certification

MBK Engineers has completed an analysis to produce hydraulic parameters for the Conditional risk analysis for the River Islands at Lathrop project. The undersigned verifies that the work performed complies with established policy, principles and procedures, and reflects the use of justified and verified assumptions. The technical review included verification of project criteria; review of assumptions, methods, procedures, and material used in analyses; review of the appropriateness of data used; and reasonableness of the results, including whether the product meets the needs of River Islands at Lathrop consistent with State and federal laws and regulations.

All concerns resulting from internal technical review of the project have been addressed.

REGISTERED PROFESSIONAL ENGINEER
JOSEPH D. COUNTRYMAN
No. 20486
Exp. 9-30-11
CIVIL
STATE OF CALIFORNIA

Joseph D. Countryman, P.E., D.WRE
MBK Engineers

Aug 25, 2010
Date

Attachment C

Conditional Risk Analysis for the River Islands at Lathrop Project

Conditional risk analysis for the River Islands at Lathrop project

August 2010

Prepared for:
Califia

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CONSULTING
ENGINEERS

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Fx. 916.447.8780

Engineer's certification

I, Joanna J. Leu, hereby certify on August 25, 2010 that I am a professional engineer licensed in the state of California and that the accompanying report was prepared by me or under my supervision.

List of revisions

The purpose of this list is to track changes to this document. All submittals and revisions are listed below.

Date issued (1)	Page number (2)	Revisions since last submittal (3)
June 3, 2010		
August 25, 2010	Throughout report	Removed DRAFT from header.
		Incorporated comments from US Army Corps of Engineers (Corps).
		Added a base scenario and changed hydraulic input based on Corps comments on Draft report.

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Situation

Construction of the River Islands at Lathrop project (RILP) requires approval by the Chief of Engineers US Army Corps of Engineers (Corps) under 33 United States Code (U.S.C.) 408. Under the terms of 33 U.S.C. 408, any proposed levee modification to a federal project must not be harmful to the public interest and must not impair the usefulness of the levee.

In June 2009, the Corps' Hydrologic Engineering Center (HEC) published *Documentation and demonstration of a process for risk analysis of proposed modifications to Sacramento River flood control project levees,* which describes a process for system-wide risk analysis. This analysis is an application that follows HEC's system-wide risk procedure.

Tasks

We followed Corps risk and uncertainty analysis procedures to determine the impacts of RILP. Impacts of the RILP were evaluated by computing (1) conditional annual exceedence probability (C-AEP) and (2) conditional conditional non-exceedence probability, or conditional assurance (C-A). We define C-AEP and C-A as "conditional" because our computed annual exceedence values are conditioned on the following:

- Only a Sacramento and San Joaquin River Basins Comprehensive Study (Comp study) San Joaquin River mainstem at Vernalis (San Joaquin Centering) storm centering is used.
- No levees fail, they only overtop.

As part of the Comp study the Corps developed hydrologic input data for a UNET hydraulic computer model of the Sacramento River and San Joaquin River basins. The hydrology is based on hypothetical storm "centerings" using historical flood patterns to define the shape and magnitude of the flow contributions from each of the basins. The centerings were designed to stress specific locations in the river system. The San Joaquin Centering, designed to stress the system far beyond system design levels at Vernalis, was used in this analysis.

For the computations, we used procedures from the June 2009 report from the Corps' HEC, referred to herein as the *Documentation and demonstration* report, as guidance for system-wide risk analysis. In addition to the procedures described in the *Documentation and demonstration* report, the Corps' Sacramento District and Califia agreed to "ground rules" for this specific application. These ground rules are additional details and refinements; they are included in this report as Attachment B.

We evaluated 4 scenarios as described in Table 1 to assess the impacts of the RILP. The existing, no action, and with-project scenarios are shown in Figure 1, Figure 2, and Figure 3, respectively. The base scenario is similar to existing, however it does not include the project levee widened in Phase 1, and highlighted in yellow in the figures below.

Table 1. RILP evaluation scenarios: C-AEP and C-A calculated for each evaluation scenario

Evaluation scenario (1)	Description (2)
Base	• System prior to construction of the River Islands interior levees that form the Phase 1 protected area, shown in Figure 1.
Existing	• Base scenario plus existing Phase 1 protected area. The Phase 1 protected area, which covers about 25% of the study area, is protected by levees completed in 2006 and accredited by FEMA. • If levees do not meet the minimum project standard they were raised in the hydraulic model to meet the minimum authorized levee height (1955 profile). • Where existing top-of-levee heights exceed the authorized height, they are modeled as such.
No action	• Evaluates hydraulic impacts for flood protection which could be built without triggering a Federal action. This scenario consists of a FEMA accredited interior levee that does not come in contact with Federal Project levees or any waters of the U.S. Represents RILP that would be constructed absent federal permits.
With-project	• Includes RILP improvements as described in *Lower San Joaquin River HEC-RAS model, modeling of River Islands at Lathrop post-project conditions* (MBK 2006).

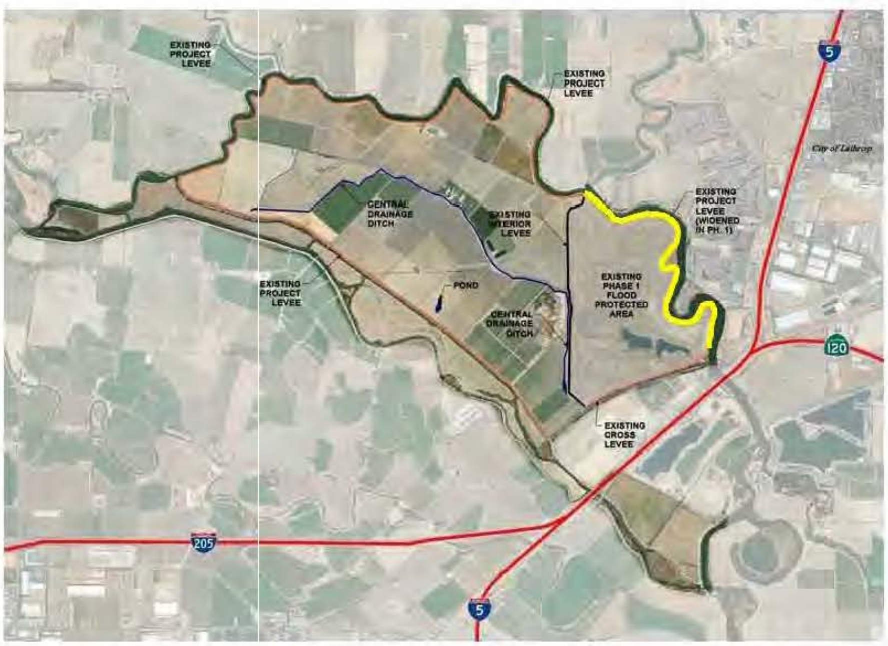

Figure 1. Features of existing scenario (courtesy MBK Engineers)

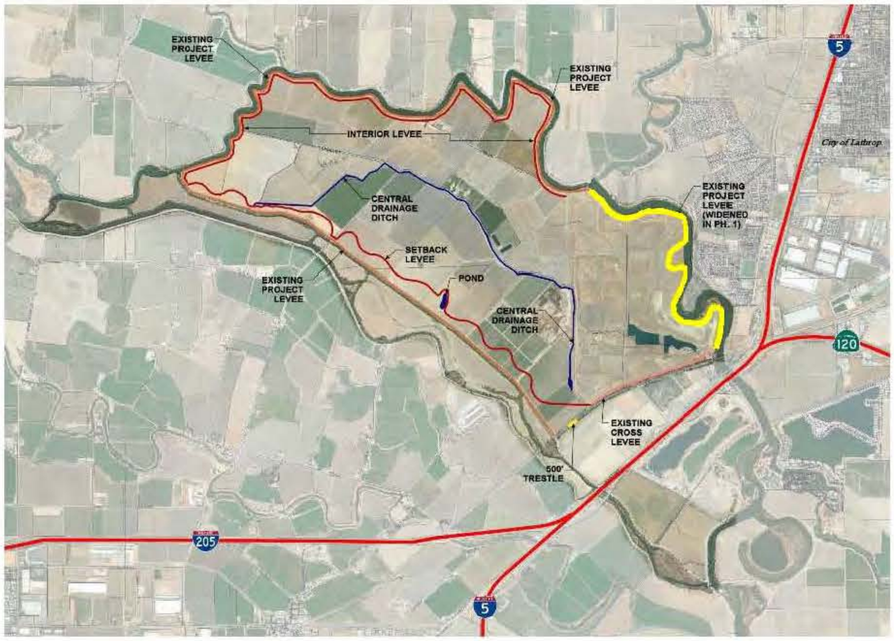

Figure 2. Features of no action scenario (courtesy MBK Engineers)

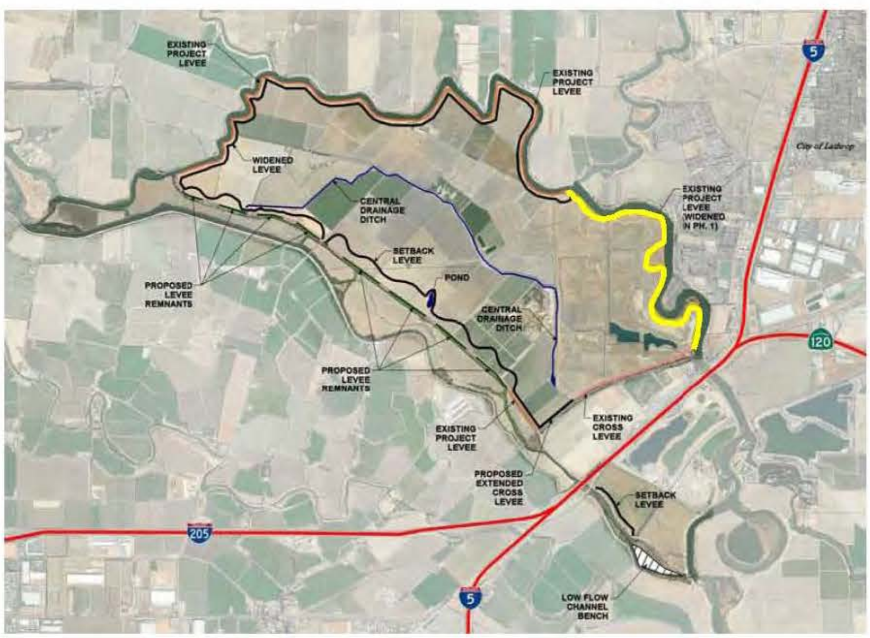

Figure 3. Features of with-project scenario (courtesy MBK Engineers)

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Actions

We computed and compared the C-AEP and C-A at 12 index locations for 4 evaluation scenarios as described above. We used the Corps' HEC-FDA version 1.2.5 software for the computations. Uncertainty model parameters for the system input flow-frequency functions are calculated using procedures consistent with the *Documentation and demonstration* report. Uncertainty model parameters for the inflow-outflow relationship and stage-flow transform use a normal distribution and are developed using methods described in the *Documentation and demonstration* report. The C-AEP values that we computed are valid for assessment of hydraulic impacts, but they are not intended to represent our opinion of the level of flood protection provided by the system at the index points. The C-A values are included here for reference as an additional statistic from the analysis. However, these values are not used for assessment of impacts.

All HEC-FDA hydraulic input was developed and provided by MBK Engineers. Their hydraulic analysis is described in detail under separate cover, *River Islands at Lathrop, Hydraulic analysis in support of risk based hydraulic impact analysis* (MBK 2010).

To complete the conditional risk analysis, we followed the step-by-step procedure outlined in the *Documentation and demonstration* report as described below. We have numbered the steps to our analysis to be consistent with Appendix A of that report.

1. Define analysis conditions.

1.a. Define study area.

The study area includes the San Joaquin River at Vernalis downstream to Stockton. It also includes tributaries Paradise Cut, Old River, Middle River, and Grant Line Canal as shown in Figure 4.

1.b. Define index locations.

We computed and compared the C-AEP and C-A at 12 index locations shown in Figure 4 and defined in Table 2. The index locations represent the levee low point in each of the specified reaches, based on the available top-of-levee profile data. We refer to index locations using the identifier as specified in column 4 of Table 2.

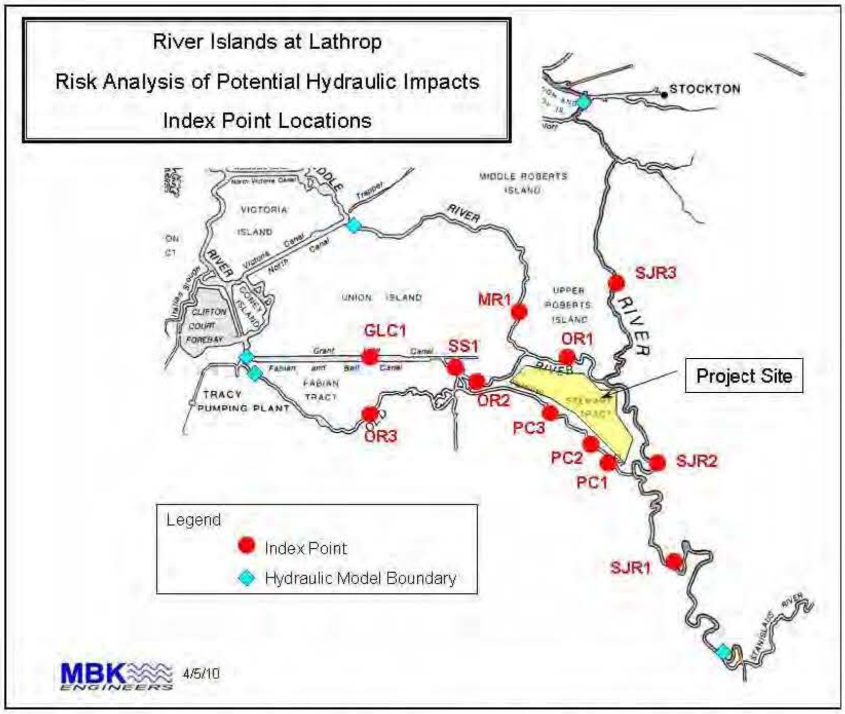

Figure 4. RILP study area with index point locations (courtesy MBK Engineers)

Table 2. RILP Index point locations for hydraulic impact conditional risk analysis

Index point		River mile	Identifier used for index point
River (1)	**Location (2)**	**(3)**	**(4)**
San Joaquin River	Vernalis to Paradise Cut	63.24	SJR1
	Paradise Cut to Old River	57.81	SJR2
	Old River to model boundary	47.80	SJR3
Paradise Cut	San Joaquin River to Old River	267.9	PC1
	San Joaquin River to Old River	239.3	PC2
	San Joaquin River to Old River	115.7	PC3
Old River	San Joaquin River to Middle River	142.0	OR1
	Middle River to Paradise Cut	172.06	OR2
	Paradise Cut to model boundary	-100.5	OR3
Middle River	Old River to model boundary	26.251	MR1
Salmon Slough	All	146.81	SS1
Grant Line Canal	All	23.6	GLC1

2. Identify analysis criteria.

2.a. Determine agency policy and guidance.

The risk analysis approach used here follows guidance in EM 1110-2-1619 (USACE 1996) and the *Documentation and demonstration* report. This conditional risk analysis was completed in accordance with 33 U.S.C. Section 408. The ground rules in Attachment B clarified or modified other guidance.

2.b. Define criteria for levee breach.

Based on the agreed upon ground rules, we assumed that levees will not fail. Rather, levees are allowed to overtop and spill water to the storage areas adjacent to the levees.

2.c. Define potential impact.

Potential impacts are assessed based upon changes in the C-AEP. At present, guidance has not been set differentiating between a hydraulic impact or changes in C-AEP due to model computational tolerances.

Steps 3 through 8 of the *Documentation and demonstration* procedure were developed and documented under separate cover by MBK Engineers (MBK 2010).

9. Evaluate alternative hydraulic conditions.

9.1. Evaluate baseline condition.

To evaluate the baseline condition as defined by step 9.1 of the *Documentation and demonstration* report, we analyzed the existing condition. As noted in Table 1, the existing condition is a without-project condition which includes currently constructed levees. Included in the existing condition is the Phase 1 widened levee.

To comply with the Corps' need to assess cumulative impacts, we have added a base scenario. The base scenario is an historical without-project condition. It is similar to the existing condition, minus the Phase 1 widened levee. Results from the base condition will be used to measure potential cumulative impacts.

MBK Engineers provided us flow-frequency curves, inflow-outflow relationships, and stage-flow transforms at each of the index points for all flood frequencies analyzed.

9.1.a. Develop hydrology at inflow locations.

MBK Engineers developed the hydrology at inflow locations. That is documented elsewhere (MBK 2010).

9.1.b. Define inflow discharge at index locations.

MBK Engineers provided us existing and base scenario flow-frequency curves at each of the index points for all flood frequencies analyzed. The flow-frequency curves include the maximum values from the summation of all the hydraulic model input flow hydrographs that occur upstream from each index point. This is consistent with the *Documentation and demonstration* procedure. We extrapolated an inflow discharge for the 0.999 and 0.001 exceedence probabilities as specified in the *Documentation and demonstration* report. Values were extrapolated by converting probabilities to standard normal deviates.

If the extrapolated value for 0.999 exceedence probability was negative, a value based on judgment was used. Flow-frequency curves for all index points are included in Attachment A.

3 index points are controlled by backwater conditions: Paradise Cut at RM 267.9 (PC1), Paradise Cut at RM 239.3 (PC2), and Paradise Cut at RM 115.7 (PC3). For these locations a stage-frequency function was provided by MBK Engineers. We extrapolated a stage for the 0.999 and 0.001 exceedence probabilities as specified in the *Documentation and demonstration* report.

9.1.c. Define inflow-outflow relationship at index locations.

MBK Engineers provided an inflow-outflow relationship at all index points for the existing and base scenarios. This relationship translates the system input flow to a regulated flow at each of the index points. Inflow-outflow relationships for all index points are included in Attachment A.

9.1.d. Adjust inflow-outflow relationship at index locations.

Adjustment to the inflow-outflow relationship was not needed.

9.1.e. Estimate stage-outflow discharge relationship at index locations.

MBK Engineers provided an existing stage-flow transform at each index point. This is a maximum flow verses maximum stage relationship. To develop this relationship, an infinite levees scenario was analyzed. Extending the levee height ensured that the stage-flow transform would encompass the top-of-levee elevation. Stage-flow transforms for all index points are included in Attachment A.

9.1.f. Adjust stage-outflow discharge relationship at index locations.

Adjustment to the stage-flow transform was not needed.

9.2. Evaluate proposed condition.

In addition to the existing and base conditions analyzed in section 9.1, MBK Engineers provided flow-frequency curves, inflow-outflow relationships, and stage-flow transforms for a with-project condition and a no action plan. The no action plan is not a "proposed condition" as step 9.2 is titled. Rather, the no action plan is a FEMA certifiable plan that is an alternative to construction of a federal levee. We evaluated the with-project and no action scenarios similar to step 9.1.

HEC-FDA requires that a stage-damage function be defined even if the user is only interested in evaluating project performance. We used placeholder values.

10. Describe uncertainty.

10.1. Describe uncertainty for the base condition.

10.1.a. Describe uncertainty at inflow discharge locations.

Uncertainty in inflow discharge was described at the index locations for the existing and base scenarios as defined below.

10.1.b. Estimate uncertainty of the inflow discharge at index locations.

We described the uncertainty about the system input flow-frequency functions using equivalent years of record, combining the uncertainty of the unregulated and regulated flow conditions. Our calculations are consistent with the *Documentation and demonstration* report. The length of period of record (N) is from the Comp study, Appendix B Computed and Adopted Statistics, San Joaquin River at Vernalis, where N is 82. We computed confidence limits and standard deviation for the unregulated and regulated flow conditions. We then computed a standard deviation for the combined flow condition. We used a trial-and-error procedure called out in the *Documentation and demonstration* report for the equivalent years of record computation, yielding a value equal to 77. The same equivalent years of record values were used for all index points and all evaluation scenarios.

For the 3 index points that used a stage-frequency function (PC1, PC2, and PC3), we described the uncertainty using equivalent years of record using the procedure as described above.

10.1.c. Estimate uncertainty in outflow discharge relationships at index locations.

MBK completed a sensitivity analysis to estimate the hydraulic input uncertainty. The sensitivity analysis included Manning's *n* values and levee weir coefficients. The Manning's *n* value uncertainty range was plus and minus 20 percent from the best estimate value. Uncertainty in levee weir coefficients and lengths ranged from 2.6 to 3.1 as defined in the *HEC-RAS hydraulic reference manual* (USACE 2010).

Results from the sensitivity analysis allowed us to describe the uncertainty in the HEC-FDA configuration file about the inflow-outflow relationship using a normal probability distribution. The standard deviation calculations are consistent with those in the *Documentation and demonstration* report. For each quantile, an upper and lower bound of outflow was found. We calculated a standard deviation of error in discharge by taking the difference in flows and dividing by 4, consistent with the *Documentation and demonstration* report and EM 1110-2-1619.

10.1.d. Estimate uncertainty of stage-outflow discharge relationship at index locations.

We described the uncertainty about the stage-flow transform using a normal probability distribution. The sensitivity analysis included uncertainties in Manning's *n* values and levee weir coefficients as described above. However, a separate set of hydraulic model simulations using an infinite levee assumption was required. This assumption restricts all flow to the channel and ensures the relationships extend above the top-of-levee elevation at each index point. The standard deviation was calculated by plotting the maximum stage and discharge values for all the simulations, taking the difference in maximum and minimum stages for a given outflow, and then dividing by 4.

10.2. Describe uncertainty in proposed condition.

Steps 10.1.a – d. were completed for the with-project and no action scenarios.

11. Analyze risk.

11.a. Develop HEC-FDA model for the base condition.

We created and configured an HEC-FDA database with version 1.2.5 of the computer program using the inputs described for the existing and base conditions.

For each index point, we specified the target elevation for which an expected C-AEP was to be computed. Here, we use the 1955 levee design elevations or existing top-of-levee elevations, whichever is greater. These target elevations were provided by MBK Engineers and are listed in Table 16 of Attachment A. Using HEC-FDA we computed project performance statistics, specifically the expected C-AEP and C-A.

11.b. Evaluate HEC-FDA results for the base condition.

HEC-FDA results for the existing and base conditions are presented in the Results section below.

11.c. Develop HEC-FDA model for the proposed condition.

With-project and no action conditions were configured in an HEC-FDA database for our computations.

The existing, base, no action, and with-project conditions use the same target elevations (top-of-levee elevations). To identify off-site impacts due to the RILP, we compare existing and with-project C-AEP using the same target elevation as a basis for comparison. The target must remain the same to compare the different scenarios.

11.d. Evaluate HEC-FDA results for the proposed conditions.

HEC-FDA results for the with-project and no action conditions are presented in the Results section below.

Results

Computed C-AEP values are shown in Table 3. The impact of RILP is the difference of the with-project and existing evaluation scenarios. Table 4 shows these. Table 5 shows the impact of the no action plan, the difference of the no action and existing evaluation scenarios. To determine the cumulative impacts of the with-project and no action plans, we compare their results with the base scenario. The difference of the with-project and base scenario is shown in Table 6 and the no-action plan potential cumulative impact is shown in Table 7.

C-A for the with-project, no action, existing and base scenarios are shown in Table 8, Table 9, Table 10, and Table 11, respectively.

As seen in column 2 of Table 4, which shows the impact of RILP, 3 of the 12 index points show no change in C-AEP, and 7 index points have a change in C-AEP of 0.0003 or less. Finding no appreciable difference in C-AEP is reasonable for these index points because at the target stage, there is no appreciable difference in the input functions for the existing and with-project scenarios.

Table 3. C-AEP results of conditional risk analysis with uncertainty

Index point (1)		**C-AEP[1] with-project (2)**	**C-AEP[1] no action (3)**	**C-AEP[1] existing (4)**	**C-AEP[1] base (5)**
San Joaquin River	SJR1	0.0093	0.0096	0.0096	0.0096
	SJR2	0.0093	0.0096	0.0096	0.0096
	SJR3	0.0043	0.0043	0.0042	0.0042
Paradise Cut	PC1	0.0088	0.0086	0.0086	0.0086
	PC2	0.0053	0.0045	0.0033	0.0030
	PC3	0.0030	0.0038	0.0023	0.0024
Old River	OR1	0.0069	0.0070	0.0070	0.0070
	OR2	0.0049	0.0054	0.0046	0.0048
	OR3	0.0031	0.0034	0.0029	0.0030
Middle River	MR1	0.0093	0.0093	0.0091	0.0092
Salmon Slough	SS1	0.0026	0.0026	0.0024	0.0024
Grant Line Canal	GLC1	0.0004	0.0002	0.0003	0.0003

1. C-AEP values are valid for assessment of hydraulic impacts, but they are not intended to represent the level of flood protection provided by the system at the index points.

Table 4. Change in C-AEP due to RILP

Index point (1)		**Change in C-AEP[1] (2)**
San Joaquin River	SJR1: Vernalis to Paradise Cut	-0.0003
	SJR2: Paradise Cut to Old River	-0.0003
	SJR3: Old River to model boundary	0.0001
Paradise Cut	PC1: San Joaquin River to Old River	0.0002
	PC2	0.0020
	PC3	0.0007
Old River	OR1: San Joaquin River to Middle River	-0.0001
	OR2: Middle River to Paradise Cut	0.0003
	OR3: Paradise Cut to model boundary	0.0002
Middle River	MR1: Old River to model boundary	0.0002
Salmon Slough	SS1: All	0.0002
Grant Line Canal	GLC1: All	0.0001[2]

1. Change in C-AEP is computed as with-project minus existing.
2. Computed C-AEP is beyond the 0.002 exceedence probability, so differences exceed precision of models.

As seen in column 2 of Table 5, which shows the impact of the no action scenario, 5 of the 12 index points show no change in C-AEP, and 5 index points have a change in C-AEP of 0.0008 or less. Finding no appreciable difference in C-AEP is reasonable for these index points because at the target stage, there is no appreciable difference in the input functions for the no action and existing scenarios.

Table 5. Change in C-AEP due to no action

Index point (1)		Change in C-AEP[1] (2)
San Joaquin River	SJR1: Vernalis to Paradise Cut	0.0000
	SJR2: Paradise Cut to Old River	0.0000
	SJR3: Old River to model boundary	0.0001
Paradise Cut	PC1: San Joaquin River to Old River	0.0000
	PC2	0.0012
	PC3	0.0015
Old River	OR1: San Joaquin River to Middle River	0.0000
	OR2: Middle River to Paradise Cut	0.0008
	OR3: Paradise Cut to model boundary	0.0005
Middle River	MR1: Old River to model boundary	0.0002
Salmon Slough	SS1: All	0.0002
Grant Line Canal	GLC1: All	-0.0001[2]

1. Change in C-AEP is computed as no action minus existing.
2. Computed C-AEP is beyond the 0.002 exceedence probability, so differences exceed precision of models.

We also compared the with-project and no action scenarios to the base condition. Recall the base and existing conditions are similar except the base does not include Phase 1 of the RILP. Therefore, the base condition is truly an historical without-project condition. Comparison of RILP and no action C-AEP results to the base scenario are shown in Table 6 and Table 7 below.

Table 6. Change in C-AEP due to RILP compared to base

Index point (1)		Change in C-AEP[1] (2)
San Joaquin River	SJR1: Vernalis to Paradise Cut	-0.0003
	SJR2: Paradise Cut to Old River	-0.0003
	SJR3: Old River to model boundary	0.0001
Paradise Cut	PC1: San Joaquin River to Old River	0.0002
	PC2	0.0023
	PC3	0.0006
Old River	OR1: San Joaquin River to Middle River	-0.0001
	OR2: Middle River to Paradise Cut	0.0001
	OR3: Paradise Cut to model boundary	0.0001
Middle River	MR1: Old River to model boundary	0.0001
Salmon Slough	SS1: All	0.0002
Grant Line Canal	GLC1: All	0.0001[2]

1. Change in C-AEP is computed as with-project minus base.
2. Computed C-AEP is beyond the 0.002 exceedence probability, so differences exceed precision of models.

Table 7. Change in C-AEP due to no action compared to base

Index point (1)		Change in C-AEP[1] (2)
San Joaquin River	SJR1: Vernalis to Paradise Cut	0.0000
	SJR2: Paradise Cut to Old River	0.0000
	SJR3: Old River to model boundary	0.0001
Paradise Cut	PC1: San Joaquin River to Old River	0.0000
	PC2	0.0015
	PC3	0.0014
Old River	OR1: San Joaquin River to Middle River	0.0000
	OR2: Middle River to Paradise Cut	0.0006
	OR3: Paradise Cut to model boundary	0.0004
Middle River	MR1: Old River to model boundary	0.0001
Salmon Slough	SS1: All	0.0002
Grant Line Canal	GLC1: All	-0.0001[2]

1. Change in C-AEP is computed as no action minus base.
2. Computed C-AEP is beyond the 0.002 exceedence probability, so differences exceed precision of models.

Table 8. Project performance parameters for with-project

Index point (1)	Target stage (ft) (2)	C-A[1] by event			
		p=0.10 (3)	p=0.01 (4)	p=0.004 (5)	p=0.002 (6)
SJR1	34.5	1.0000	0.6197	0.0494	0.0237
SJR2	29.2	1.0000	0.5162	0.1515	0.1090
SJR3	20.8	1.0000	0.9796	0.4283	0.2765
PC1	26.3	0.9997	0.7005	0.0194	0.0018
PC2	25.3	0.9997	0.9997	0.1741	0.0428
PC3	24.6	0.9997	0.9997	0.7450	0.2682
OR1	22.0	1.0000	0.8050	0.2044	0.1494
OR2	19.9	1.0000	0.9991	0.2610	0.0077
OR3	18.0	1.0000	0.9999	0.7401	0.2455
MR1	18.0	1.0000	0.6615	0.0165	0.0020
SS1	21.8	1.0000	1.0000	0.8823	0.3545
GLC1	20.5	1.0000	1.0000	0.9940	0.8285

1. C-A values are valid for assessment of hydraulic impacts, but they are not intended to represent the level of flood protection provided by the system at the index points.

Table 9. Project performance parameters for no action

Index point (1)	Target stage (ft) (2)	C-A[1] by event			
		p=0.10 (3)	p=0.01 (4)	p=0.004 (5)	p=0.002 (6)
SJR1	34.5	1.0000	0.5861	0.0434	0.0209
SJR2	29.2	1.0000	0.4817	0.1406	0.1031
SJR3	20.8	1.0000	0.9800	0.4309	0.2777
PC1	26.3	0.9997	0.6995	0.0283	0.0019
PC2	25.3	0.9997	0.9997	0.3626	0.0911
PC3	24.6	0.9997	0.9997	0.5134	0.1722
OR1	22.0	1.0000	0.7971	0.2029	0.1498
OR2	19.9	1.0000	0.9983	0.1600	0.0035
OR3	18.0	1.0000	0.9999	0.6369	0.2266
MR1	18.0	1.0000	0.6662	0.0103	0.0014
SS1	21.8	1.0000	1.0000	0.8421	0.3507
GLC1	20.5	1.0000	1.0000	0.9942	0.8705

1. C-A values are valid for assessment of hydraulic impacts, but they are not intended to represent the level of flood protection provided by the system at the index points.

Table 10. Project performance parameters for existing condition

Index point (1)	Target stage (ft) (2)	C-A[1] by event			
		p=0.10 (3)	p=0.01 (4)	p=0.004 (5)	p=0.002 (6)
SJR1	34.5	1.0000	0.5861	0.0434	0.0209
SJR2	29.2	1.0000	0.4817	0.1406	0.1033
SJR3	20.8	1.0000	0.9807	0.4498	0.2809
PC1	26.3	0.9997	0.6995	0.0317	0.0019
PC2	25.3	0.9997	0.9997	0.6992	0.1920
PC3	24.6	0.9997	0.9997	0.9237	0.4397
OR1	22.0	1.0000	0.7971	0.2029	0.1498
OR2	19.9	1.0000	0.9997	0.3486	0.0123
OR3	18.0	1.0000	1.0000	0.8134	0.2757
MR1	18.0	1.0000	0.6831	0.0210	0.0016
SS1	21.8	1.0000	1.0000	0.9206	0.3932
GLC1	20.5	1.0000	1.0000	0.9955	0.8300

1. C-A values are valid for assessment of hydraulic impacts, but they are not intended to represent the level of flood protection provided by the system at the index points.

Table 11. Project performance parameters for base condition

Index point (1)	Target stage (ft) (2)	C-A[1] by event			
		p=0.10 (3)	p=0.01 (4)	p=0.004 (5)	p=0.002 (6)
SJR1	34.5	1.0000	0.5861	0.0434	0.0209
SJR2	29.2	1.0000	0.4817	0.1406	0.1033
SJR3	20.8	1.0000	0.9809	0.4530	0.2816
PC1	26.3	0.9997	0.6991	0.0322	0.0020
PC2	25.3	0.9997	0.9997	0.8046	0.2188
PC3	24.6	0.9997	0.9997	0.8923	0.4389
OR1	22.0	1.0000	0.7972	0.2031	0.1499
OR2	19.9	1.0000	0.9996	0.2801	0.0079
OR3	18.0	1.0000	1.0000	0.7747	0.2624
MR1	18.0	1.0000	0.6776	0.0143	0.0013
SS1	21.8	1.0000	1.0000	0.9080	0.3890
GLC1	20.5	1.0000	1.0000	0.9955	0.8465

1. C-A values are valid for assessment of hydraulic impacts, but they are not intended to represent the level of flood protection provided by the system at the index points.

Table 12. Change in C-A due to RILP

Index point (1)	Target stage (ft) (2)	Change in C-A by event[1, 2]			
		p=0.10 (3)	p=0.01 (4)	p=0.004 (5)	p=0.002 (6)
SJR1	34.5	0.0000	0.0336	0.0060	0.0028
SJR2	29.2	0.0000	0.0345	0.0109	0.0057
SJR3	20.8	0.0000	-0.0011	-0.0215	-0.0044
PC1	26.3	0.0000	0.0010	-0.0123	-0.0001
PC2	25.3	0.0000	0.0000	-0.5251	-0.1492
PC3	24.6	0.0000	0.0000	-0.1787	-0.1715
OR1	22.0	0.0000	0.0079	0.0015	-0.0004
OR2	19.9	0.0000	-0.0006	-0.0876	-0.0046
OR3	18.0	0.0000	-0.0001	-0.0733	-0.0302
MR1	18.0	0.0000	-0.0216	-0.0045	0.0004
SS1	21.8	0.0000	0.0000	-0.0383	-0.0387
GLC1	20.5	0.0000	0.0000	-0.0015	-0.0015

1. Change in C-A is computed as with-project minus existing.
2. C-A values are valid for assessment of hydraulic impacts, but they are not intended to represent the level of flood protection provided by the system at the index points.

Table 13. Change in C-A due to no action

Index point (1)	Target stage (ft) (2)	Change in C-A by event[1, 2]			
		p=0.10 (3)	p=0.01 (4)	p=0.004 (5)	p=0.002 (6)
SJR1	34.5	0.0000	0.0000	0.0000	0.0000
SJR2	29.2	0.0000	0.0000	0.0000	-0.0002
SJR3	20.8	0.0000	-0.0007	-0.0189	-0.0032
PC1	26.3	0.0000	0.0000	-0.0034	0.0000
PC2	25.3	0.0000	0.0000	-0.3366	-0.1009
PC3	24.6	0.0000	0.0000	-0.4103	-0.2675
OR1	22.0	0.0000	0.0000	0.0000	0.0000
OR2	19.9	0.0000	-0.0014	-0.1886	-0.0088
OR3	18.0	0.0000	-0.0001	-0.1765	-0.0491
MR1	18.0	0.0000	-0.0169	-0.0107	-0.0002
SS1	21.8	0.0000	0.0000	-0.0785	-0.0425
GLC1	20.5	0.0000	0.0000	-0.0013	0.0405

1. Change in C-A is computed as no action minus existing.
2. C-A values are valid for assessment of hydraulic impacts, but they are not intended to represent the level of flood protection provided by the system at the index points.

Table 14. Change in C-A due to RILP compared to base

Index point (1)	Target stage (ft) (2)	Change in C-A by event[1, 2]			
		p=0.10 (3)	p=0.01 (4)	p=0.004 (5)	p=0.002 (6)
SJR1	34.5	0.0000	0.0336	0.0060	0.0028
SJR2	29.2	0.0000	0.0345	0.0109	0.0057
SJR3	20.8	0.0000	-0.0013	-0.0247	-0.0051
PC1	26.3	0.0000	0.0014	-0.0128	-0.0002
PC2	25.3	0.0000	0.0000	-0.6305	-0.1760
PC3	24.6	0.0000	0.0000	-0.1473	-0.1707
OR1	22.0	0.0000	0.0078	0.0013	-0.0005
OR2	19.9	0.0000	-0.0005	-0.0191	-0.0002
OR3	18.0	0.0000	-0.0001	-0.0346	-0.0169
MR1	18.0	0.0000	-0.0161	0.0022	0.0007
SS1	21.8	0.0000	0.0000	-0.0257	-0.0345
GLC1	20.5	0.0000	0.0000	-0.0015	-0.0180

1. Change in C-A is computed as with-project minus base.
2. C-A values are valid for assessment of hydraulic impacts, but they are not intended to represent the level of flood protection provided by the system at the index points.

Table 15. Change in C-A due to no action compared to base

Index point (1)	Target stage (ft) (2)	Change in C-A by event[1, 2]			
		p=0.10 (3)	p=0.01 (4)	p=0.004 (5)	p=0.002 (6)
SJR1	34.5	0.0000	0.0000	0.0000	0.0000
SJR2	29.2	0.0000	0.0000	0.0000	-0.0002
SJR3	20.8	0.0000	-0.0009	-0.0221	-0.0039
PC1	26.3	0.0000	0.0004	-0.0039	-0.0001
PC2	25.3	0.0000	0.0000	-0.4420	-0.1277
PC3	24.6	0.0000	0.0000	-0.3789	-0.2667
OR1	22.0	0.0000	-0.0001	-0.0002	-0.0001
OR2	19.9	0.0000	-0.0013	-0.1201	-0.0044
OR3	18.0	0.0000	-0.0001	-0.1378	-0.0358
MR1	18.0	0.0000	-0.0114	-0.0040	0.0001
SS1	21.8	0.0000	0.0000	-0.0659	-0.0383
GLC1	20.5	0.0000	0.0000	-0.0013	0.0240

1. Change in C-A is computed as no action minus base.
2. C-A values are valid for assessment of hydraulic impacts, but they are not intended to represent the level of flood protection provided by the system at the index points.

Attachment A. Analysis inputs

The following tables provide function values and uncertainty model parameters for the index points.

Table 16. Target elevations for project performance calculations

Index point (1)		Target elevation[1] (ft NAVD88) (2)	Top-of-levee elevation source (3)
San Joaquin River	Vernalis to Paradise Cut	34.5	CA levee database
	Paradise Cut to Old River	29.2	CA levee database
	Old River to model boundary	20.8	CA levee database
Paradise Cut	San Joaquin River to Old River	26.3	CA levee database
	PC2	25.3	CA levee database
	PC3	24.6	CA levee database
Old River	San Joaquin River to Middle River	22.0	CA levee database
	Middle River to Paradise Cut	19.9	CA levee database
	Paradise Cut to model boundary	18.0	DWR bathymetry survey, 1997
Middle River	Old River to model boundary	18.0	Comprehensive study topo
Salmon Slough	All	21.8	CA levee database
Grant Line Canal	All	20.5	DWR bathymetry survey, 1997

1. Target elevations converted from vertical datum NGVD29 to NAVD88 based on relationship of NAVD88 elevation = NGVD29 elevation + 2.4 ft as per Carlson, Barbee, Gibson survey.

Index point San Joaquin River: Vernalis to Paradise Cut RM 63.24 (SJR1) HEC-FDA input

Table 17. Inflow-outflow relationship and uncertainty model parameters for index point SJR1

		Outflow (cfs)							
		Existing		Base		No action		With-project	
Exceedence probability (1)	Inflow (cfs) (2)	Flow (3)	Standard deviation (4)	Flow (5)	Standard deviation (6)	Flow (7)	Standard deviation (8)	Flow (9)	Standard deviation (10)
0.999	0								
0.5	17,320	17,300	8	17,300	8	17,300	8	17,300	5
0.1	35,110	35,090	3	35,090	3	35,090	3	35,090	3
0.04	42,310	42,260	5	42,260	5	42,260	5	42,260	5
0.02	47,660	47,470	13	47,470	13	47,470	13	47,470	10
0.01	78,100	77,330	1,290	77,330	1,290	77,330	1,290	77,300	1,278
0.005	144,390	91,950	7,965	91,950	7,965	91,950	7,965	92,000	7,958
0.002	223,990	97,680	9,008	97,680	9,008	97,680	9,008	97,750	9,000
0.001	279,800[1]	101,700[1]	9,725[1]	101,700[1]	9,725[1]	101,700[1]	9,725[1]	101,800[1]	9,725[1]

1. Values shown are extrapolated.

Table 18. Stage-flow transform and uncertainty model parameters for index point SJR1

Existing, base, & no action			With-project		
Flow (cfs) (1)	Stage (ft NAVD88) (2)	Standard deviation (ft NAVD88) (3)	Flow (cfs) (4)	Stage (ft NAVD88) (5)	Standard deviation (ft NAVD88) (6)
0	0.0	0.7[1]	0	0.0	0.7[1]
11,260	17.0	0.7[1]	11,260	17.0	0.7[1]
17,300	20.1	0.7[1]	17,300	20.1	0.7[1]
35,100	26.1	0.7[1]	35,100	26.0	0.7[1]
42,300	27.8	0.7[1]	42,300	27.8	0.7[1]
47,500	29.0	0.7[1]	47,500	28.9	0.7[1]
77,100	34.6	0.7[1]	77,100	34.5	0.7[1]
122,200	41.1	0.7[1]	122,200	41.0	0.7[1]
163,300	46.6	0.8	163,400	46.5	0.8

1. A minimum SD of 0.7 was used consistent with guidance on risk analysis in EM 1110-2-1619 (USACE 1996).

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Index point San Joaquin River: Paradise Cut to Old River RM 57.81 (SJR2) HEC-FDA input

Table 19. Inflow-outflow relationship and uncertainty model parameters for index point SJR2

		Outflow (cfs)							
		Existing		Base		No action		With-project	
Exceedence probability (1)	Inflow (cfs) (2)	Flow (3)	Standard deviation (4)	Flow (5)	Standard deviation (6)	Flow (7)	Standard deviation (8)	Flow (9)	Standard deviation (10)
0.999	0								
0.5	17,320	15,750	488	15,750	488	15,750	488	15,750	558
0.1	35,110	27,870	703	27,870	703	27,870	703	27,370	693
0.04	42,310	32,490	818	32,490	818	32,490	818	31,990	813
0.02	47,660	35,740	903	35,740	903	35,740	903	35,240	908
0.01	78,100	54,830	2,408	54,830	2,408	54,830	2,408	54,120	2,410
0.005	144,390	59,700	6,438	59,700	6,438	59,700	6,438	59,180	6,463
0.002	223,990	61,810	6,743	61,810	6,743	61,810	6,735	61,410	6,758
0.001	279,800[1]	63,300[1]	6,950[1]	63,300[1]	6,950[1]	63,300[1]	6,950[1]	63,000[1]	6,975[1]

1. Values shown are extrapolated.

Table 20. Stage-flow transform and uncertainty model parameters for index point SJR2

Existing, base, & no action			With-project		
Flow (cfs) (1)	Stage (ft NAVD88) (2)	Standard deviation (ft NAVD88) (3)	Flow (cfs) (4)	Stage (ft NAVD88) (5)	Standard deviation (ft NAVD88) (6)
0	0.0	0.7[1]	0	0.0	0.7[1]
10,970	14.2	0.7[1]	10,990	14.2	0.7[1]
15,800	16.7	0.7[1]	15,800	16.7	0.7[1]
27,900	21.7	0.7[1]	27,400	21.5	0.7[1]
32,500	23.3	0.7[1]	32,000	23.1	0.7[1]
35,700	24.4	0.7[1]	35,200	24.2	0.7[1]
54,300	29.7	0.7[1]	53,700	29.6	0.7[1]
82,400	36.3	0.8	81,600	36.1	0.8
107,900	41.8	0.9	107,000	41.6	0.9

1. A minimum SD of 0.7 was used consistent with guidance on risk analysis in EM 1110-2-1619 (USACE 1996).

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Index point San Joaquin River: Old River to model boundary RM 47.80 (SJR3) HEC-FDA input

Table 21. Inflow-outflow relationship and uncertainty model parameters for index point SJR3

		Outflow (cfs)							
		Existing		Base		No action		With-project	
Exceedence probability (1)	Inflow (cfs) (2)	Flow (3)	Standard deviation (4)	Flow (5)	Standard deviation (6)	Flow (7)	Standard deviation (8)	Flow (9)	Standard deviation (10)
0.999	0								
0.5	17,320	7,000	115	7,000	115	7,000	115	7,010	140
0.1	35,110	12,630	260	12,630	260	12,630	260	12,470	253
0.04	42,310	14,560	350	14,560	350	14,560	350	14,420	343
0.02	47,660	15,780	408	15,780	408	15,780	408	15,660	403
0.01	78,100	22,180	895	22,180	895	22,180	893	22,140	865
0.005	144,390	26,710	1,580	26,680	1,578	26,870	1,585	26,880	1,588
0.002	223,990	28,150	2,088	28,150	2,090	28,190	2,110	28,190	2,100
0.001	279,800[1]	29,200[1]	2,450[1]	29,200[1]	2,450[1]	29,100[1]	2,475[1]	29,100[1]	2,450[1]

1. Values shown are extrapolated.

Table 22. Stage-flow transform and uncertainty model parameters for index point SJR3

Existing, base, & no action			With-project		
Flow (cfs) (1)	Stage (ft NAVD88) (2)	Standard deviation (ft NAVD88) (3)	Flow (cfs) (4)	Stage (ft NAVD88) (5)	Standard deviation (ft NAVD88) (6)
0	0.0	0.7[1]	0	0.0	0.7[1]
4,560	10.1	0.7[1]	4,570	10.1	0.7[1]
7,000	11.1	0.7[1]	7,000	11.1	0.7[1]
12,600	14.1	0.7[1]	12,500	14.0	0.7[1]
14,600	15.2	0.7[1]	14,400	15.1	0.7[1]
15,800	15.9	0.7[1]	15,700	15.8	0.7[1]
22,500	19.1	0.7[1]	22,400	19.1	0.7[1]
34,200	24.0	0.7[1]	34,100	23.9	0.7[1]
44,900	27.8	0.7[1]	44,700	27.7	0.7[1]

1. A minimum SD of 0.7 was used consistent with guidance on risk analysis in EM 1110-2-1619 (USACE 1996).

Index point Paradise Cut: San Joaquin River to Old River RM 267.9 (PC1) HEC-FDA input

Table 23. Stage-frequency functions for index point PC1

Exceedence probability (1)	Stage (ft NAVD88)			
	Existing (2)	Base (3)	No action (4)	With-project (5)
0.999	0	0	0	0
0.5	13.8	13.8	13.8	13.8
0.1	19.2	19.2	19.2	19.2
0.04	20.6	20.6	20.6	20.6
0.02	21.5	21.5	21.5	21.5
0.01	25.6	25.6	25.6	25.6
0.005	28.4	28.4	28.5	28.8
0.002	30.7	30.7	30.7	30.7
0.001	32.3[1]	32.4[1]	32.3[1]	32.0[1]

1. Values are extrapolated.

Index point Paradise Cut: San Joaquin River to Old River RM 239.3 (PC2) HEC-FDA input

Table 24. Stage-frequency functions for index point PC2

Exceedence probability (1)	Stage (ft NAVD88)			
	Existing (2)	Base (3)	No action (4)	With-project (5)
0.999	0	0	0	0
0.5	11.6	11.6	11.6	11.4
0.1	16.9	16.9	16.9	16.2
0.04	17.9	17.9	17.9	17.5
0.02	18.5	18.5	18.5	18.2
0.01	21.4	21.4	21.4	21.1
0.005	24.3	23.9	25.3	26.1
0.002	26.2	26.1	26.7	27.5
0.001	27.6[1]	27.6[1]	27.6[1]	28.6[1]

1. Values are extrapolated.

Index point Paradise Cut: San Joaquin River to Old River RM 115.7 (PC3) HEC-FDA input

Table 25. Stage-frequency functions for index point PC3

Exceedence probability (1)	Stage (ft NAVD88)			
	Existing (2)	Base (3)	No action (4)	With-project (5)
0.999	0	0	0	0
0.5	10.5	10.5	10.5	10.4
0.1	14.2	14.2	14.2	13.8
0.04	15.1	15.1	15.1	14.8
0.02	15.8	15.8	15.8	15.5
0.01	19.0	19.0	19.0	18.8
0.005	22.2	22.5	24.1	23.1
0.002	24.8	24.8	25.9	25.5
0.001	26.7[1]	26.5[1]	27.2[1]	27.2[1]

1. Values are extrapolated.

Index point Old River: San Joaquin River to Middle River RM 142.0 (OR1) HEC-FDA input

Table 26. Inflow-outflow relationship and uncertainty model parameters for index point OR1

		Outflow (cfs)							
		Existing		Base		No action		With-project	
Exceedence probability (1)	Inflow (cfs) (2)	Flow (3)	Standard deviation (4)	Flow (5)	Standard deviation (6)	Flow (7)	Standard deviation (8)	Flow (9)	Standard deviation (10)
0.999	0								
0.5	17,320	8,750	373	8,750	373	8,750	373	8,740	420
0.1	35,110	15,250	443	15,250	443	15,250	443	14,890	440
0.04	42,310	17,930	470	17,930	470	17,930	470	17,560	470
0.02	47,660	19,940	500	19,940	500	19,940	500	19,560	508
0.01	78,100	31,220	2,008	31,220	2,008	31,220	2,008	30,910	1,960
0.005	144,390	36,930	3,640	36,930	3,643	36,930	3,640	36,640	3,640
0.002	223,990	38,240	4,135	38,240	4,138	38,240	4,133	38,030	4,155
0.001	279,800[1]	39,200[1]	4,475[1]	39,200[1]	4,475[1]	39,200[1]	4,475[1]	39,000[1]	4,525[1]

1. Values shown are extrapolated.

Table 27. Stage-flow transform and uncertainty model parameters for index point OR1

Existing, base, & no action			With-project		
Flow (cfs) (1)	Stage (ft NAVD88) (2)	Standard deviation (ft NAVD88) (3)	Flow (cfs) (4)	Stage (ft NAVD88) (5)	Standard deviation (ft NAVD88) (6)
0	0.0	0.7[1]	0	0.0	0.7[1]
6,250	10.0	0.7[1]	6,250	10.0	0.7[1]
8,800	11.5	0.7[1]	8,700	11.5	0.7[1]
15,200	15.0	0.7[1]	14,900	15.0	0.7[1]
17,900	16.3	0.7[1]	17,600	16.2	0.7[1]
19,900	17.2	0.7[1]	19,600	17.1	0.7[1]
31,700	21.5	0.7[1]	31,200	21.4	0.7[1]
48,000	26.5	0.7[1]	47,400	26.5	0.7[1]
62,900	30.4	0.8	62,100	30.4	0.8

1. A minimum SD of 0.7 was used consistent with guidance on risk analysis in EM 1110-2-1619 (USACE 1996).

Index point Old River: Middle River to Paradise Cut RM 172.06 (OR2) HEC-FDA input

Table 28. Inflow-outflow relationship and uncertainty model parameters for index point OR2

		Outflow (cfs)							
		Existing		Base		No action		With-project	
Exceedence probability (1)	Inflow (cfs) (2)	Flow (3)	Standard deviation (4)	Flow (5)	Standard deviation (6)	Flow (7)	Standard deviation (8)	Flow (9)	Standard deviation (10)
0.999	0								
0.5	17,320	9,400	93	9,400	93	9,400	93	9,400	118
0.1	35,110	20,510	258	20,510	258	20,510	258	20,680	250
0.04	42,310	25,290	335	25,290	335	25,290	335	25,430	330
0.02	47,660	28,850	380	28,850	380	28,850	380	28,990	378
0.01	78,100	48,540	1,695	48,540	1,695	48,540	1,695	48,970	1,565
0.005	144,390	70,510	1,363	73,130	1,410	78,630	3,248	74,040	4,058
0.002	223,990	108,970	3,858	108,700	3,498	109,850	3,865	111,450	3,885
0.001	279,800[1]	135,900[1]	5,600[1]	133,700[1]	4,950[1]	131,700[1]	4,300[1]	137,700[1]	3,750[1]

1. Values shown are extrapolated.

Table 29. Stage-flow transform and uncertainty model parameters for index point OR2

Existing, base, & no action			With-project		
Flow (cfs) (1)	Stage (ft NAVD88) (2)	Standard deviation (ft NAVD88) (3)	Flow (cfs) (4)	Stage (ft NAVD88) (5)	Standard deviation (ft NAVD88) (6)
0	0.0	0.7[1]	0	0.0	0.7[1]
5,710	8.9	0.7[1]	5,710	8.9	0.7[1]
9,400	9.4	0.7[1]	9,400	9.4	0.7[1]
20,500	11.5	0.7[1]	20,700	11.5	0.7[1]
25,300	12.4	0.7[1]	25,400	12.4	0.7[1]
28,900	13.1	0.7[1]	29,000	13.2	0.7[1]
49,400	16.5	0.7[1]	49,600	16.5	0.7[1]
78,900	20.6	0.7[1]	79,000	20.6	0.7[1]
106,000	23.8	0.7[1]	106,100	23.8	0.7[1]

1. A minimum SD of 0.7 was used consistent with guidance on risk analysis in EM 1110-2-1619 (USACE 1996).

Index point Old River: Paradise Cut to model boundary RM -100.5 (OR3) HEC-FDA input

Table 30. Inflow-outflow relationship and uncertainty model parameters for index point OR3

Exceedence probability (1)	Inflow (cfs) (2)	Outflow (cfs)							
		Existing		Base		No action		With-project	
		Flow (3)	Standard deviation (4)	Flow (5)	Standard deviation (6)	Flow (7)	Standard deviation (8)	Flow (9)	Standard deviation (10)
0.999	0								
0.5	17,320	2,140	23	2,140	23	2,140	23	2,130	28
0.1	35,110	4,780	100	4,780	100	4,780	100	4,820	103
0.04	42,310	6,190	193	6,190	193	6,190	193	6,230	190
0.02	47,660	7,290	205	7,290	205	7,290	205	7,330	205
0.01	78,100	13,330	438	13,330	438	13,330	438	13,460	423
0.005	144,390	20,180	373	21,010	420	22,800	1,030	21,330	1,248
0.002	223,990	27,530	2,425	27,510	2,400	27,610	2,463	27,740	2,493
0.001	279,800[1]	32,700[1]	3,875[1]	32,100[1]	3,775[1]	31,000[1]	3,475[1]	32,200[1]	3,375[1]

1. Values shown are extrapolated.

Table 31. Stage-flow transform and uncertainty model parameters for index point OR3

Existing, base, & no action			With-project		
Flow (cfs) (1)	Stage (ft NAVD88) (2)	Standard deviation (ft NAVD88) (3)	Flow (cfs) (4)	Stage (ft NAVD88) (5)	Standard deviation (ft NAVD88) (6)
0	0.0	0.7[1]	0	0.0	0.7[1]
1,280	8.7	0.7[1]	1,280	8.7	0.7[1]
2,100	8.9	0.7[1]	2,100	8.9	0.7[1]
4,800	9.9	0.7[1]	4,800	9.9	0.7[1]
6,200	10.5	0.7[1]	6,200	10.6	0.7[1]
7,300	11.2	0.7[1]	7,300	11.2	0.7[1]
13,600	13.9	0.7[1]	13,600	13.9	0.7[1]
22,900	17.4	0.7[1]	23,000	17.4	0.7[1]
31,700	20.3	0.7[1]	31,700	20.3	0.7[1]

1. A minimum SD of 0.7 was used consistent with guidance on risk analysis in EM 1110-2-1619 (USACE 1996).

Index point Middle River: Old River to model boundary RM 26.251 (MR1) HEC-FDA input

Table 32. Inflow-outflow relationship and uncertainty model parameters for index point MR1

Exceedence probability (1)	Inflow (cfs) (2)	Outflow (cfs)							
		Existing		Base		No action		With-project	
		Flow (3)	Standard deviation (4)	Flow (5)	Standard deviation (6)	Flow (7)	Standard deviation (8)	Flow (9)	Standard deviation (10)
0.999	0								
0.5	17,320	900	15	900	15	900	15	900	13
0.1	35,110	1,940	3	1,940	3	1,940	3	1,930	3
0.04	42,310	2,390	5	2,390	5	2,390	5	2,370	3
0.02	47,660	2,720	5	2,720	5	2,720	5	2,710	5
0.01	78,100	4,820	195	4,820	195	4,820	195	4,830	183
0.005	144,390	6,410	420	6,530	380	6,830	505	6,640	540
0.002	223,990	7,960	700	7,960	700	7,920	710	7,850	728
0.001	279,800[1]	9,000[1]	900[1]	9,000[1]	900[1]	8,700[1]	850[1]	8,700[1]	850[1]

1. Values shown are extrapolated.

Table 33. Stage-flow transform and uncertainty model parameters for index point MR1

Existing, base, & no action			With-project		
Flow (cfs) (1)	Stage (ft NAVD88) (2)	Standard deviation (ft NAVD88) (3)	Flow (cfs) (4)	Stage (ft NAVD88) (5)	Standard deviation (ft NAVD88) (6)
0	0.0	0.7[1]	0	0.0	0.7[1]
520	9.2	0.7[1]	520	9.2	0.7[1]
900	10.0	0.7[1]	900	10.0	0.7[1]
1,940	12.5	0.7[1]	1,930	12.5	0.7[1]
2,390	13.5	0.7[1]	2,370	13.5	0.7[1]
2,720	14.2	0.7[1]	2,710	14.2	0.7[1]
4,840	17.8	0.7[1]	4,820	17.8	0.7[1]
8,230	22.0	0.7[1]	8,200	22.0	0.7[1]
11,440	25.3	0.7[1]	11,430	25.2	0.7[1]

1. A minimum SD of 0.7 was used consistent with guidance on risk analysis in EM 1110-2-1619 (USACE 1996).

Index point Salmon Slough: All RM 146.81 (SS1) HEC-FDA input

Table 34. Inflow-outflow relationship and uncertainty model parameters for index point SS1

		Outflow (cfs)							
		Existing		Base		No action		With-project	
Exceedence probability (1)	Inflow (cfs) (2)	Flow (3)	Standard deviation (4)	Flow (5)	Standard deviation (6)	Flow (7)	Standard deviation (8)	Flow (9)	Standard deviation (10)
0.999	0								
0.5	17,320	7,260	70	7,260	70	7,260	70	7,260	88
0.1	35,110	15,730	155	15,730	155	15,730	155	15,850	150
0.04	42,310	19,100	145	19,100	145	19,100	145	19,200	140
0.02	47,660	21,560	173	21,560	173	21,560	173	21,650	170
0.01	78,100	35,200	1,253	35,200	1,253	35,200	1,253	35,490	1,163
0.005	144,390	50,120	985	51,880	980	55,590	2,290	52,550	2,805
0.002	223,990	67,270	3,860	67,210	3,815	67,470	3,850	67,800	3,870
0.001	279,800[1]	79,300[1]	5,875[1]	78,000[1]	5,825[1]	75,800[1]	4,950[1]	78,500[1]	4,600[1]

1. Values shown are extrapolated.

Table 35. Stage-flow transform and uncertainty model parameters for index point SS1

Existing, base, & no action			With-project		
Flow (cfs) (1)	Stage (ft NAVD88) (2)	Standard deviation (ft NAVD88) (3)	Flow (cfs) (4)	Stage (ft NAVD88) (5)	Standard deviation (ft NAVD88) (6)
0	0.0	0.7[1]	0	0.0	0.7[1]
4,430	8.9	0.7[1]	4,430	8.9	0.7[1]
7,260	9.3	0.7[1]	7,260	9.3	0.7[1]
15,730	11.3	0.7[1]	15,850	11.3	0.7[1]
19,100	12.2	0.7[1]	19,200	12.2	0.7[1]
21,560	12.9	0.7[1]	21,650	12.9	0.7[1]
35,800	16.2	0.7[1]	35,910	16.3	0.7[1]
55,950	20.3	0.7[1]	56,010	20.3	0.7[1]
74,210	23.5	0.7[1]	74,270	23.5	0.7[1]

1. A minimum SD of 0.7 was used consistent with guidance on risk analysis in EM 1110-2-1619 (USACE 1996).

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Index point Grant Line Canal: All RM 23.6 (GLC1) HEC-FDA input

Table 36. Inflow-outflow relationship and uncertainty model parameters for index point GLC1

		Outflow (cfs)							
		Existing		Base		No action		With-project	
Exceedence probability (1)	Inflow (cfs) (2)	Flow (3)	Standard deviation (4)	Flow (5)	Standard deviation (6)	Flow (7)	Standard deviation (8)	Flow (9)	Standard deviation (10)
0.999	0								
0.5	17,320	7,260	70	7,260	70	7,260	70	7,260	88
0.1	35,110	15,730	155	15,730	155	15,730	155	15,850	150
0.04	42,310	19,100	145	19,100	145	19,100	145	19,200	140
0.02	47,660	21,560	173	21,560	173	21,560	173	21,650	168
0.01	78,100	35,200	1,250	35,200	1,250	35,200	1,250	35,490	1,160
0.005	144,390	50,090	985	51,850	978	55,570	2,285	52,530	2,803
0.002	223,990	67,260	3,860	67,200	3,815	67,450	3,848	67,790	3,868
0.001	279,800[1]	79,300[1]	5,875[1]	78,000[1]	5,825[1]	75,800[1]	4,950[1]	78,500[1]	4,625[1]

1. Values shown are extrapolated.

Table 37. Stage-flow transform and uncertainty model parameters for index point GLC1

Existing, base, & no action			With-project		
Flow (cfs) (1)	Stage (ft NAVD88) (2)	Standard deviation (ft NAVD88) (3)	Flow (cfs) (4)	Stage (ft NAVD88) (5)	Standard deviation (ft NAVD88) (6)
0	0.0	0.7[1]	0	0.0	0.7[1]
4,430	8.8	0.7[1]	4,430	8.8	0.7[1]
7,260	9.0	0.7[1]	7,260	9.0	0.7[1]
15,730	10.3	0.7[1]	15,850	10.3	0.7[1]
19,100	11.0	0.7[1]	19,200	11.0	0.7[1]
21,560	11.6	0.7[1]	21,650	11.6	0.7[1]
35,790	14.2	0.7[1]	35,910	14.2	0.7[1]
55,940	17.5	0.7[1]	56,000	17.5	0.7[1]
74,660	20.2	0.7[1]	73,750	20.1	0.7[1]
83,900	21.6	0.7[1]	82,500	21.4	0.7[1]

1. A minimum SD of 0.7 was used consistent with guidance on risk analysis in EM 1110-2-1619 (USACE 1996).

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Attachment B. Ground rules

April 14, 2010

Proposed Ground Rules for Section 408 Risk Analysis of Potential Hydraulic Impacts of River Islands at Lathrop Project

1. Levee Performance

    a. Levees overtop without failing.

2. Evaluation Scenarios

    a. **Existing** - existing (Feb. 2010) levees and channel geometry (see Figure 1). In addition:

        i. If levees do not meet the minimum project standard they would be raised in the hydraulic model to meet the minimum authorized levee height (1955 Profile); and

        ii. Where existing top of levees heights exceed the authorized height, they are modeled as such.

    b. **No Action** - FEMA certifiable interior levee constructed for entire project site (see Figure 2). Interior levee does not come in contact with Federal Project levee or required levee easements. Represents River Islands Project that would be constructed absent federal permits.

    c. **With Project** - Existing scenario plus addition of proposed River Islands Project and Paradise Cut Improvement Project (see Figure 3).

3. Hydrology

    a. Sacramento and San Joaquin River Basins Comprehensive Study San Joaquin River mainstem at Vernalis storm centering.

4. Risk Analysis Procedures

    a. System input flow-frequency curves derived using the same procedures as in the HEC Section 408 risk analysis demonstration project (June 2009) will be used. These curves represent the summation of regulated flow hydrographs at hydraulic model boundary conditions upstream of a given Index Point.

b. Inflow-Outflow relationships derived using the same procedures as in the demonstration project will be used. These relationships will be used to account for system routing and loss of flow due to spills over levees. This relationship translates the system input flow to a regulated flow at each of the Index Points.

c. Flow-discharge Transform Functions at Index Points will be based on an infinite levee scenario (no spills). This is a maximum flow versus maximum stage relationship.

d. The inflow-outflow relationship should be based on sensitivity analysis of Manning's n-value roughness coefficients and levee overtopping weir flow coefficients. The Manning's n-value uncertainty range will be determined recognizing model calibration variability at the index points. The levee overtopping weir coefficient is not a calibrated parameter so its uncertainty range will be based on the typical coefficient range for broad crested weirs of 2.6 to 3.1 as defined in the HEC-RAS Hydraulic Reference Manual, CPD-69, March 2008 (Table 8-1).

5. Analysis of Conditional Annual Exceedance Probability

a. The procedures being utilized will not produce a level of protection evaluation for each index point in the system. This is because of the necessity to make simplifying assumptions concerning levee performance and hydrologic inputs. The assumption of no levee failures will result in AEP's that are conditioned on that assumption and will thereby overestimate the level of protection provided throughout the system. Therefore for this analysis a Conditional Annual Exceedance Probability (C-AEP) will be calculated for each index point. All of the factors governing the "Conditional" aspect of the AEP will be documented.

b. "Conditional" Conditional Non-Exceedance Probabilities (C-CNP) shall be reported, too.

c. The target levee elevations used to compute Without Project Condition C-AEP and C-CNP's shall be consistent with the levee elevations used to establish the Base Condition (see item 2.a).

d. For Index Points controlled by backwater such that stage-discharge relationships do not exist, the analysis will be based on stage-frequency and not flow-frequency methodology. In these same areas the C-AEP's and C-CNP's will be based on the authorized levee elevation as shown on the 1955 Design flood profiles.

6. Index Point Locations

a. A list of index points is provided in Table 1. A map showing the index point locations is shown in Figure 4.

Table 1. Index Points

Reach	Location [1]	Index Point ID	Channel Invert Elev. (ft. NGVD29)	Fed Project Design Top of Levee, 1955 Profile (ft. NGVD29)	Top of Levee Elevation (ft. NGVD29)	Top of Levee Elevation Source
San Joaquin River						
Vernalis to Paradise Cut	63.24	SJR1	-19	32.1	31.8	CA Levee Database [2]
Paradise Cut to Old River	57.81	SJR2	-14	26.8	25.8	CA Levee Database [2]
Old River to model boundary	47.80	SJR3	-15	18.1	18.4	CA Levee Database [2]
Paradise Cut						
San Joaquin R. to Old R.	267.9	PC1	7	23.8	23.9	CA Levee Database [2]
San Joaquin R. to Old R.	239.3	PC2	-1	22.9	21.6	CA Levee Database [2]
San Joaquin R. to Old R.	115.7	PC3	-5	19.8	22.2	CA Levee Database [2]
Old River						
San Joaquin R. to Middle R.	142.0	OR1	-8	19.6	19.6	CA Levee Database [2]
Middle R. to Paradise Cut	172.06	OR2	-20	14.8	17.5	CA Levee Database [2]
Paradise Cut to model boundary	-100.5	OR3	-8	na	15.6	DWR bathymetry survey, 1997
Middle River						
Old R. to model boundary	26.251	MR1	-4	na	15.6	Comprehensive Study topo
Salmon Slough						
All	146.81	SS1	-14	14.4	19.4	CA Levee Database [2]
Grant Line Canal						
All	23.6	GLC 1	-13	na	18.1	DWR bathymetry survey, 1997

[1] Hydraulic model cross-section ID. San Joaquin River and Middle River are referenced to Comp Study River Mile. Paradise Cut, Old River and Grant Line Canal are based on individual reach stationing on 100 foot increments.
[2] Converted from vertical datum NAVD88 to NGVD29 based on relationship of 0 ft. NGVD29 = 2.4 ft. NAVD88 as per Carlson, Barbee, Gibson.

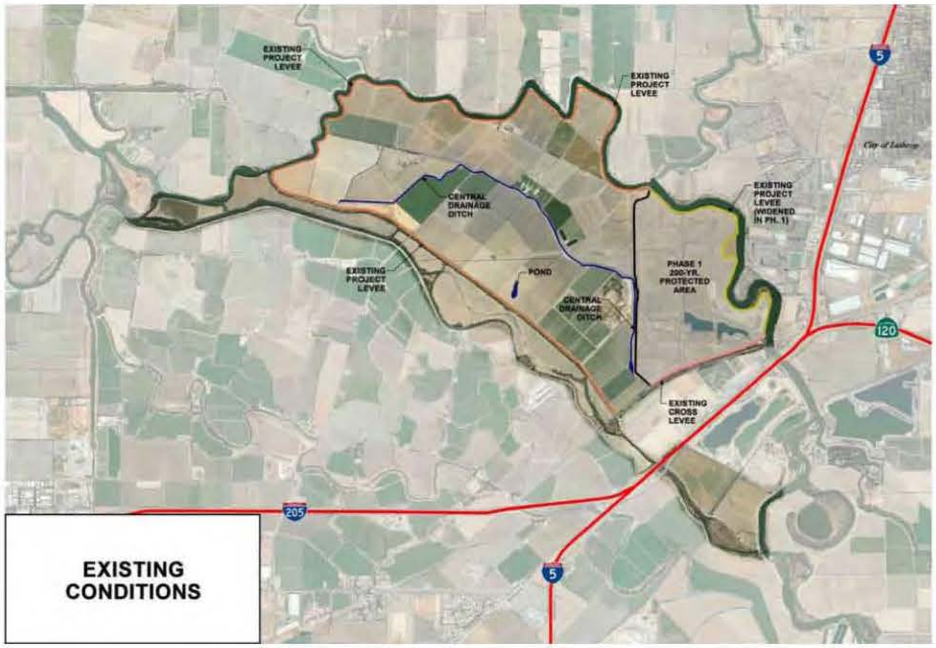

Figure 1.

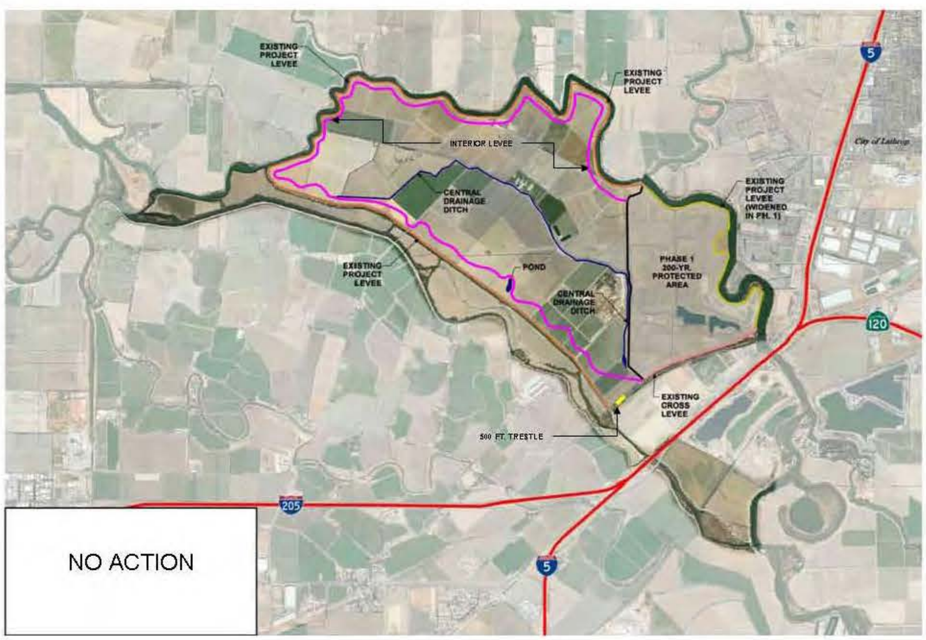

Figure 2.

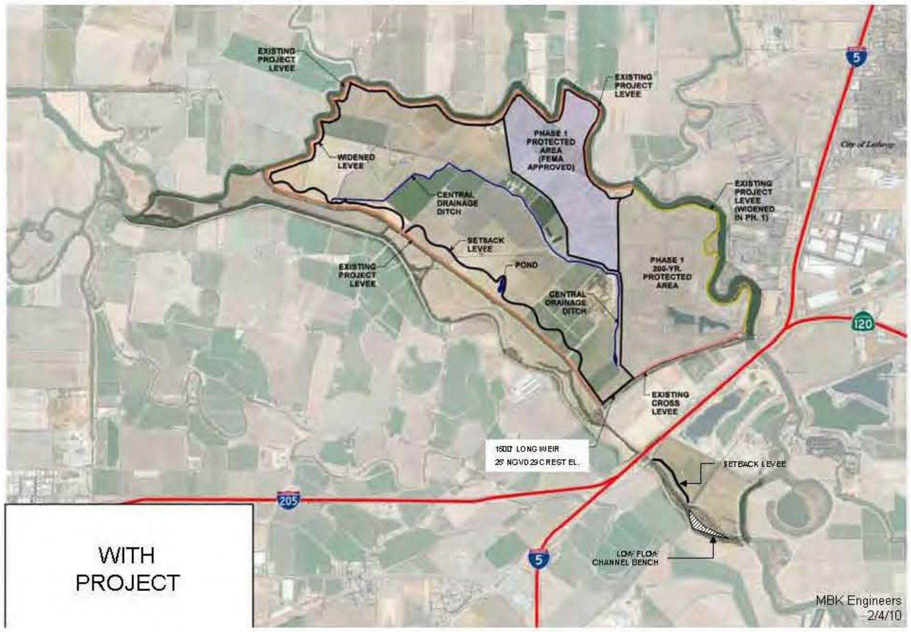

Figure 3.

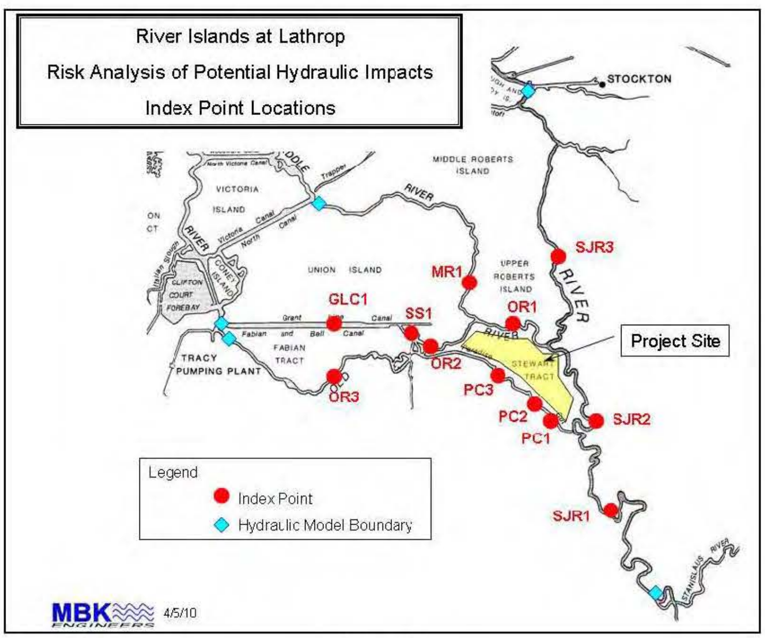

Figure 4.

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Attachment C. Certification of internal quality control

David Ford Consulting Engineers, Inc. has completed the Conditional risk analysis for the River Islands at Lathrop project. The internal technical review was appropriate to the level of risk and complexity inherent in the project. The technical reviewer has verified that the work performed complies with established policy, principles, and procedures, and reflects the use of justified and verified assumptions. The technical review included review of underlying assumptions; methods, procedures, and materials used in analyses; alternatives evaluated; the appropriateness of data used; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps policy. The undersigned recommends certification of the internal quality control process for this work product.

All concerns resulting from internal technical review of the project have been addressed.

8/25/2010

David Ford, PhD, PE
President
David Ford Consulting Engineers

(date)

Attachment D

Calibration Water Surface Profiles

Figure D-1. San Joaquin River
Figure D-2. Paradise Cut
Figure D-3. Old River

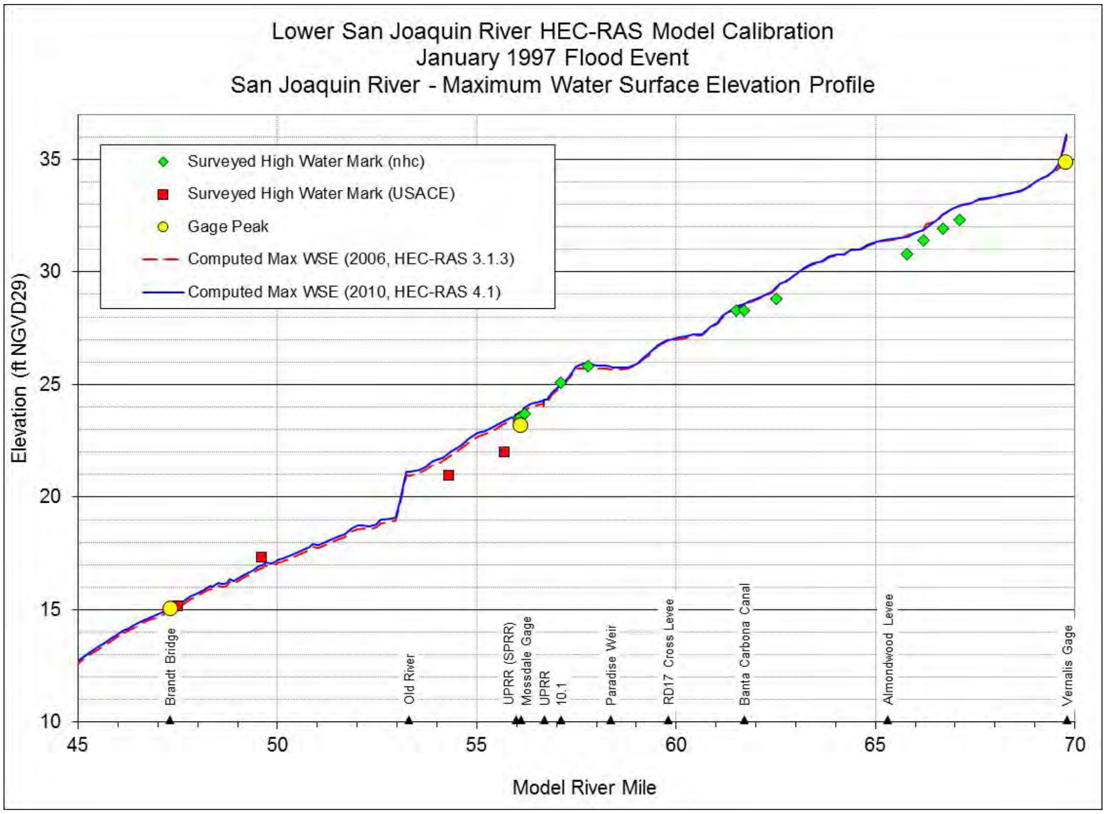

Figure D-1

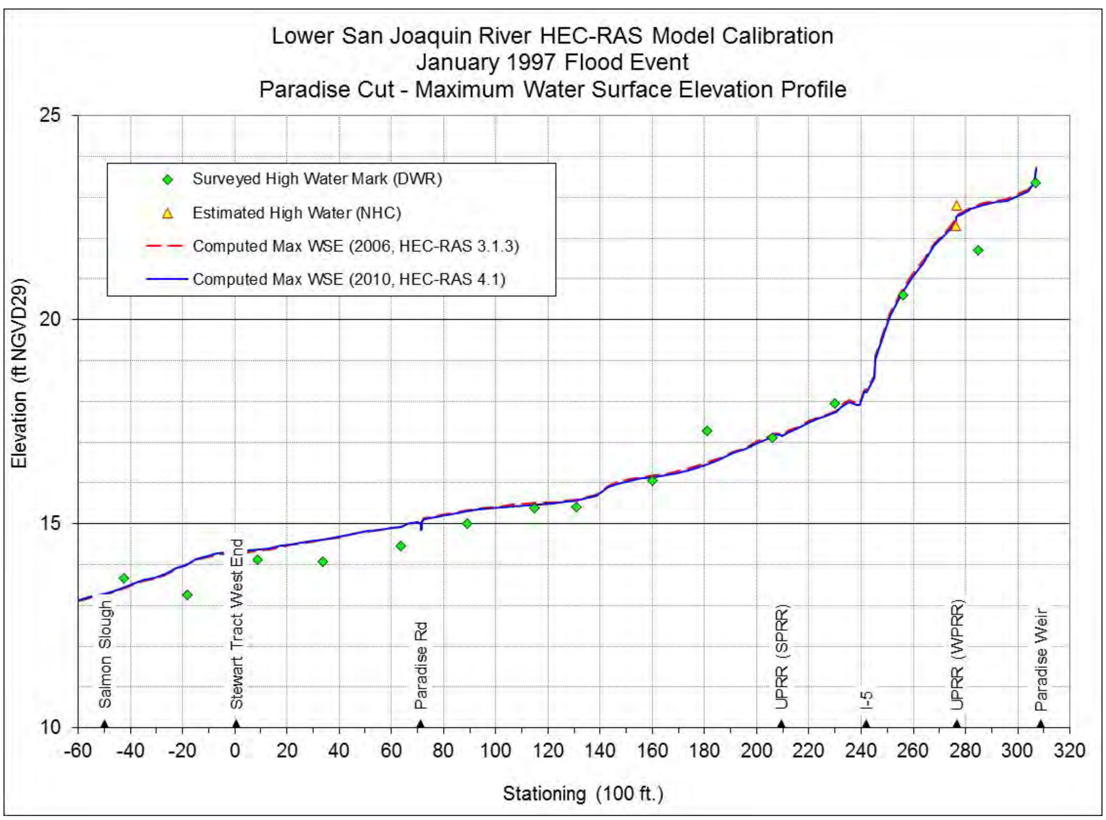

Figure D-2

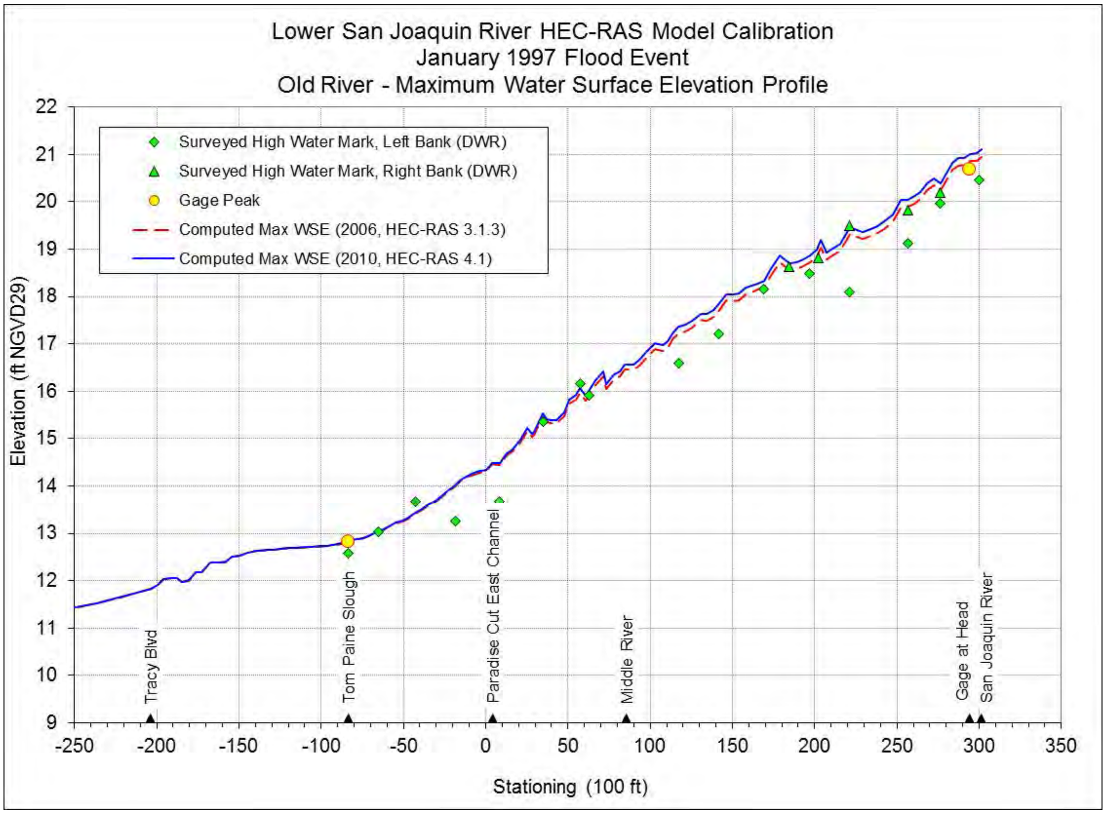
Lower San Joaquin River HEC-RAS Model Calibration
January 1997 Flood Event
Old River - Maximum Water Surface Elevation Profile
Surveyed High Water Mark, Left Bank (DWR)
Surveyed High Water Mark, Right Bank (DWR)
Gage Peak
Computed Max WSE (2006, HEC-RAS 3.1.3)
Computed Max WSE (2010, HEC-RAS 4.1)
Elevation (ft NGVD29)
Stationing (100 ft)
Tracy Blvd
Tom Paine Slough
Paradise Cut East Channel
Middle River
Gage at Head
San Joaquin River
22
21
20
19
18
17
16
15
14
13
12
11
10
9
-250
-200
-150
-100
-50
0
50
100
150
200
250
300
350

Figure D-3

Attachment E

Basis for Converting Elevations from NGVD29 to NAVD88

July 21, 2009
Job No.: 0905-000

MEMORANDUM

TO: Susan Dell'Osso, River Islands at Lathrop

FROM: Chris Harmison, P.L.S.

CC: John Zhang, P.E., Carlson, Barbee & Gibson, Inc.

SUBJECT: Vertical Datum Conversion – River Islands

Per your request, Carlson, Barbee & Gibson, Inc. (CBG) is providing this memorandum to describe the method used to convert elevations between the National Geodetic Vertical Datum of 1929 (NGVD 29) and the North American Vertical Datum of 1988 (NAVD 88) throughout the River Islands project in Lathrop, California.

In 2003, Aerometric Surveys prepared an aerial topography for the entire River Islands project based on the NAVD 88 datum. CBG assisted in the preparation of the aerial topography by locating three (3) first order NAVD 88 benchmarks within the River Islands project, published by the National Oceanic and Atmosphere Administration (NOAA), National Geodetic Survey (NGS) data sheets (www.ngs.noaa.gov). These data sheets also published the NGVD 29 elevations for the benchmarks.

Project Benchmarks

Benchmark No. 1 – NGS disk (PID HS0518) stamped "H-1041 1959" located in the top of the northeast concrete abutment of the Manthey Road Bridge Spanning Paradise Cut.

Elevation = 27.25 feet (NAVD 88)
Elevation = 24.86 feet (NGVD 29)

Difference = 2.39 feet

Benchmark No. 2 – NGS disk (PID HS0512) stamped "Bridges 1959" located near the northeast abutment of the Union Pacific Railroad drawbridge.

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Elevation = 28.57 feet (NAVD 88)
Elevation = 26.23 feet (NGVD 29)

Difference = 2.34 feet

Benchmark No. 3 – NGS disk (PID HS0515) stamped "Bridges 1959 No 3 1971" located near the southwest abutment of the Union Pacific drawbridge.

Elevation = 32.80 feet (NAVD 88)
Elevation = 30.4 feet (NGVD 29)

Difference = 2.40 feet

Based on the mean difference between the NGVD 29 and the NAVD 88 elevations, CBG determined the conversion factor to be **2.38 feet**.

This conversion factor equation shall be applied when translating topographic mapping between the NGVD 29 and NAVD 88 for the River Islands project:

NGVD 29 (feet) + 2.38 (feet) = NAVD 88 (feet)

Please see the attached NGS Data Sheets and Exhibit A for descriptions and locations.

Christopher S. Harmison

LICENSED LAND SURVEYOR
CHRISTOPHER S. HARMISON
No. 7176
Exp. 12/31/09
STATE OF CALIFORNIA

Christopher S. Harmison, PLS
Senior Surveyor

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The NGS Data Sheets

HS0518
****
HS0518 DESIGNATION - H 1041
HS0518 PID - HS0518
HS0518 STATE/COUNTY- CA/SAN JOAQUIN
HS0518 USGS QUAD - LATHROP (1987)
HS0518
HS0518 *CURRENT SURVEY CONTROL
HS0518 ____
HS0518* NAD 83(1986)- 37 46 18. (N) 121 19 40. (W) SCALED
HS0518* NAVD 88 - 8.305 (meters) 27.25 (feet) ADJUSTED
HS0518 ____
HS0518 GEOID HEIGHT- -32.15 (meters) GEOID03
HS0518 DYNAMIC HT - 8.300 (meters) 27.23 (feet) COMP
HS0518 MODELED GRAV- 979,928.9 (mgal) NAVD 88
HS0518
HS0518 VERT ORDER - FIRST CLASS II
HS0518
HS0518.The horizontal coordinates were scaled from a topographic map and have
HS0518.an estimated accuracy of +/- 6 seconds.
HS0518
HS0518.The orthometric height was determined by differential leveling
HS0518.and adjusted in July 2002.
HS0518.No vertical observational check was made to the station.
HS0518
HS0518.The geoid height was determined by GEOID03.
HS0518
HS0518.The dynamic height is computed by dividing the NAVD 88
HS0518.geopotential number by the normal gravity value computed on the
HS0518.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
HS0518.degrees latitude (g = 980.6199 gals.).
HS0518
HS0518.The modeled gravity was interpolated from observed gravity values.
HS0518
HS0518; North East Units Estimated Accuracy
HS0518;SPC CA 3 - 641,450. 1,927,080. MT (+/- 180 meters Scaled)
HS0518
HS0518 SUPERSEDED SURVEY CONTROL
HS0518
HS0518 NGVD 29 (??/??/92) 7.576 (m) 24.86 (f) ADJ UNCH 2 0
HS0518

HS0518.Superseded values are not recommended for survey control.
HS0518.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
HS0518.See file dsdata.txt to determine how the superseded data were derived.
HS0518
HS0518_U.S. NATIONAL GRID SPATIAL ADDRESS: 10SFG472817(NAD 83)
HS0518_MARKER: DB = BENCH MARK DISK
HS0518_SETTING: 38 = SET IN THE ABUTMENT OR PIER OF A LARGE BRIDGE
HS0518_SP_SET: BRIDGE ABUTMENT
HS0518_STAMPING: H 1041 1959
HS0518_MARK LOGO: CGS
HS0518_MAGNETIC: N = NO MAGNETIC MATERIAL
HS0518_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
HS0518_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
HS0518+SATELLITE: SATELLITE OBSERVATIONS - June 24, 2000
HS0518
HS0518 HISTORY - Date Condition Report By
HS0518 HISTORY - 1959 MONUMENTED CGS
HS0518 HISTORY - 1965 GOOD NGS
HS0518 HISTORY - 20000624 GOOD NGS
HS0518
HS0518 STATION DESCRIPTION
HS0518
HS0518'DESCRIBED BY COAST AND GEODETIC SURVEY 1959
HS0518'4.6 MI SW FROM LATHROP.
HS0518'3.0 MILES SOUTHWEST ALONG THE SOUTHERN PACIFIC COMPANY
RAILROAD
HS0518'FROM THE STATION AT LATHROP, THENCE 1.6 MILES SOUTHWEST ALONG
HS0518'U.S. HIGHWAY 50, 1.4 MILES SOUTHWEST OF THE DRAWBRIDGE OVER
THE
HS0518'SAN JOAQUIN RIVER, ALONG THE NORTHWEST TRAFFIC LANES OF THE
HIGHWAY,
HS0518'AT CONCRETE BRIDGE 29-32L OVER PARADISE CUT, IN THE TOP OF THE
HS0518'NORTHEAST CONCRETE ABUTMENT, 18 1/2 FEET NORTHWEST OF THE
CENTER
HS0518'LINE OF THE NORTHWEST TRAFFIC LANES, 4.0 FEET SOUTHEAST OF THE
HS0518'NORTHWEST END OF THE ABUTMENT, AND LEVEL WITH THE HIGHWAY
AND BRIDGE
HS0518'DECK.
HS0518
HS0518 STATION RECOVERY (1965)
HS0518
HS0518'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1965
HS0518'RECOVERED IN GOOD CONDITION.

HS0518
HS0518 STATION RECOVERY (2000)
HS0518
HS0518'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 2000 (GAS)
HS0518'15.6 KM (9.70 MI) SOUTHERLY ALONG INTERSTATE HIGHWAY 5 FROM THE
HS0518'JUNCTION OF STATE HIGHWAY 4 EAST IN STOCKTON, THENCE 0.5 KM (0.30 MI)
HS0518'SOUTHERLY ALONG THE LOUISE ROAD EXIT RAMP, THENCE 0.1 KM (0.05 MI)
HS0518'WESTERLY ALONG LOUISE AVENUE, THENCE 5.4 KM (3.35 MI) SOUTHWESTERLY
HS0518'ALONG MANTHEY ROAD, IN TOP OF AND 1.2 M (3.9 FT) SOUTHEAST OF THE
HS0518'NORTHWEST END OF THE NORTHEAST CONCRETE ABUTMENT OF THE ROAD BRIDGE
HS0518'SPANNING PARADISE CUT, AND 5.6 M (18.4 FT) NORTHWEST OF AND LEVEL WITH
HS0518'THE ROAD CENTERLINE. NOTE--THE MONUMENT IS ON THE ROAD RIGHT-OF-WAY.

HS0512
****
HS0512 DESIGNATION - BRIDGES
HS0512 PID - HS0512
HS0512 STATE/COUNTY- CA/SAN JOAQUIN
HS0512 USGS QUAD - LATHROP (1987)
HS0512
HS0512 *CURRENT SURVEY CONTROL
HS0512 ____
HS0512* NAD 83(1992)- 37 47 15.84232(N) 121 18 25.72365(W) ADJUSTED
HS0512* NAVD 88 - 8.709 (meters) 28.57 (feet) ADJUSTED
HS0512 ____
HS0512 EPOCH DATE - 1991.35
HS0512 LAPLACE CORR- 1.25 (seconds) DEFLEC99
HS0512 GEOID HEIGHT- -32.12 (meters) GEOID03
HS0512 DYNAMIC HT - 8.702 (meters) 28.55 (feet) COMP
HS0512 MODELED GRAV- 979,931.7 (mgal) NAVD 88
HS0512
HS0512 HORZ ORDER - SECOND
HS0512 VERT ORDER - FIRST CLASS II
HS0512
HS0512.The horizontal coordinates were established by classical geodetic methods

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HS0512.and adjusted by the National Geodetic Survey in March 1994.
HS0512.The horizontal coordinates are valid at the epoch date displayed above.
HS0512.The epoch date for horizontal control is a decimal equivalence
HS0512.of Year/Month/Day.
HS0512
HS0512.The orthometric height was determined by differential leveling
HS0512.and adjusted in July 2002.
HS0512.No vertical observational check was made to the station.
HS0512
HS0512.The Laplace correction was computed from DEFLEC99 derived deflections.
HS0512
HS0512.The geoid height was determined by GEOID03.
HS0512
HS0512.The dynamic height is computed by dividing the NAVD 88
HS0512.geopotential number by the normal gravity value computed on the
HS0512.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
HS0512.degrees latitude (g = 980.6199 gals.).
HS0512
HS0512.The modeled gravity was interpolated from observed gravity values.
HS0512

```
HS0512;              North        East      Units Scale Factor Converg.
HS0512;SPC CA 3   -   643,220.565 1,928,908.475   MT  0.99992938   -0 29 39.0
HS0512;SPC CA 3   - 2,110,299.47  6,328,427.22   sFT  0.99992938   -0 29 39.0
HS0512;UTM  10    - 4,183,613.603   649,060.944   MT  0.99987367   +1 02 14.9
HS0512
HS0512!          - Elev Factor  x  Scale Factor =   Combined Factor
HS0512!SPC CA 3  -  1.00000367  x   0.99992938  =   0.99993305
HS0512!UTM  10   -  1.00000367  x   0.99987367  =   0.99987734
HS0512
HS0512|---------------------------------------------------------------------|
HS0512| PID    Reference Object              Distance     Geod. Az  |
HS0512|                                                  dddmmss.s |
HS0512| HS0514 BRIDGES RM 1                8.153 METERS 06824     |
HS0512| HS0515 BRIDGES RM 3                8.154 METERS 06827     |
HS0512| HS0513 BRIDGES RM 2               14.712 METERS 16440     |
HS0512| HS0516 BRIDGES AZ MK                             2114314.0 |
HS0512| HS0520 PAINE                    APPROX. 3.9 KM 2311345.5 |
HS0512|---------------------------------------------------------------------|
HS0512
HS0512                SUPERSEDED SURVEY CONTROL
HS0512
HS0512  NAD 83(1986)-  37 47 15.83596(N)    121 18 25.72337(W) AD(1984.00) 2
HS0512  NAD 27      -  37 47 16.09600(N)    121 18 21.92930(W) AD(       ) 2
```

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HS0512 NGVD 29 (??/??/92) 7.995 (m) 26.23 (f) ADJ UNCH 1 2
HS0512
HS0512.Superseded values are not recommended for survey control.
HS0512.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
HS0512.See file dsdata.txt to determine how the superseded data were derived.
HS0512
HS0512_U.S. NATIONAL GRID SPATIAL ADDRESS: 10SFG4906183614(NAD 83)
HS0512_MARKER: DS = TRIANGULATION STATION DISK
HS0512_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
HS0512_SP_SET: SET IN TOP OF CONCRETE MONUMENT
HS0512_STAMPING: BRIDGES 1959
HS0512_MARK LOGO: CGS
HS0512_MAGNETIC: N = NO MAGNETIC MATERIAL
HS0512_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
HS0512+STABILITY: SURFACE MOTION
HS0512_SATELLITE: THE SITE LOCATION WAS REPORTED AS NOT SUITABLE FOR
HS0512+SATELLITE: SATELLITE OBSERVATIONS - June 25, 2000
HS0512
HS0512 HISTORY - Date Condition Report By
HS0512 HISTORY - 1959 MONUMENTED CGS
HS0512 HISTORY - 1959 GOOD CGS
HS0512 HISTORY - 1963 SEE DESCRIPTION CGS
HS0512 HISTORY - 1971 SEE DESCRIPTION NGS
HS0512 HISTORY - 1971 GOOD NGS
HS0512 HISTORY - 20000625 GOOD NGS
HS0512
HS0512 STATION DESCRIPTION
HS0512
HS0512'DESCRIBED BY COAST AND GEODETIC SURVEY 1959 (JEG)
HS0512'THE STATION IS LOCATED ABOUT 11 MILES AIRLINE, SOUTH OF
STOCKTON,
HS0512'AND ABOUT 200 YARDS WEST OF THE U.S. HIGHWAY 50 SAN JOAQUIN
HS0512'RIVER BRIDGE, ON THE SOUTHERN PACIFIC RAILROAD RIGHT OF WAY.
HS0512'
HS0512'TO REACH THE STATION FROM THE JUNCTION OF U.S. HIGHWAY 50 AND
HS0512'STATE HIGHWAY 4, AT THE SOUTH EDGE OF STOCKTON, GO SOUTH AND
HS0512'SOUTHWEST ON U.S. HIGHWAY 50 FOR 11.2 MILES TO A PARKING AREA
HS0512'AT THE NORTH END OF THE SAN JOAQUIN RIVER BRIDGE. THIS IS THE
HS0512'END OF TRUCK TRAVEL. FROM THIS POINT PACK WESTERLY ABOUT 200
HS0512'YARDS TO THE NORTHEAST END OF THE SOUTHERN PACIFIC RAILROAD
HS0512'DRAW BRIDGE, AND THE STATION.
HS0512'
HS0512'THE STATION MARK IS A STANDARD BRONZE DISK STAMPED BRIDGES

HS0512'1959, SET IN THE TOP OF A 10 INCH SQUARE CONCRETE MONUMENT,
HS0512'WHICH PROJECTS 8 INCHES ABOVE GROUND LEVEL. MARK IS 3 FEET
HS0512'SOUTH OF A BRIDGE RAIL, 4 FEET WEST OF A CONCRETE BRIDGE
ABUTMENT,
HS0512'AND 6 FEET NORTH NORTHWEST OF A METAL WITNESS POST.
HS0512'
HS0512'REFERENCE MARK NUMBER ONE IS A STANDARD BRONZE DISK
STAMPED
HS0512'BRIDGES NO 1 1959, CEMENTED IN A DRILL HOLE IN A CONCRETE
HS0512'BRIDGE ABUTMENT. MARK IS 1 FOOT SOUTH OF A BRIDGE RAIL, 27
HS0512'FEET NORTH NORTHEAST OF A POWER POLE, AND ABOUT 5 FEET HIGHER
HS0512'IN ELEVATION THAN THE STATION.
HS0512'
HS0512'REFERENCE MARK NUMBER TWO IS A STANDARD BRONZE DISK
STAMPED
HS0512'BRIDGES NO 2 1959, SET IN THE TOP OF A 10 INCH SQUARE CONCRETE
HS0512'MONUMENT, WHICH PROJECTS 6 INCHES ABOVE GROUND LEVEL. MARK
IS
HS0512'27 FEET SOUTH OF A POWER POLE, AND ABOUT 4 FEET HIGHER IN
HS0512'ELEVATION THAN THE STATION.
HS0512'
HS0512'TO REACH THE AZIMUTH MARK FROM THE STATION WALK SOUTH
ACROSS
HS0512'THE DRAW BRIDGE TO AN OILED ROAD AT THE SOUTH END OF THE
BRIDGE.
HS0512'TURN LEFT AND GO EASTERLY FOR 0.05 MILE TO THE AZIMUTH MARK
HS0512'ON THE RIGHT.
HS0512'
HS0512'THE AZIMUTH MARK IS A STANDARD BRONZE DISK STAMPED BRIDGES
HS0512'1959, SET IN THE TOP OF A 10 INCH SQUARE CONCRETE MONUMENT,
WHICH
HS0512'IS FLUSH WITH GROUND LEVEL. MARK IS 16 FEET SOUTH OF A HARD
HS0512'SURFACED ROAD, 8 FEET NORTHEAST OF POWER POLE NUMBER 19, AND
ABOUT
HS0512'40 FEET SOUTH OF A ROW OF CABINS.
HS0512'
HS0512'HEIGHT OF LIGHT ABOVE STATION MARK 4.14 METERS.
HS0512
HS0512 STATION RECOVERY (1959)
HS0512
HS0512'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1959
HS0512'3.2 MI SW FROM LATHROP.

HS0512'3.2 MILES SOUTHWEST ALONG THE SOUTHERN PACIFIC COMPANY RAILROAD
HS0512'FROM THE STATION AT LATHROP, NEAR THE NORTHEAST END OF THE STEEL
HS0512'DRAW BRIDGE 78.24 OVER THE SAN JOAQUIN RIVER, 69 FEET NORTHEAST
HS0512'OF THE NORTHEAST END OF THE SOUTHEAST STEEL GIRDER, 4 FEET WEST
HS0512'OF THE SOUTHEAST END OF THE FIRST CONCRETE BENT NORTHEAST OF
HS0512'THE BRIDGE, 3 FEET SOUTHEAST OF THE SOUTHEAST WOODEN BRIDGE RAIL,
HS0512'7 FEET SOUTHEAST OF THE SOUTHEAST RAIL OF THE SOUTHEAST TRACK, 6
HS0512'FEET NORTH-NORTHWEST OF A WITNESS POST, ABOUT 6 FEET LOWER THAN
HS0512'THE TRACK, AND SET IN THE TOP OF A CONCRETE POST PROJECTING 0.2
HS0512'FOOT ABOVE THE GROUND.
HS0512
HS0512 STATION RECOVERY (1963)
HS0512
HS0512'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1963 (JT)
HS0512'THE STATION, R.M. 1 AND R.M. 2 WERE RECOVERED IN GOOD CONDITION.
HS0512'
HS0512'THE STATION IS LOCATED ABOUT 3.2 MILES SOUTHWEST OF LATHROP.
HS0512'TO REACH FROM THE SOUTHERN PACIFIC COMPANY RAILROAD STATION
HS0512'IN LATHROP, GO 3.2 MILES SOUTHWEST ALONG RAILROAD TO STEEL
HS0512'DRAWBRIDGE 78.24 OVER THE SAN JOAQUIN RIVER.
HS0512'
HS0512'THE STATION IS A C AND GS TRIANGULATION STATION DISK, STAMPED
HS0512'BRIDGES 1959, 69 FEET NORTHEAST OF THE NORTHEAST END OF THE
HS0512'SOUTHEAST STEEL GIRDER, 7 FEET SOUTHEAST OF THE SOUTHEAST
HS0512'RAIL, ABOUT 6 FEET LOWER THAN TRACK, SET IN THE TOP OF A
HS0512'CONCRETE POST PROJECTING 0.2 FOOT ABOVE THE GROUND.
HS0512'
HS0512'R.M. 1 IS A C AND GS REFERENCE MARK DISK, STAMPED BRIDGES NO 1 1959,
HS0512'26.8 FEET EAST-NORTHEAST OF THE STATION, 6.3 FEET SOUTHEAST
HS0512'OF THE SOUTHEAST RAIL, AND IN THE TOP OF THE SOUTHEAST END OF
HS0512'THE SOUTHWEST CONCRETE ABUTMENT FOR THE WOODEN TRESTLE AT THE
HS0512'NORTHEAST END OF THE BRIDGE.
HS0512'
HS0512'R.M. 2 IS A C AND GS REFERENCE MARK DISK, STAMPED BRIDGES NO 2
HS0512'1959, 48.2 FEET SOUTH-SOUTHEAST OF THE STATION, 53 FEET SOUTHEAST

HS0512'OF THE SOUTHEAST RAIL OF THE TRACK, AND SET IN THE TOP OF A
HS0512'CONCRETE POST.
HS0512
HS0512 STATION RECOVERY (1971)
HS0512
HS0512'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1971 (LFS)
HS0512'THE STATION MARK WAS RECOVERED IN GOOD CONDITION. THE
REFERENCE
HS0512'MARK 2 DISK WAS FOUND SOMEWHAT BATTERED BY HAMMERING AND
SLIGHTLY
HS0512'LOOSE SO IT WAS REINFORCED WITH CONCRETE ON THIS DATE. THE
HS0512'REFERENCE MARK 1 DISK WAS FOUND TO HAVE BEEN PRIED OUT SO THE
HS0512'DRILL HOLE WAS DEEPENED AND REFERENCE MARK 3 WAS SET IN IT ON
HS0512'THIS DATE. THE AZIMUTH MARK WAS DESTROYED DURING ROAD
HS0512'CONSTRUCTION IN 1965. THE 1959 DESCRIPTION IS ADEQUATE WITH THE
HS0512'FOLLOWING ADDITIONS--
HS0512'
HS0512'REFERENCE MARK 2 IS ABOUT 2 FEET HIGHER THAN THE STATION
HS0512'MARK.
HS0512'
HS0512'REFERENCE MARK 3 IS A C AND GS REFERENCE MARK DISK STAMPED
HS0512'BRIDGES 1959 NO 3 1971 CEMENTED IN A DRILL HOLE IN THE TOP OF
HS0512'THE SOUTHEAST END OF THE SOUTHWEST CONCRETE ABUTMENT FOR
THE
HS0512'WOODEN TRESTLE AT THE NORTHEAST END OF THE BRIDGE, 20.7 FEET
HS0512'SOUTHEAST OF THE SOUTHEAST RAIL OF THE TRACK, ABOUT 1 FOOT
LOWER
HS0512'THAN THE TRACK AND ABOUT 4 FEET HIGHER THAN THE STATION
MARK.
HS0512
HS0512 STATION RECOVERY (1971)
HS0512
HS0512'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1971
HS0512'RECOVERED IN GOOD CONDITION.
HS0512
HS0512 STATION RECOVERY (2000)
HS0512
HS0512'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 2000 (GAS)
HS0512'15.6 KM (9.70 MI) SOUTHERLY ALONG INTERSTATE HIGHWAY 5 FROM THE
HS0512'JUNCTION OF STATE HIGHWAY 4 EAST IN STOCKTON, THENCE 0.5 KM
(0.30 MI)
HS0512'SOUTHERLY ALONG THE LOUISE AVENUE EXIT RAMP, THENCE 0.1 KM
(0.05 MI)

HS0512'WESTERLY ALONG LOUISE AVENUE, THENCE 2.7 KM (1.65 MI) SOUTHERLY ALONG
HS0512'MANTHEY ROAD, THENCE 0.3 KM (0.20 MI) SOUTHWESTERLY ALONG THE UNION
HS0512'PACIFIC RAILROAD, 8.3 M (27.2 FT) SOUTHWEST OF REFERENCE MARK 3, 6.6 M
HS0512'(21.7 FT) SOUTHEAST OF THE NEAR RAIL, 1.6 M (5.2 FT) BELOW THE LEVEL
HS0512'OF THE TRACKS, 0.9 M (3.0 FT) SOUTHWEST OF THE SOUTHWEST EDGE OF THE
HS0512'NORTHEAST ABUTMENT OF A RAILROAD DRAWBRIDGE, 0.6 M (2.0 FT) SOUTHEAST
HS0512'OF A BRIDGE RAIL, AND THE MONUMENT IS RECESSED 0.2 M (0.7 FT) BELOW
HS0512'THE GROUND SURFACE. NOTE--THE MONUMENT IS ON PROPERTY OWNED BY THE
HS0512'UNION PACIFIC RAILROAD, 833 EAST 8TH STREET, STOCKTON, CA 95206,
HS0512'TELEPHONE (916) 799-3832.

HS0515
****
HS0515 TIDAL BM - This is a Tidal Bench Mark.
HS0515 DESIGNATION - BRIDGES RM 3
HS0515 PID - HS0515
HS0515 STATE/COUNTY- CA/SAN JOAQUIN
HS0515 USGS QUAD - LATHROP (1987)
HS0515
HS0515 *CURRENT SURVEY CONTROL
HS0515 ____
HS0515* NAD 83(1986)- 37 47 16. (N) 121 18 31. (W) SCALED
HS0515* NAVD 88 - 9.998 (meters) 32.80 (feet) ADJUSTED
HS0515 ____
HS0515 GEOID HEIGHT- -32.12 (meters) GEOID03
HS0515 DYNAMIC HT - 9.991 (meters) 32.78 (feet) COMP
HS0515 MODELED GRAV- 979,931.8 (mgal) NAVD 88
HS0515
HS0515 VERT ORDER - FIRST CLASS II
HS0515
HS0515.The horizontal coordinates were scaled from a topographic map and have
HS0515.an estimated accuracy of +/- 6 seconds.
HS0515
HS0515.The orthometric height was determined by differential leveling
HS0515.and adjusted in July 2002.
HS0515.No vertical observational check was made to the station.

HS0515
HS0515.This Tidal Bench Mark is designated as VM 12237
HS0515.by the Center for Operational Oceanographic Products and Services.
HS0515
HS0515.The geoid height was determined by GEOID03.
HS0515
HS0515.The dynamic height is computed by dividing the NAVD 88
HS0515.geopotential number by the normal gravity value computed on the
HS0515.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
HS0515.degrees latitude (g = 980.6199 gals.).
HS0515
HS0515.The modeled gravity was interpolated from observed gravity values.
HS0515
HS0515; North East Units Estimated Accuracy
HS0515;SPC CA 3 - 643,230. 1,928,780. MT (+/- 180 meters Scaled)
HS0515
HS0515 SUPERSEDED SURVEY CONTROL
HS0515
HS0515 NGVD 29 (08/19/04) 9.26 (m) 30.4 (f) RESET 3
HS0515
HS0515.Superseded values are not recommended for survey control.
HS0515.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
HS0515.See file dsdata.txt to determine how the superseded data were derived.
HS0515
HS0515_U.S. NATIONAL GRID SPATIAL ADDRESS: 10SFG489836(NAD 83)
HS0515_MARKER: DR = REFERENCE MARK DISK
HS0515_SETTING: 38 = SET IN THE ABUTMENT OR PIER OF A LARGE BRIDGE
HS0515_SP_SET: BRIDGE ABUTMENT
HS0515_STAMPING: BRIDGES 1959 NO 3 1971
HS0515_MARK LOGO: NGS
HS0515_MAGNETIC: N = NO MAGNETIC MATERIAL
HS0515_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
HS0515_SATELLITE: THE SITE LOCATION WAS REPORTED AS NOT SUITABLE FOR
HS0515+SATELLITE: SATELLITE OBSERVATIONS - June 24, 2000
HS0515
HS0515 HISTORY - Date Condition Report By
HS0515 HISTORY - 1971 MONUMENTED NGS
HS0515 HISTORY - 20000624 GOOD NGS
HS0515
HS0515 STATION DESCRIPTION
HS0515
HS0515'DESCRIBED BY NATIONAL GEODETIC SURVEY 1971
HS0515'3.2 MI SW FROM LATHROP.

HS0515'3.2 MILES SOUTHWEST ALONG THE SOUTHERN PACIFIC COMPANY RAILROAD
HS0515'FROM THE STATION AT LATHROP, NEAR THE NORTHEAST END OF STEEL
HS0515'DRAWBRIDGE 78.24 OVER THE SAN JOAQUIN RIVER, 96 FEET NORTHEAST
HS0515'OF THE NORTHEAST END OF THE SOUTHEAST STEEL GIRDER, IN THE TOP
HS0515'OF THE SOUTHEAST END OF THE SOUTHWEST CONCRETE ABUTMENT FOR THE
HS0515'WOODEN TRESTLE AT THE NORTHEAST END OF THE BRIDGE, 26.8 FEET
HS0515'EAST-NORTHEAST OF TRIANGULATION STATION BRIDGES, 20.7 FEET
HS0515'SOUTHEAST OF THE SOUTHEAST RAIL OF THE TRACK, AND ABOUT 1 FOOT
HS0515'LOWER THAN THE TRACK.
HS0515
HS0515 STATION RECOVERY (2000)
HS0515
HS0515'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 2000 (GAS)
HS0515'15.6 KM (9.70 MI) SOUTHERLY ALONG INTERSTATE HIGHWAY 5 FROM THE
HS0515'JUNCTION OF STATE HIGHWAY 4 EAST IN STOCKTON, THENCE 0.5 KM (0.30 MI)
HS0515'SOUTHERLY ALONG THE LOUISE AVENUE EXIT RAMP, THENCE 0.1 KM (0.05 MI)
HS0515'WESTERLY ALONG LOUISE AVENUE, THENCE 2.7 KM (1.65 MI) SOUTHERLY ALONG
HS0515'MANTHEY ROAD, THENCE 0.3 KM (0.20 MI) SOUTHWESTERLY ALONG THE UNION
HS0515'PACIFIC RAILROAD, IN TOP OF AND 0.3 M (1.0 FT) NORTHWEST OF THE
HS0515'SOUTHEAST END OF THE SOUTHWEST CONCRETE ABUTMENT OF A RAILROAD TRESTLE
HS0515'NORTHEAST OF THE RAILROAD DRAW BRIDGE SPANNING THE SAN JOAQUIN RIVER,
HS0515'8.3 M (27.2 FT) NORTHEAST OF TRIANGULATION STATION BRIDGES, 6.5 M
HS0515'(21.3 FT) SOUTHEAST OF THE NEAR RAIL, AND 0.4 M (1.3 FT) BELOW THE
HS0515'LEVEL OF THE TRACKS. NOTE--THE MONUMENT IS ON PROPERTY OWNED BY THE
HS0515'UNION PACIFIC RAILROAD, 833 EAST 8TH STREET, STOCKTON, CA 95206.
HS0515'TELEPHONE (916) 799-3832.

LEGEND

- PROJECT BENCHMARK
- PROJECT BOUNDARY

EXHIBIT A

RIVER ISLANDS

CITY OF LATHROP SAN JOAQUIN COUNTY CALIFORNIA

SCALE: 1"=4,000' DATE: JULY 16, 2009

Carlson, Barbee & Gibson, Inc.
CIVIL ENGINEERS • SURVEYORS • PLANNERS
6111 Bollinger Canyon Road, Suite 150 • San Ramon, CA 94583
925-866-0322 • fax 925-866-8575
www.cbandg.com

SHEET NUMBER
1
OF 1 SHEETS

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Attachment F

Levee Overtopping Maps

Figure F-1. Levee overtopping, 100-year flood event (1 of 2)
Figure F-2. Levee overtopping, 100-year flood event (2 of 2)
Figure F-3. Levee overtopping, 200-year flood event (1 of 2)
Figure F-4. Levee overtopping, 200-year flood event (2 of 2)

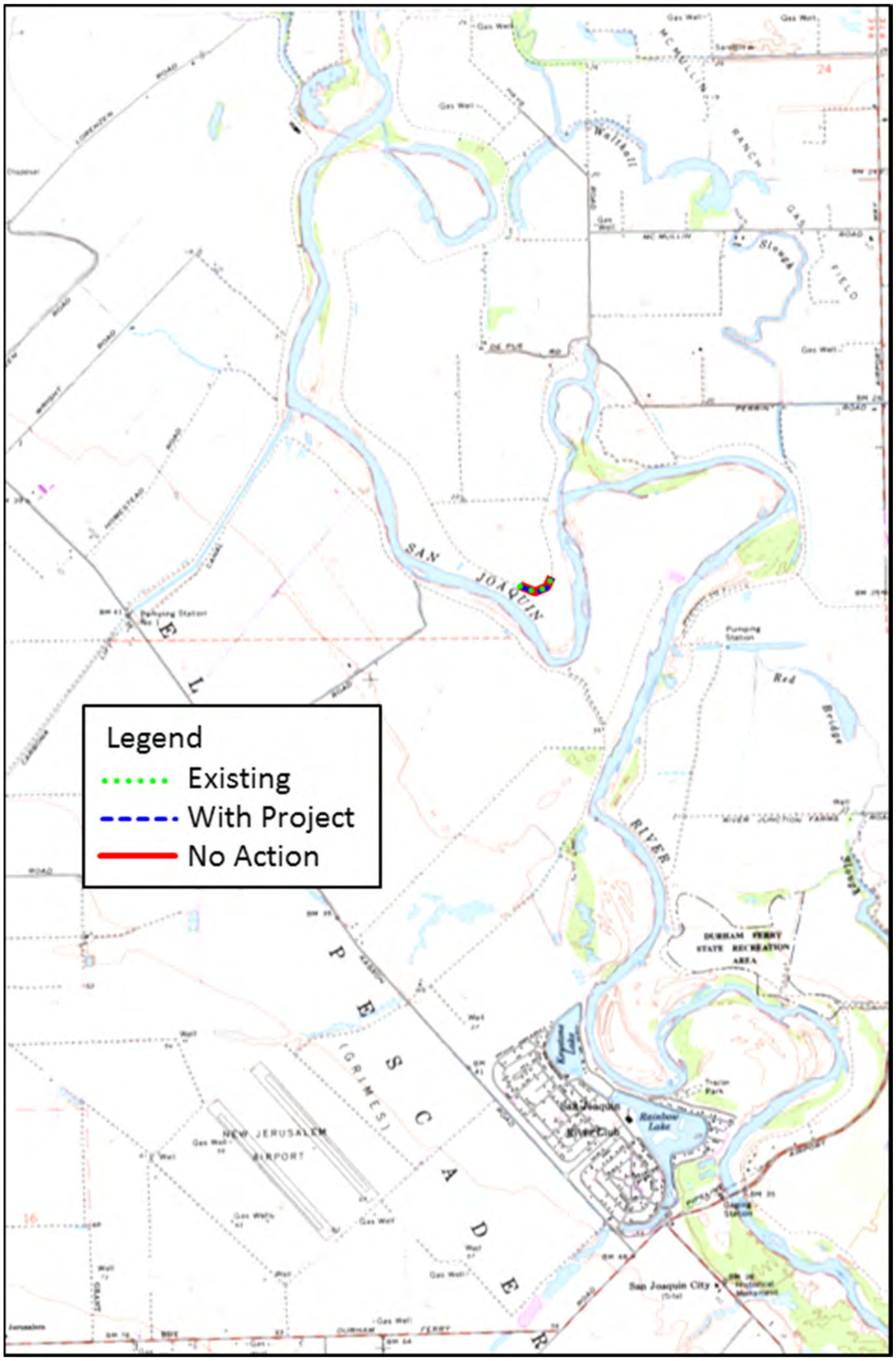


Figure F-1. Levee overtopping, 100-year flood event (1 of 2)

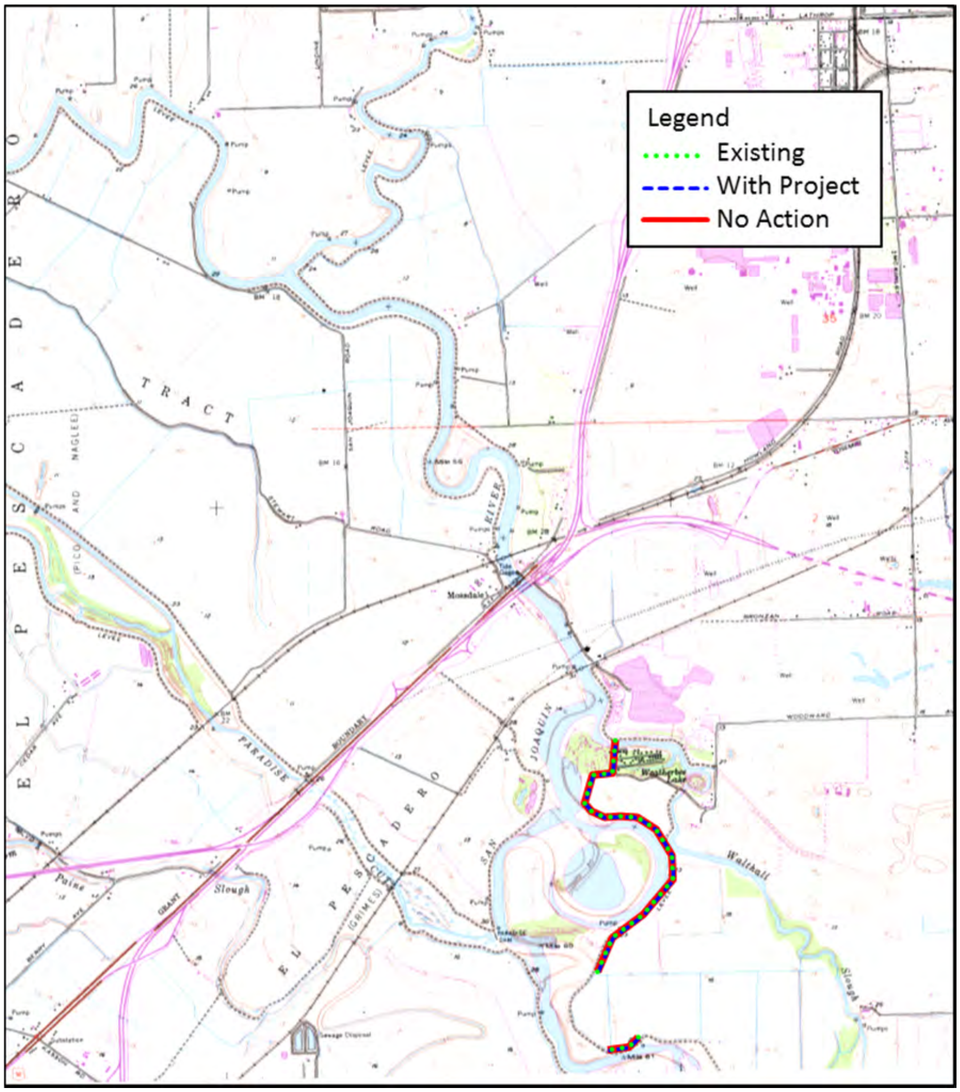


Figure F-2. Levee overtopping, 100-year flood event (2 of 2)

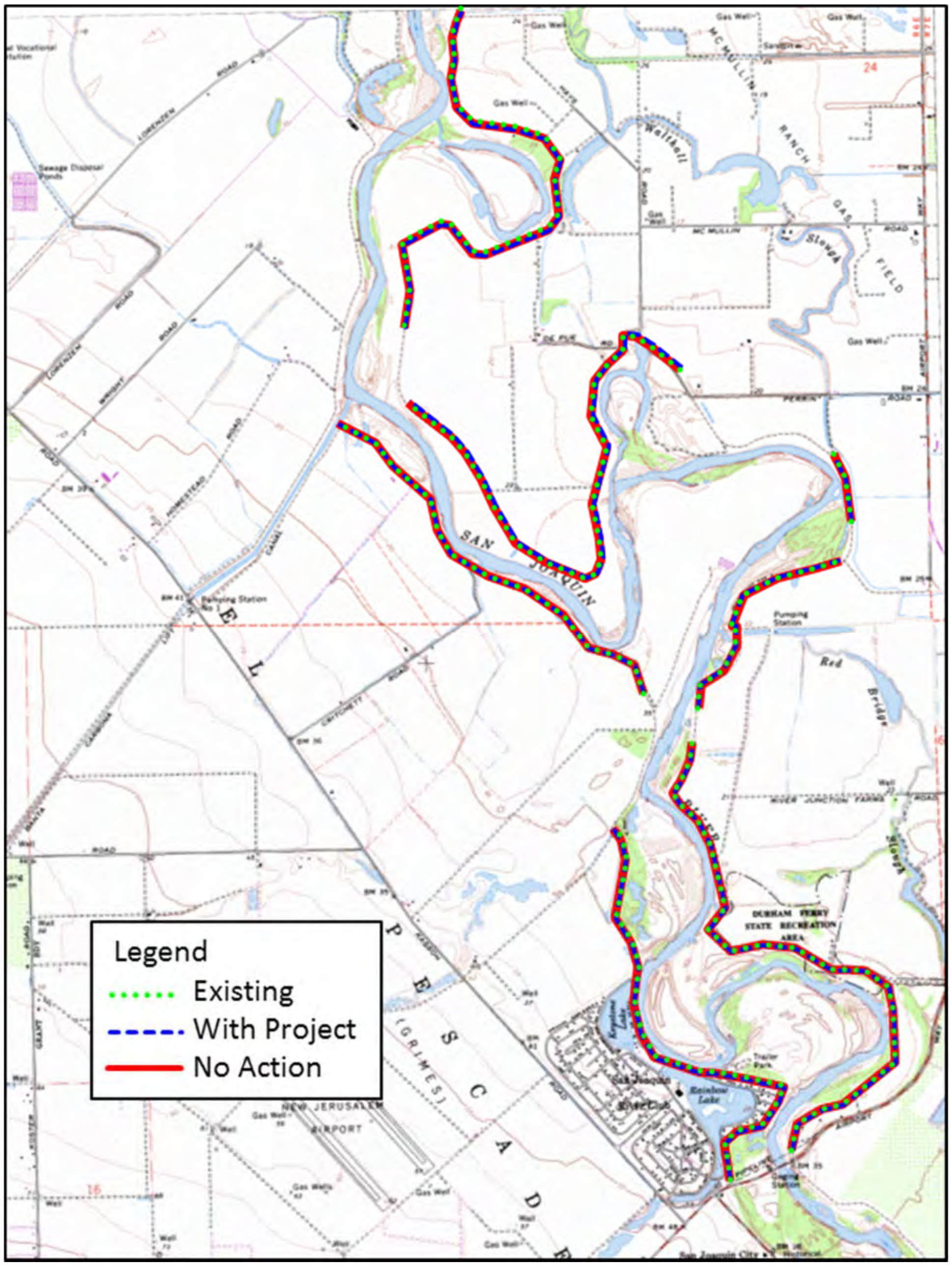


Figure F-3. Levee overtopping, 200-year flood event (1 of 2)

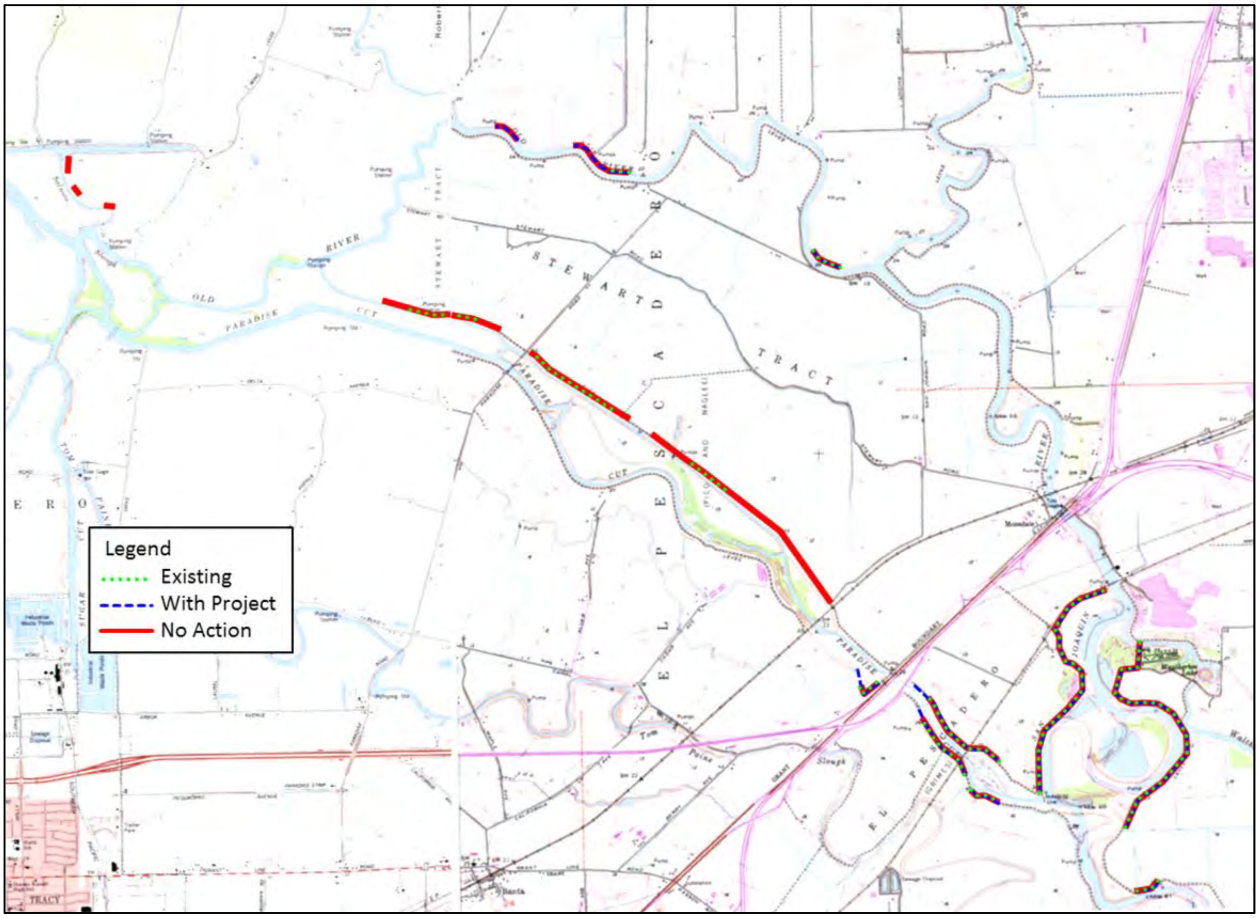


Figure F-4. Levee overtopping, 200-year flood event (2 of 2)

Attachment G

Peak Water Surface Elevation Profile Plots
Levees Breach when Water Reaches Top of Levee

Figure G-1. Maximum water surface elevation profiles, San Joaquin River, 50-year
Figure G-2. Changes in maximum water surface elevation profiles, San Joaquin River, 50-year
Figure G-3. Maximum water surface elevation profiles, San Joaquin River, 100-year
Figure G-4. Changes in maximum water surface elevation profiles, San Joaquin River, 100-year
Figure G-5. Maximum water surface elevation profiles, San Joaquin River, 200-year
Figure G-6. Changes in maximum water surface elevation profiles, San Joaquin River, 200-year
Figure G-7. Maximum water surface elevation profiles, San Joaquin River, 500-year
Figure G-8. Changes in maximum water surface elevation profiles, San Joaquin River, 500-year
Figure G-9. Maximum water surface elevation profiles, Paradise Cut, 50-year
Figure G-10. Changes in maximum water surface elevation profiles, Paradise Cut, 50-year
Figure G-11. Maximum water surface elevation profiles, Paradise Cut, 100-year
Figure G-12. Changes in maximum water surface elevation profiles, Paradise Cut, 100-year
Figure G-13. Maximum water surface elevation profiles, Paradise Cut, 200-year
Figure G-14. Changes in maximum water surface elevation profiles, Paradise Cut, 200-year
Figure G-15. Maximum water surface elevation profiles, Paradise Cut, 500-year
Figure G-16. Changes in maximum water surface elevation profiles, Paradise Cut, 500-year
Figure G-17. Maximum water surface elevation profiles, Old River, 50-year
Figure G-18. Changes in maximum water surface elevation profiles, Old River, 50-year
Figure G-19. Maximum water surface elevation profiles, Old River, 100-year
Figure G-20. Changes in maximum water surface elevation profiles, Old River, 100-year
Figure G-21. Maximum water surface elevation profiles, Old River, 200-year
Figure G-22. Changes in maximum water surface elevation profiles, Old River, 200-year
Figure G-23. Maximum water surface elevation profiles, Old River, 500-year
Figure G-24. Changes in maximum water surface elevation profiles, Old River, 500-year

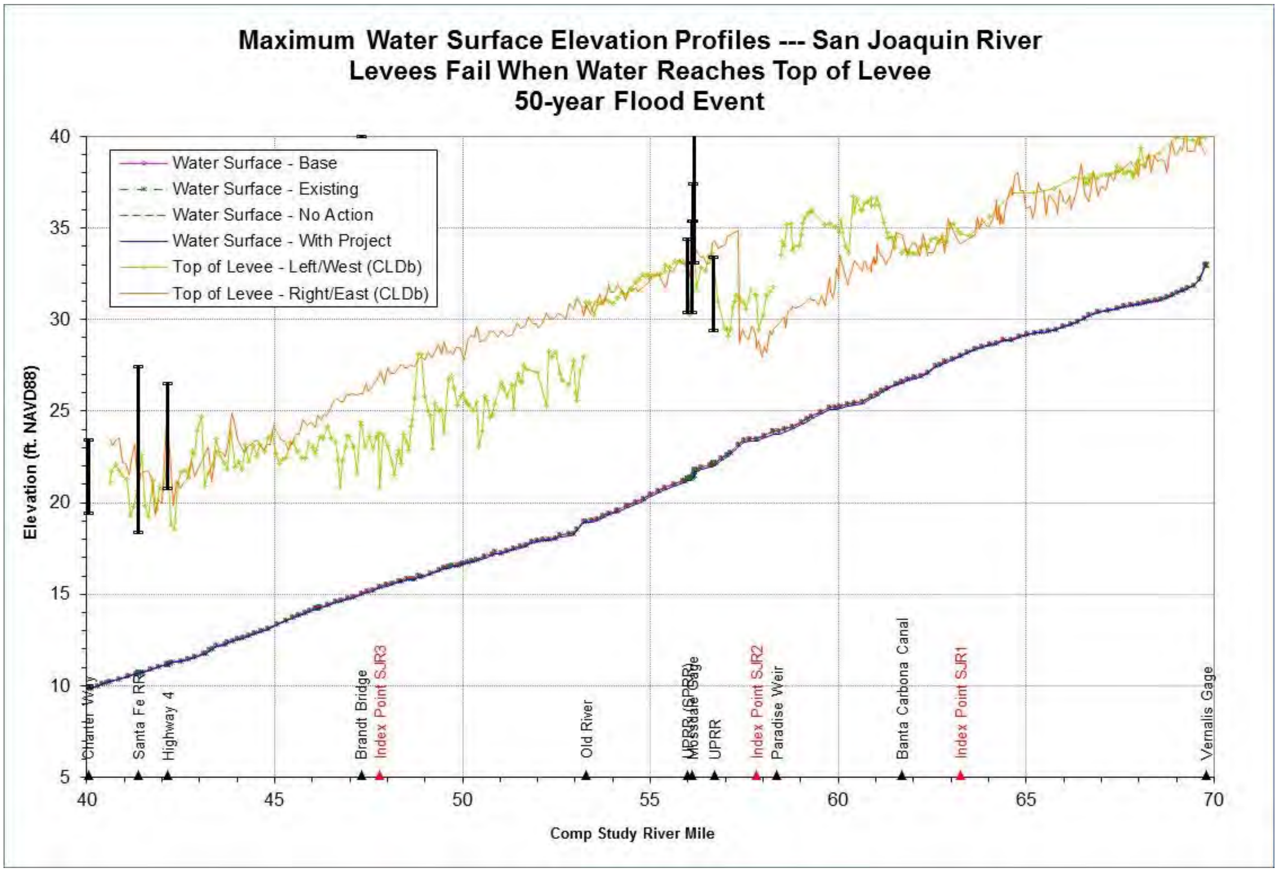


Figure G-1

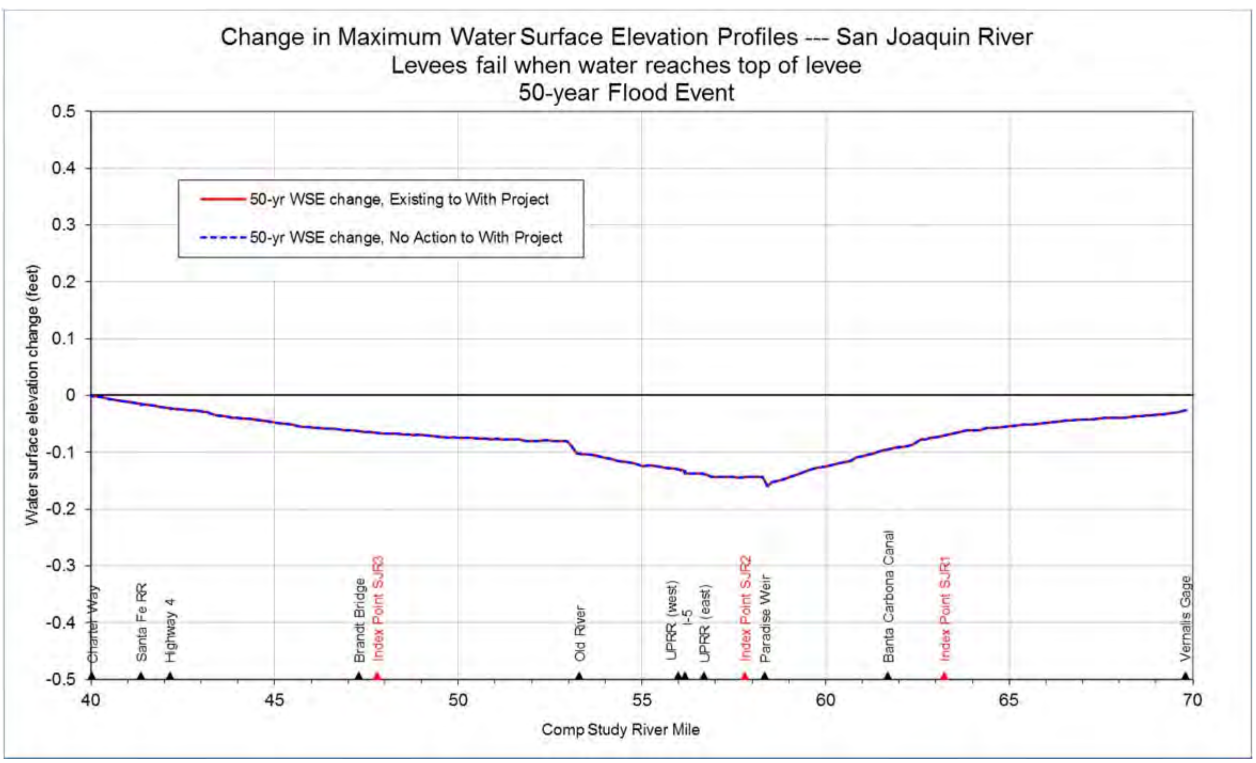
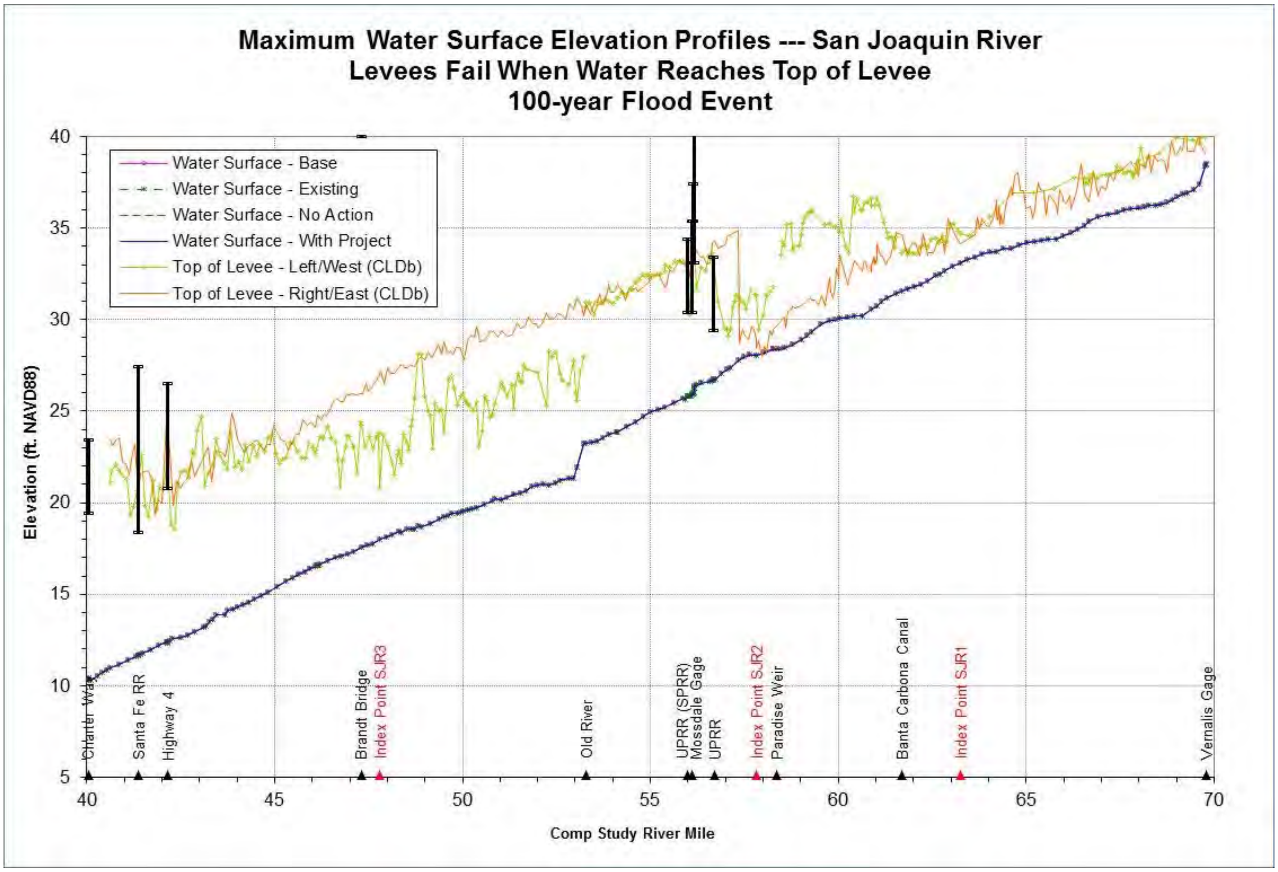


Figure G-2



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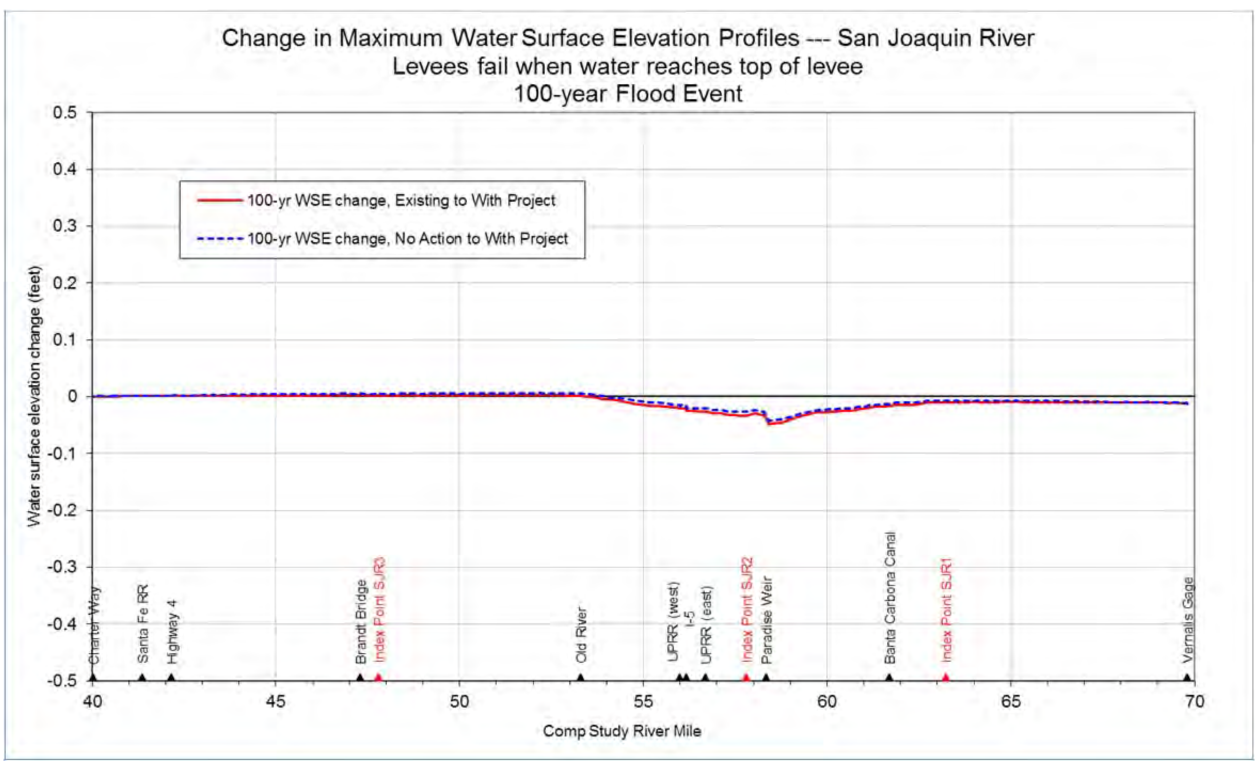
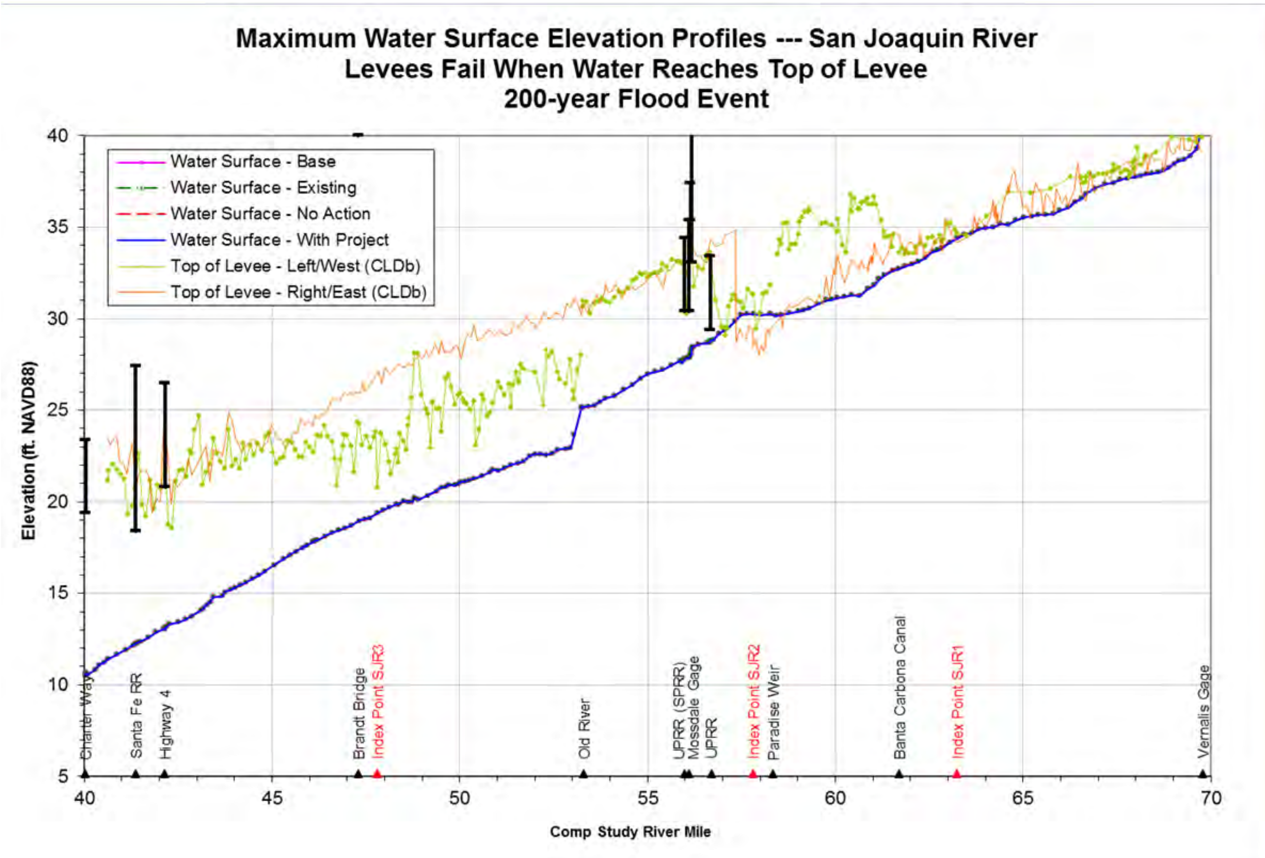


Figure G-4



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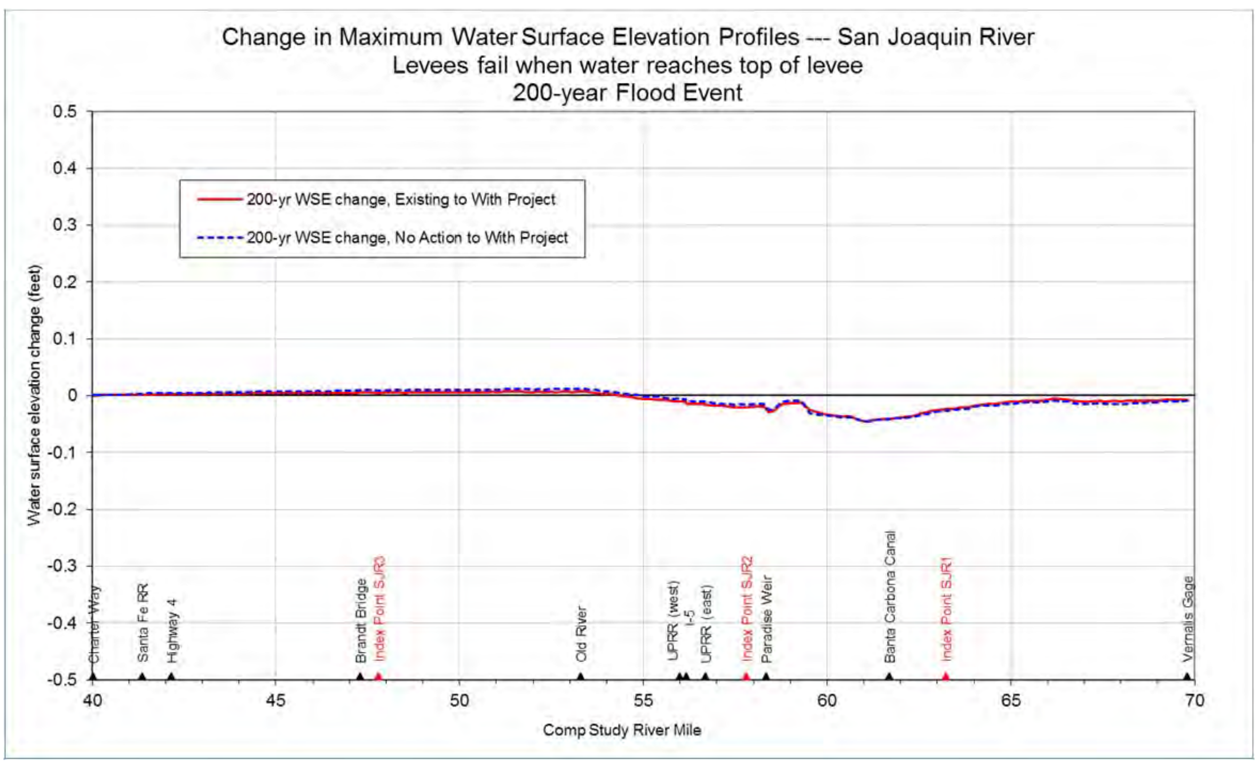
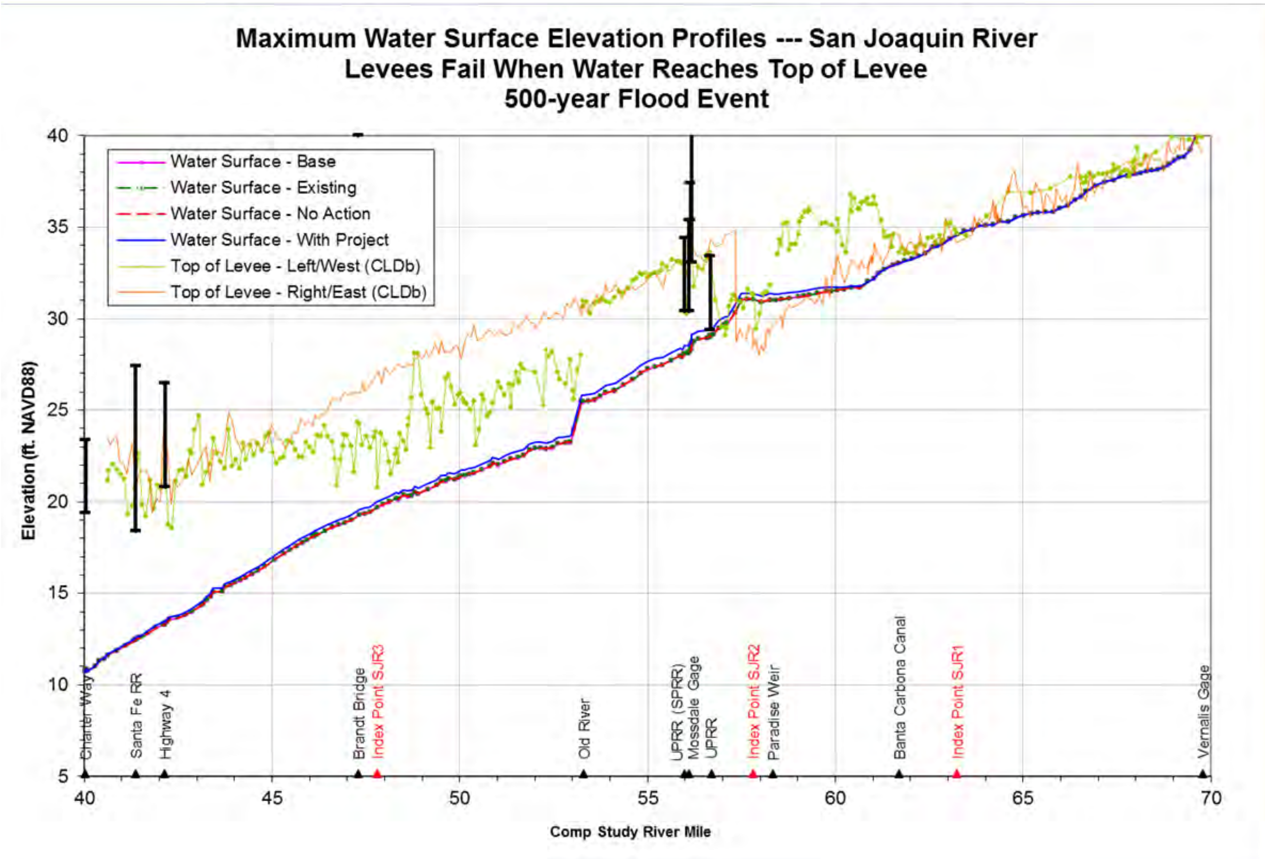


Figure G-6



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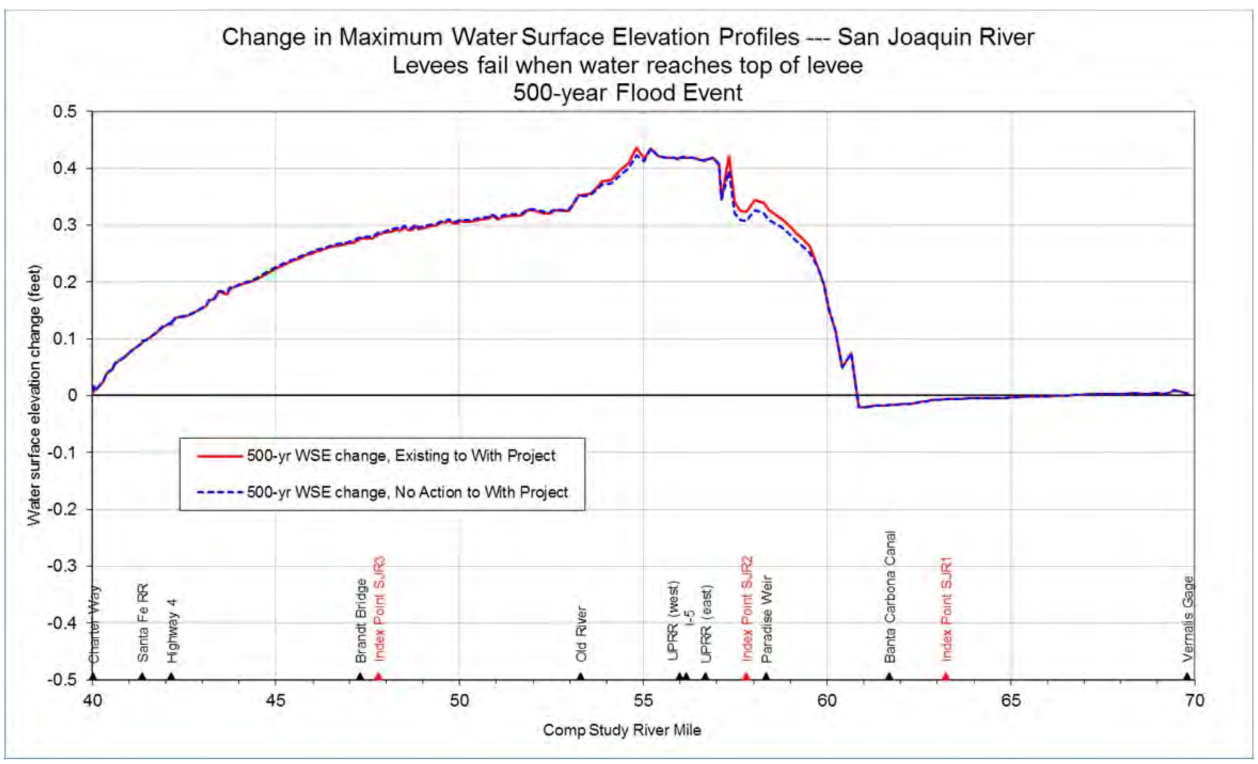
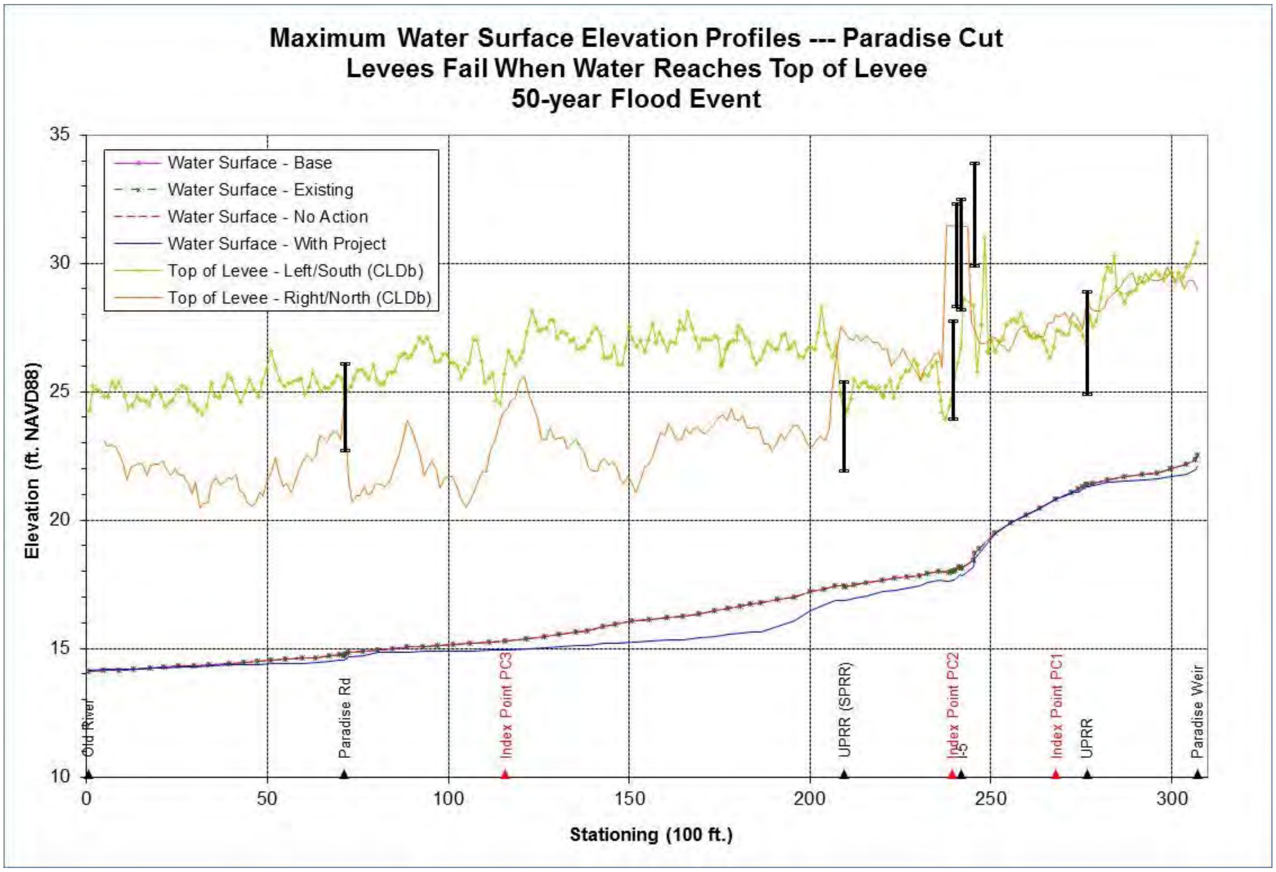


Figure G-8



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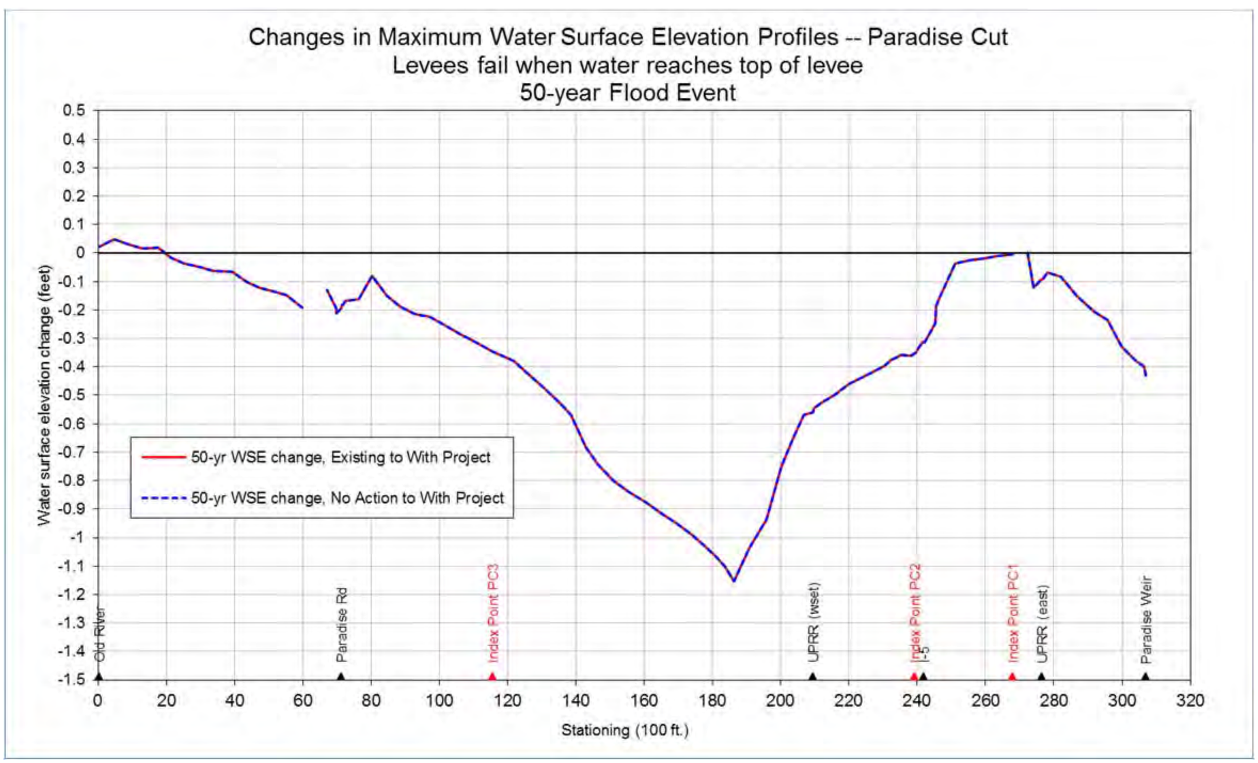


Figure G-10

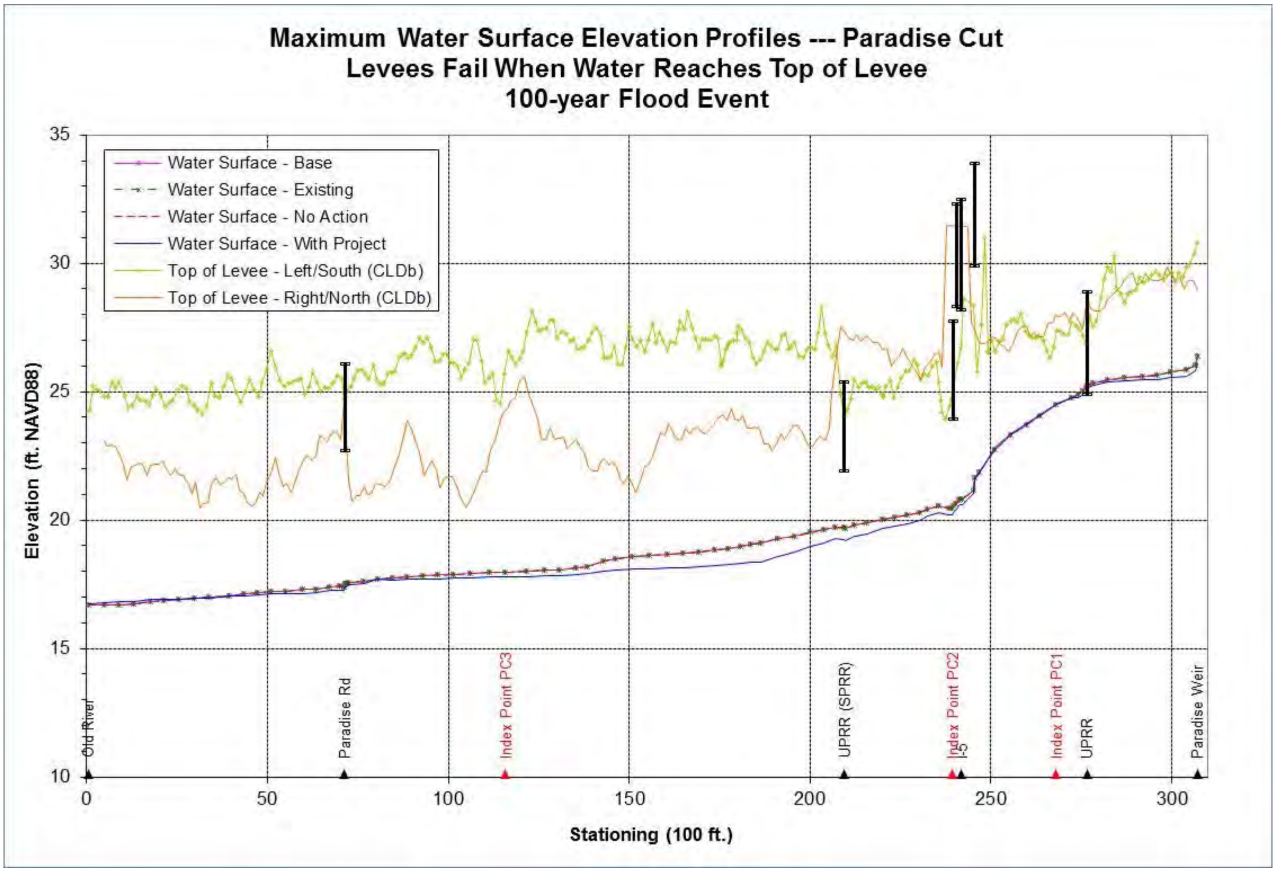


Figure G-11

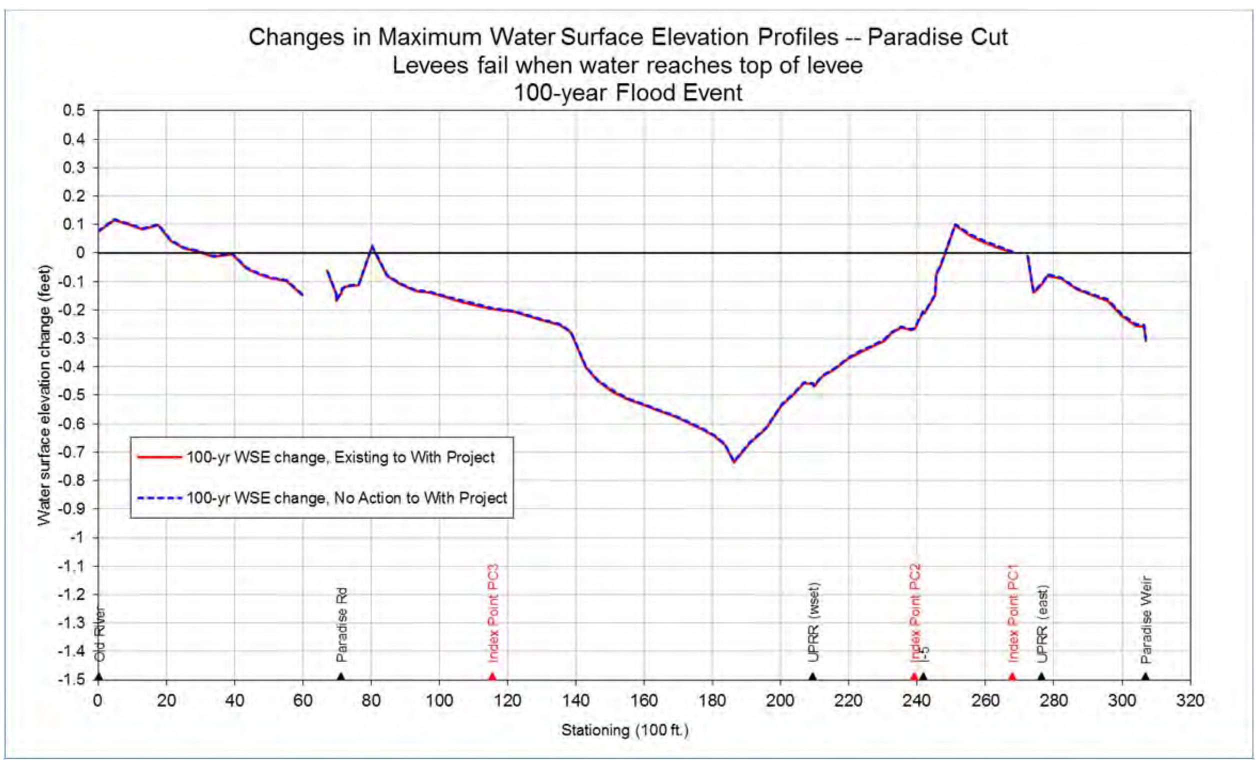
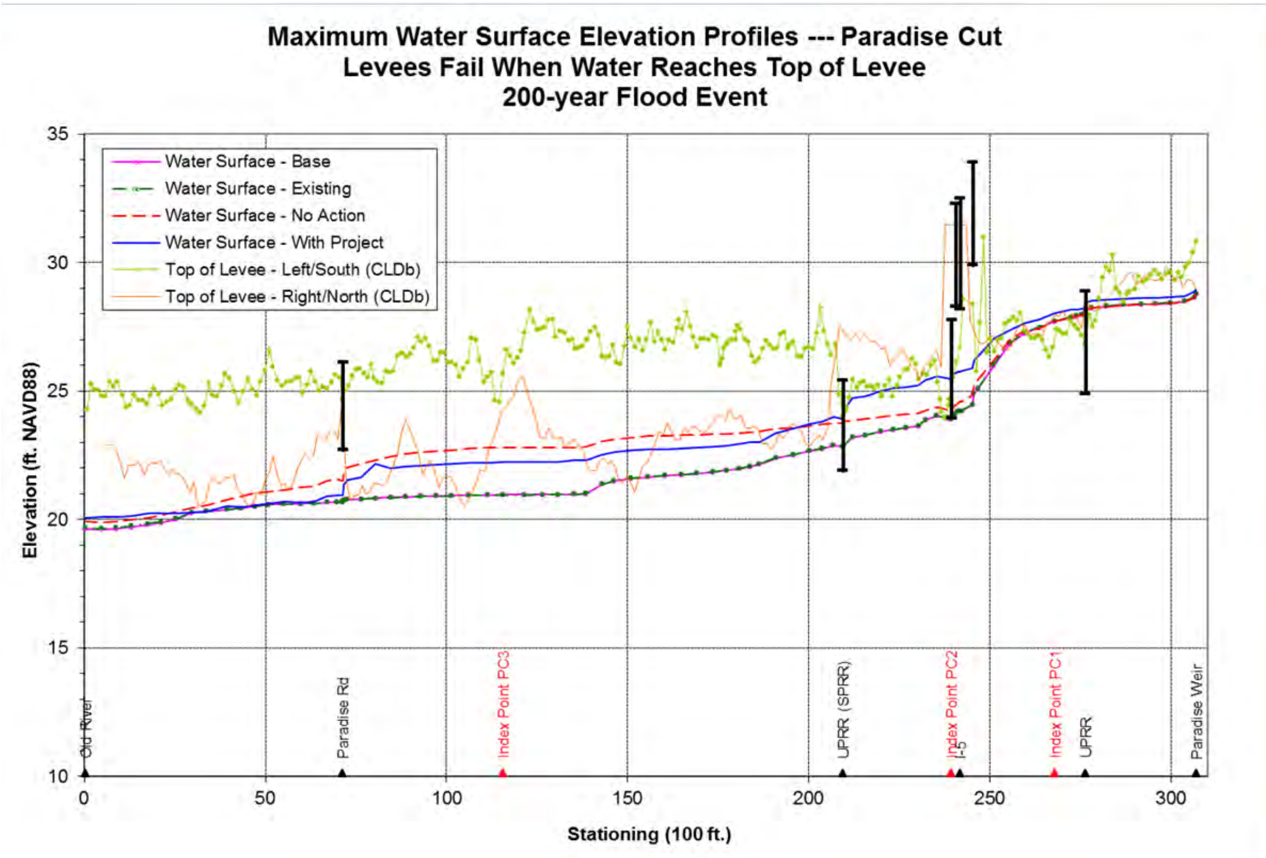


Figure G-12



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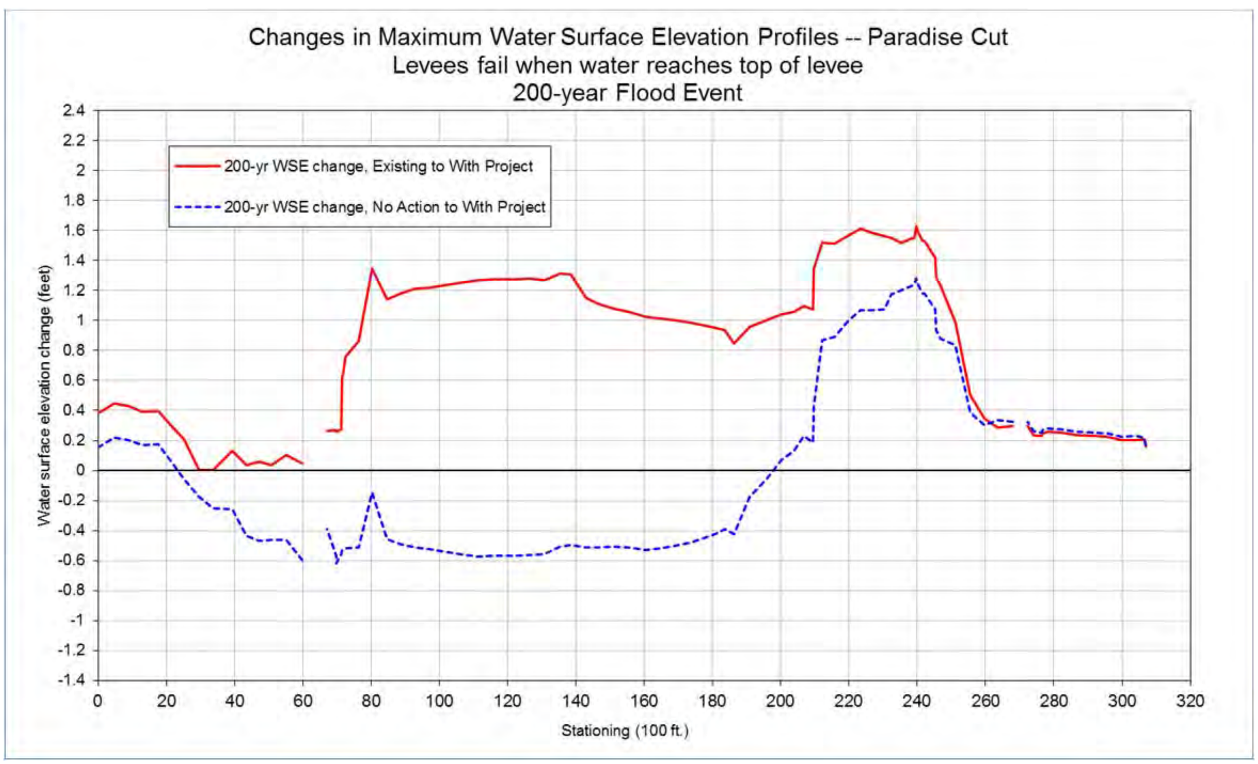

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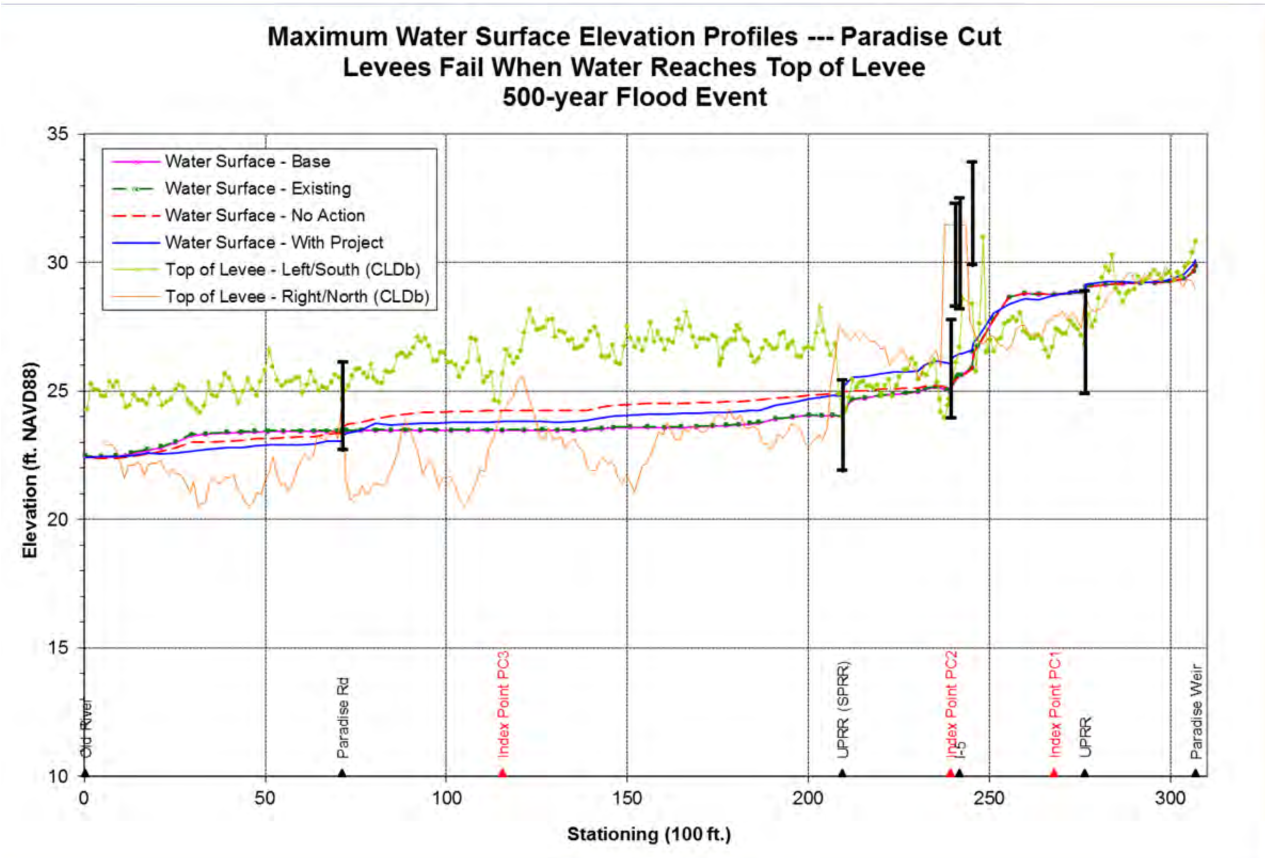

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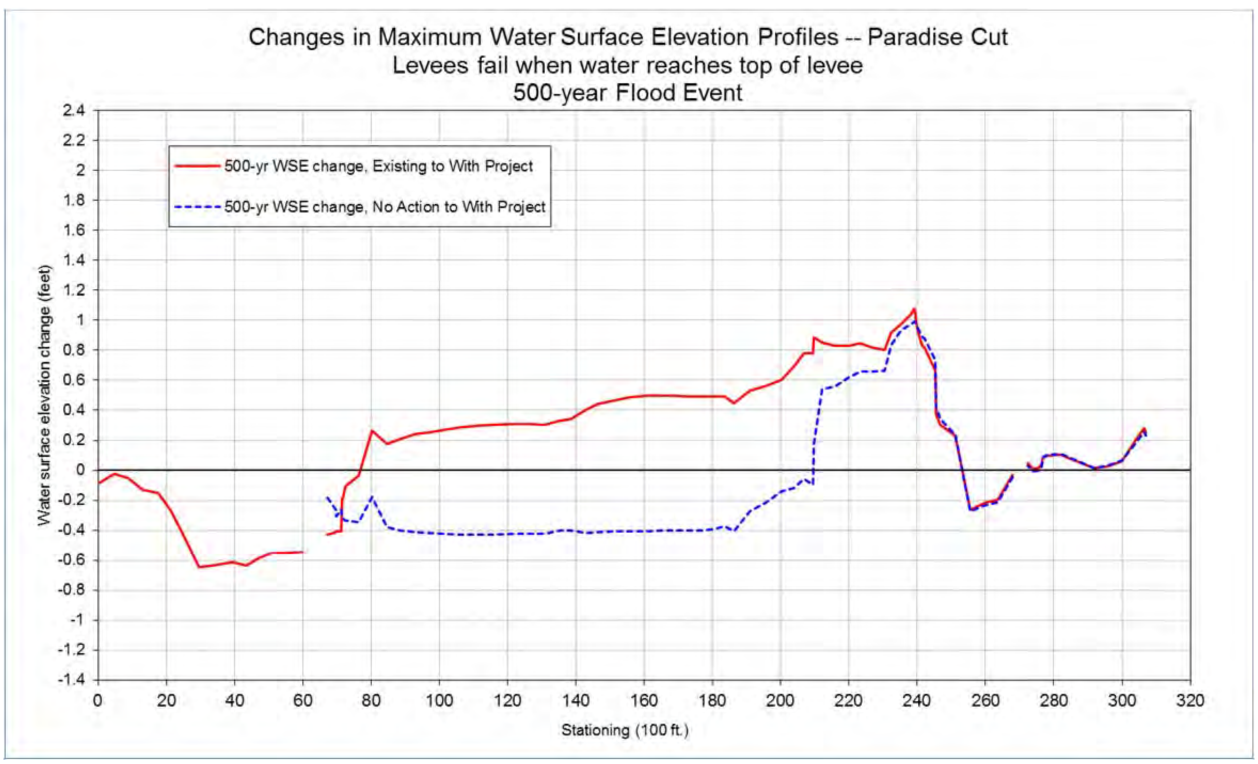

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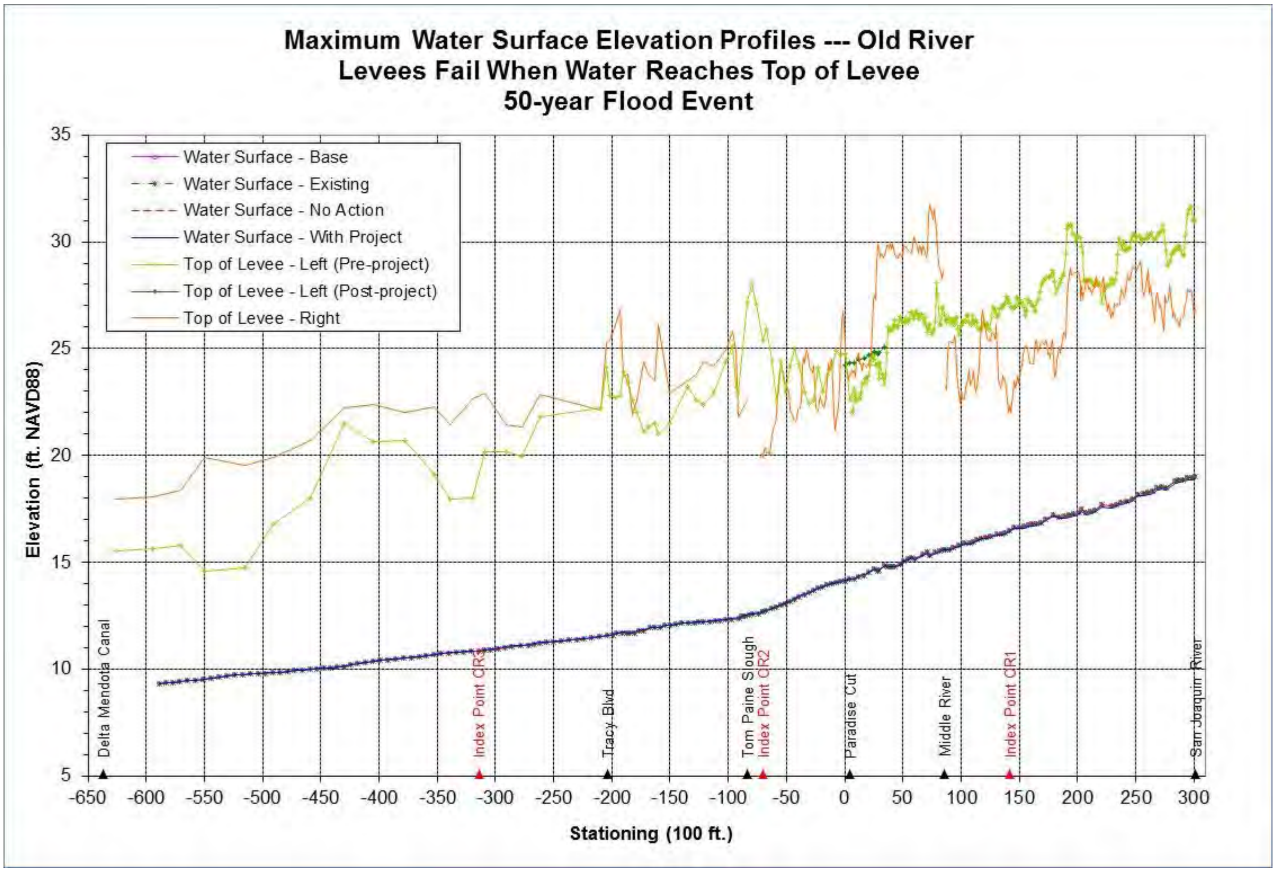

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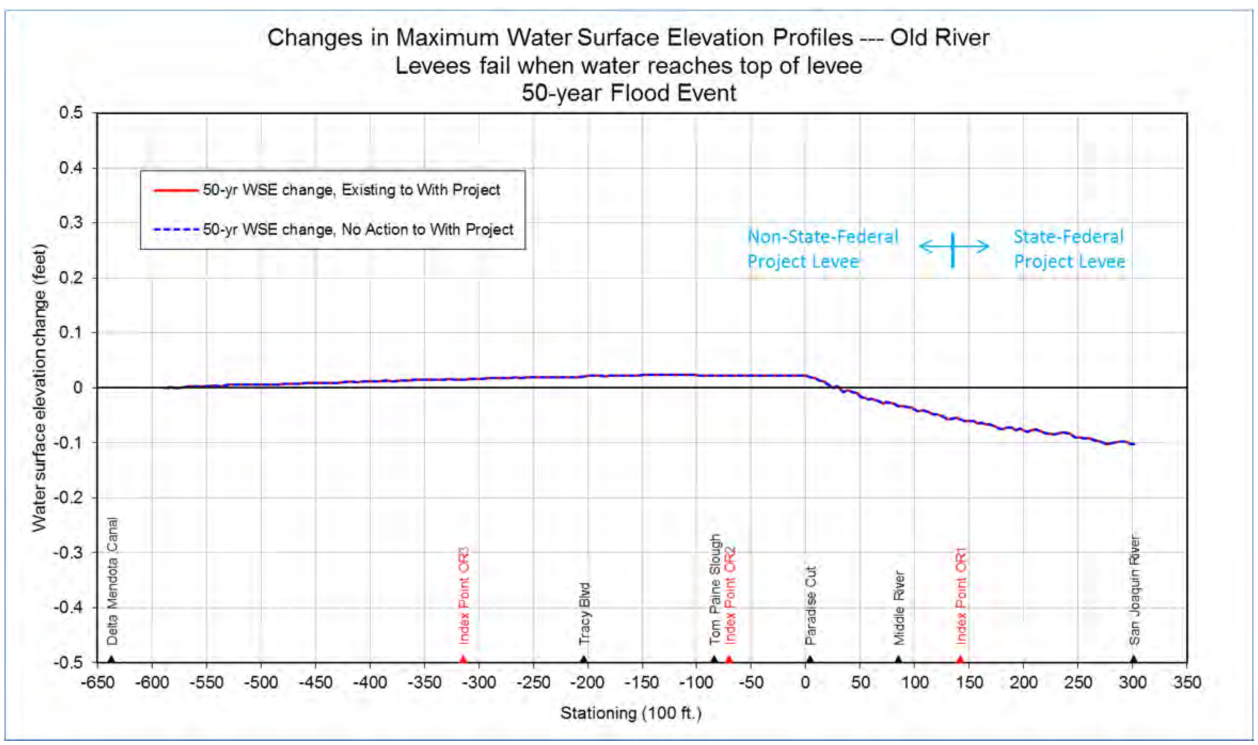

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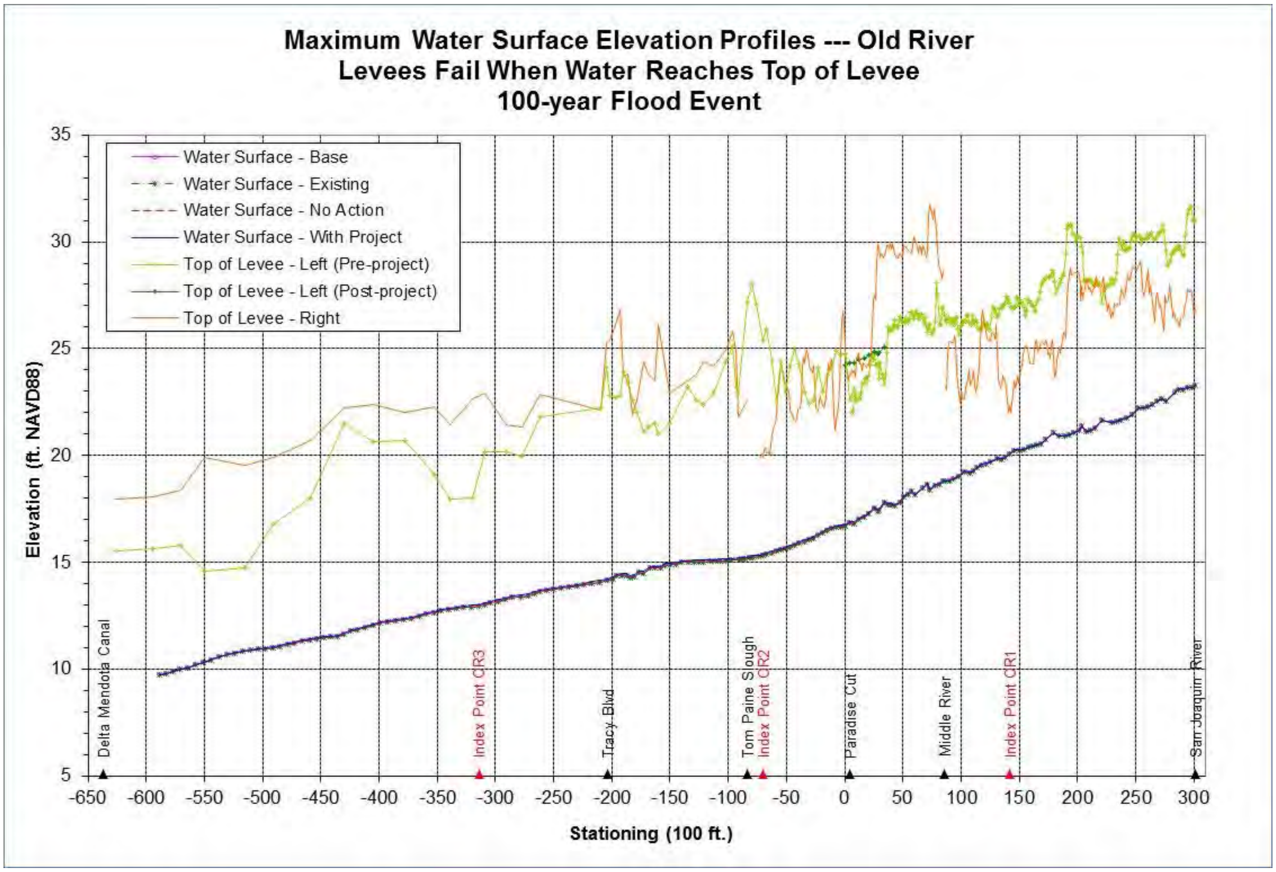

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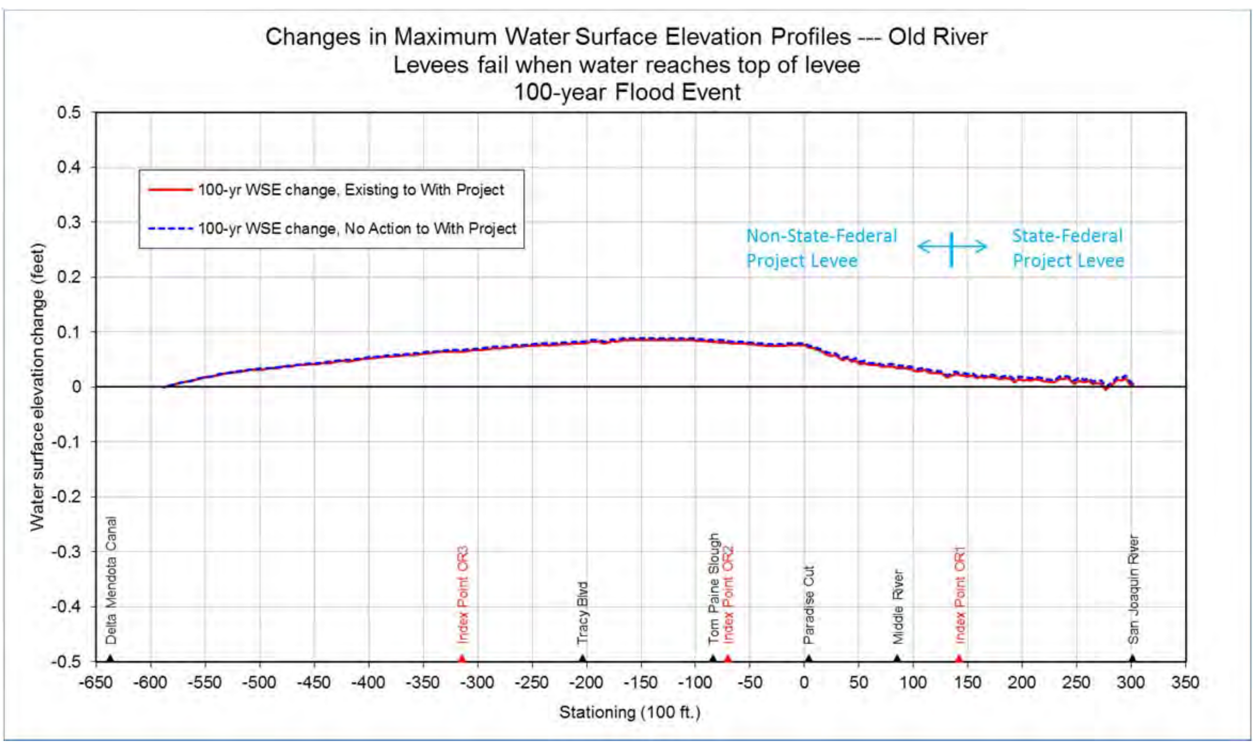


Figure G-20

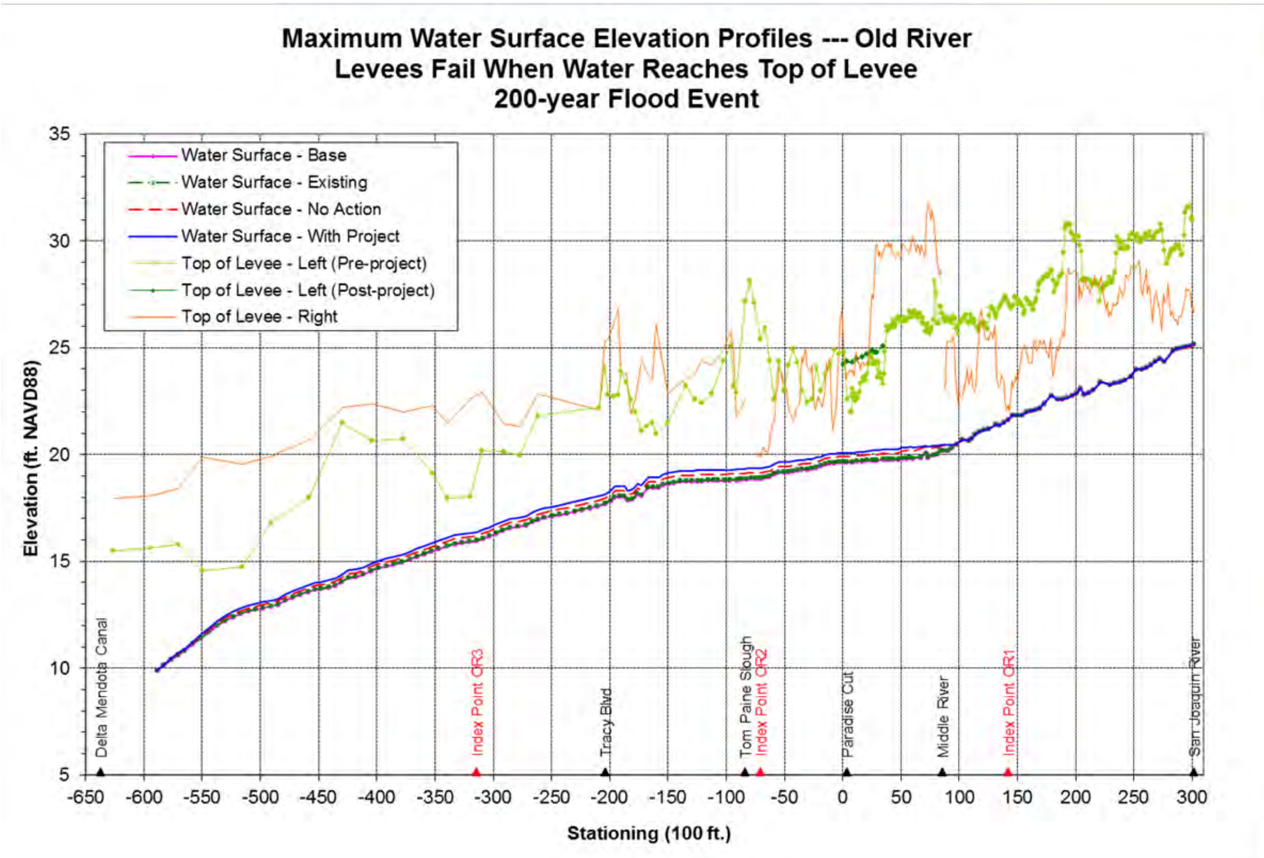


Figure G-21

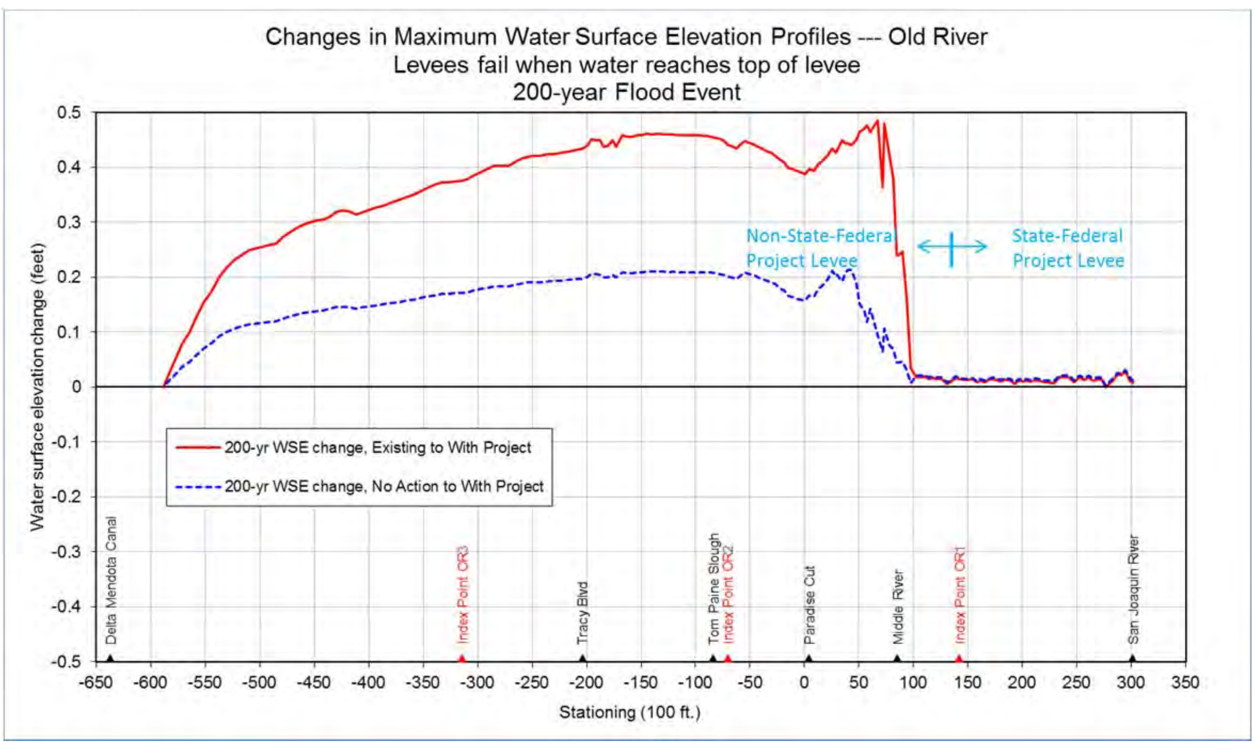


Figure G-22

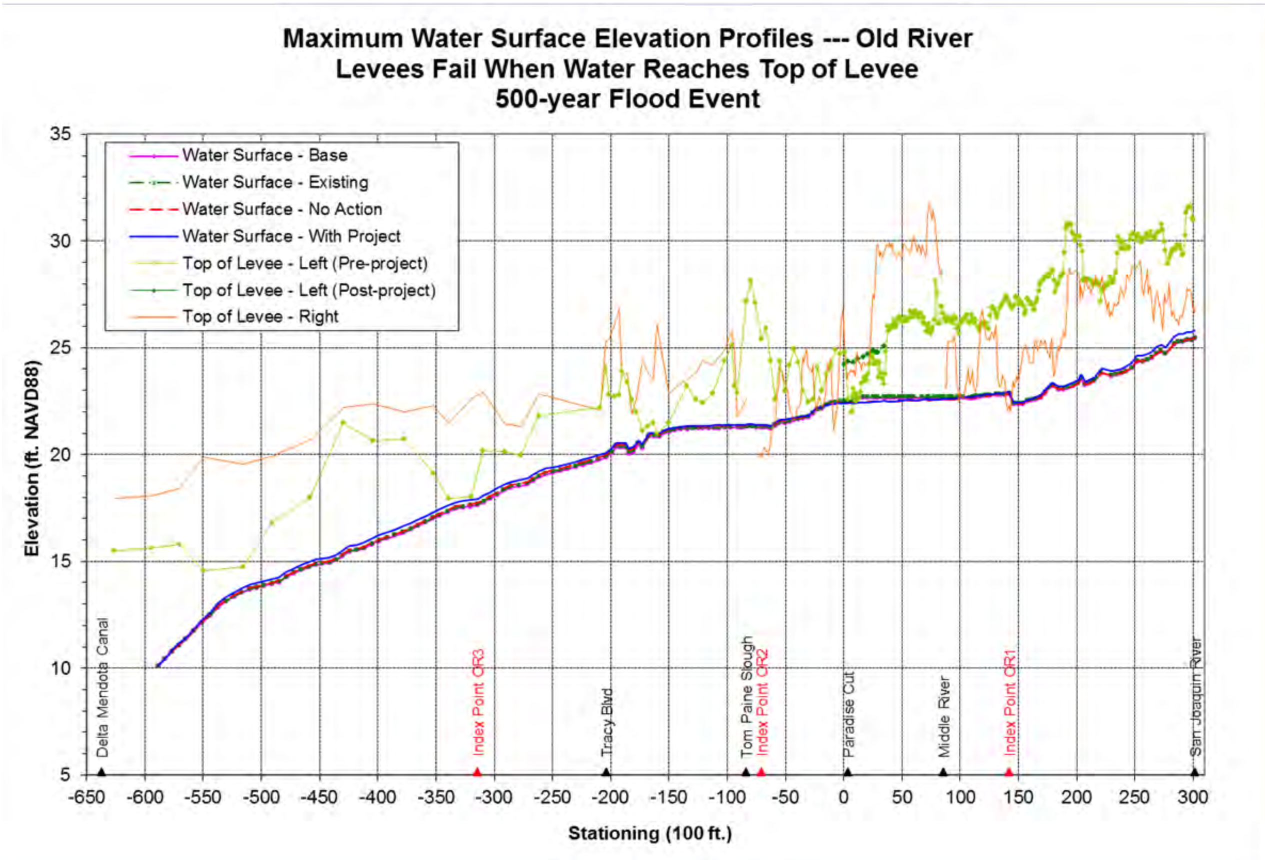


Figure G-23

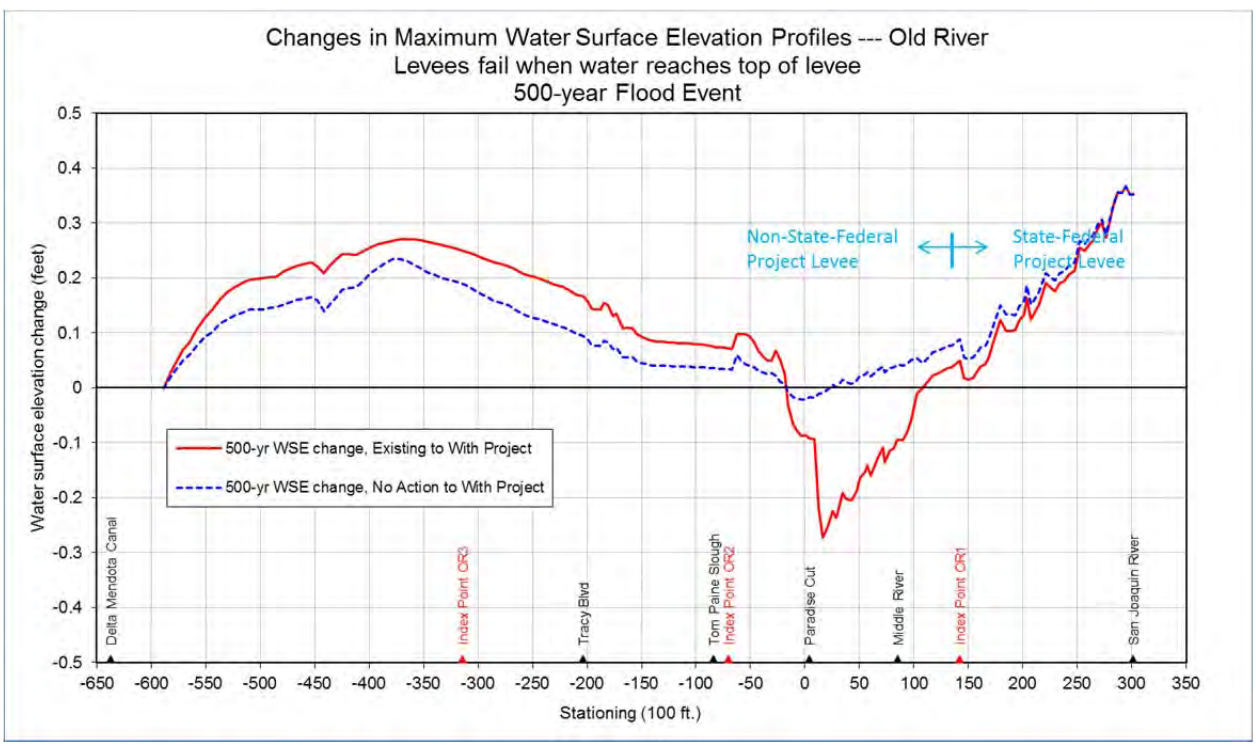


Figure G-24

Attachment H

Peak Water Surface Elevation Profile Plots
Levees Overtop Without Failing

Figure H-1. San Joaquin River, 50-year
Figure H-2. San Joaquin River, 100-year
Figure H-3. San Joaquin River, 200-year
Figure H-4. San Joaquin River, 500-year
Figure H-5. Paradise Cut, 50-year
Figure H-6. Paradise Cut, 100-year
Figure H-7. Paradise Cut, 200-year
Figure H-8. Paradise Cut, 500-year
Figure H-9. Old River, 50-year
Figure H-10. Old River, 100-year
Figure H-11. Old River, 200-year
Figure H-12. Old River, 500-year

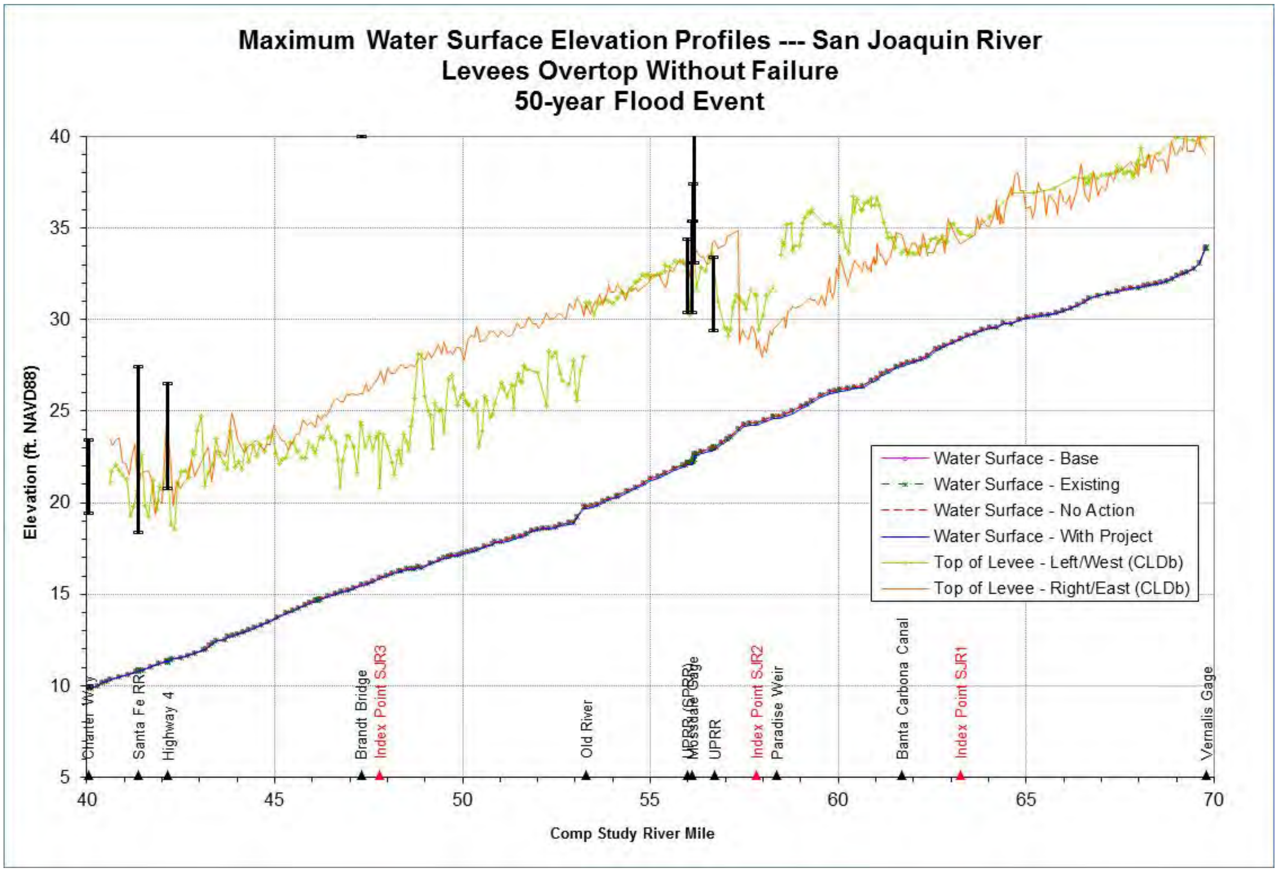


Figure H-1

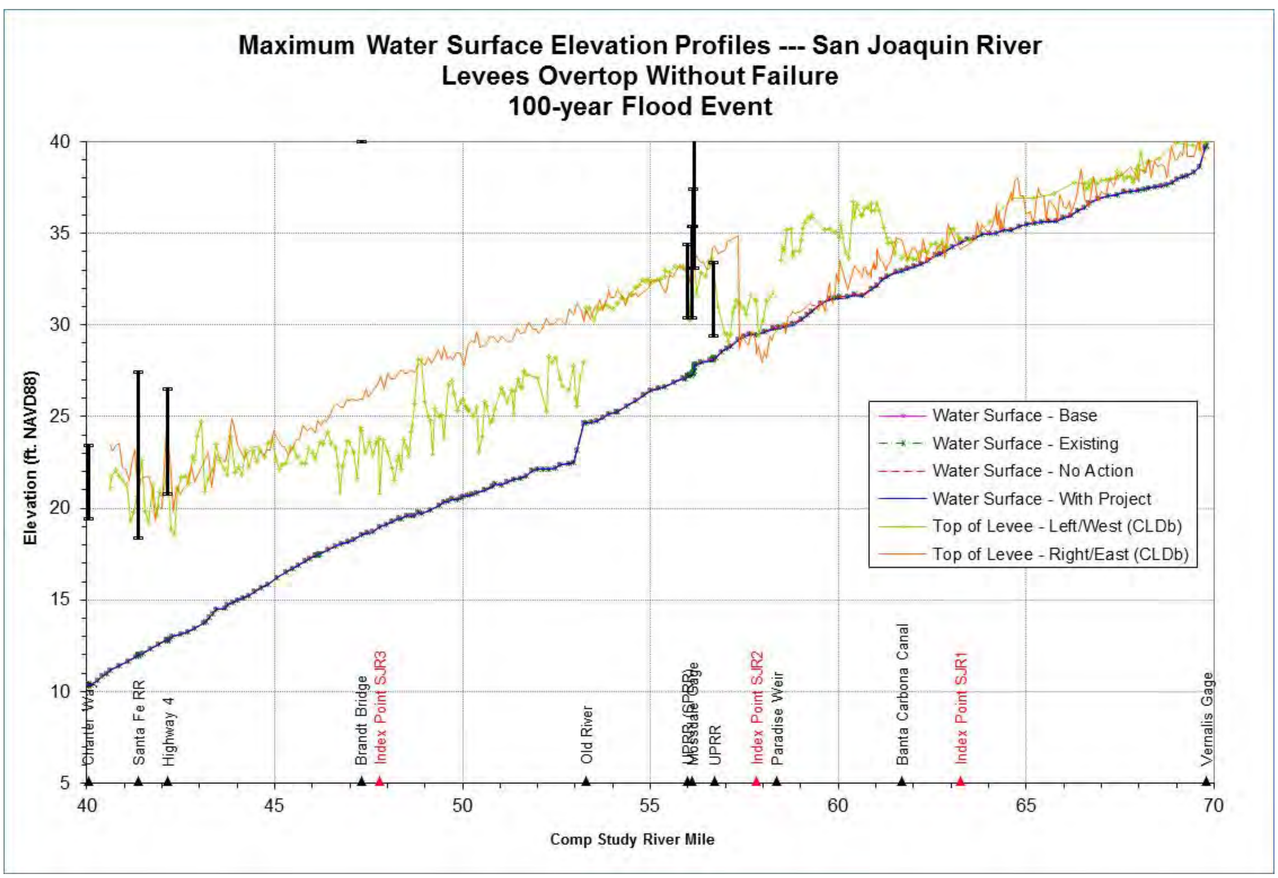
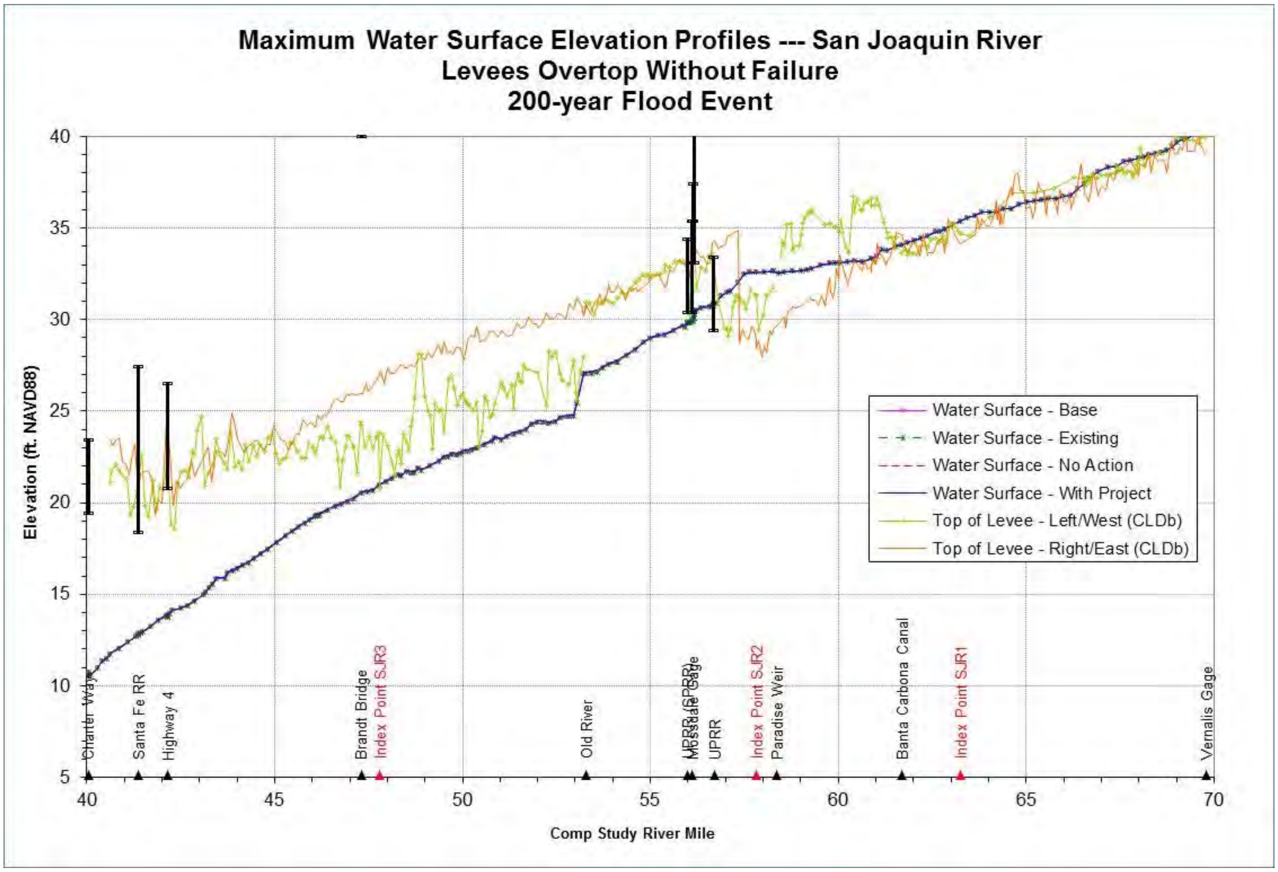


Figure H-2



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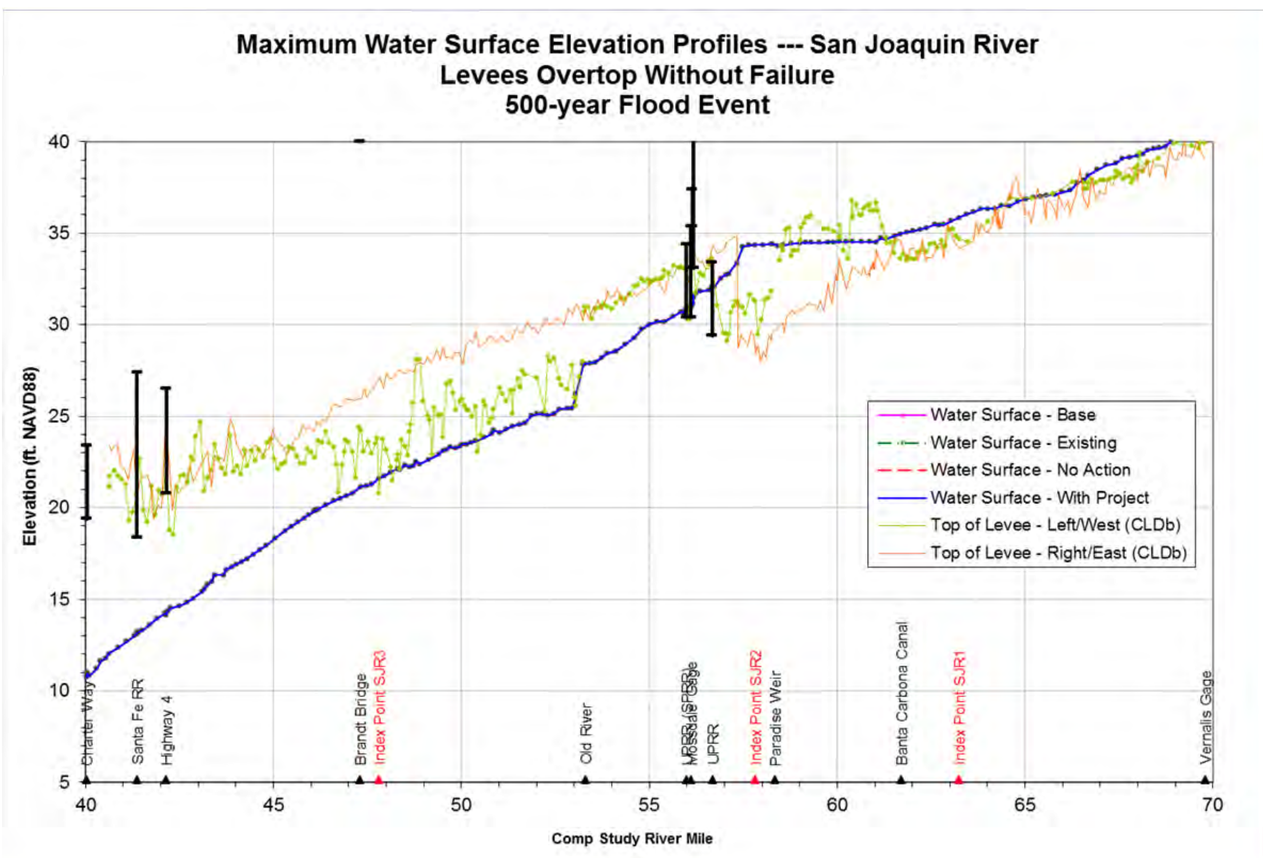


Figure H-4

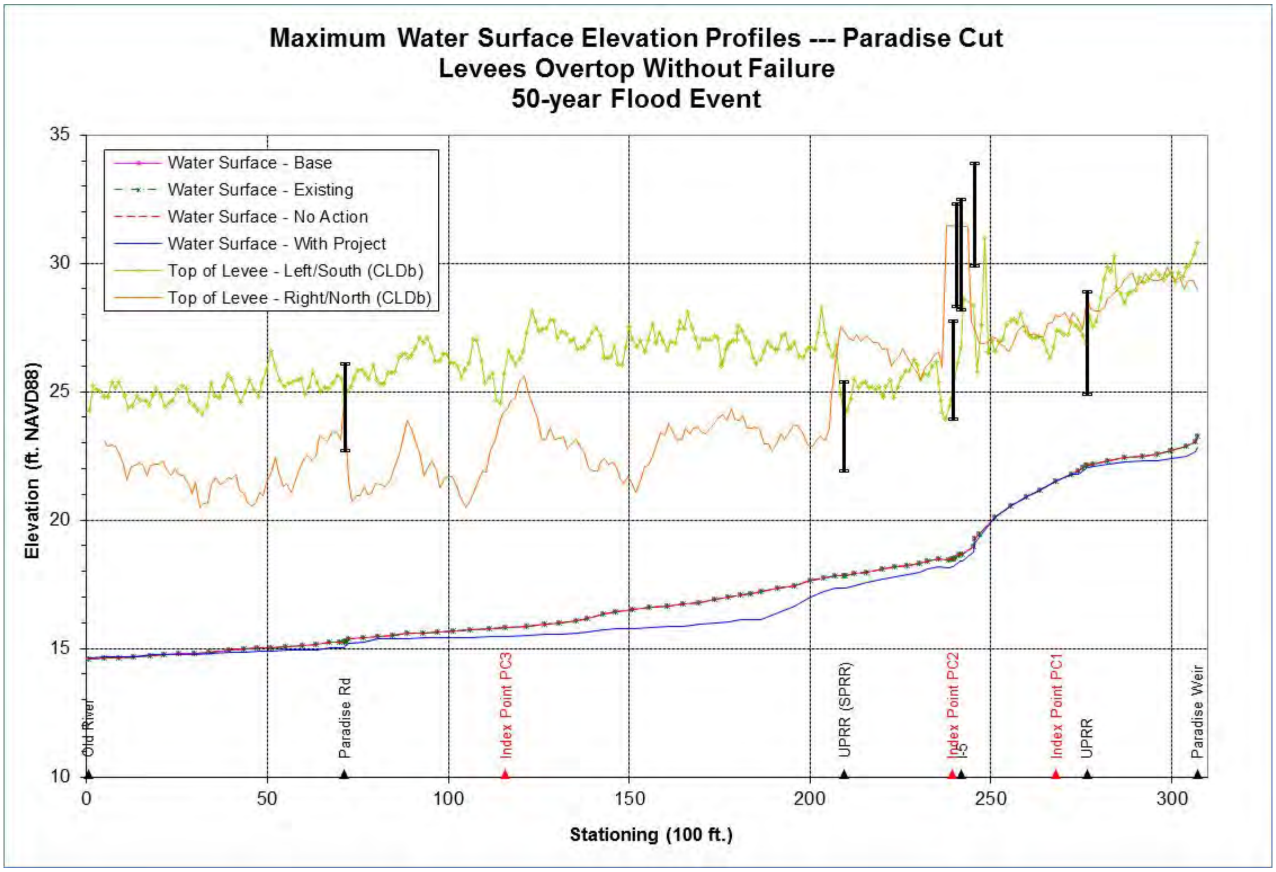


Figure H-5

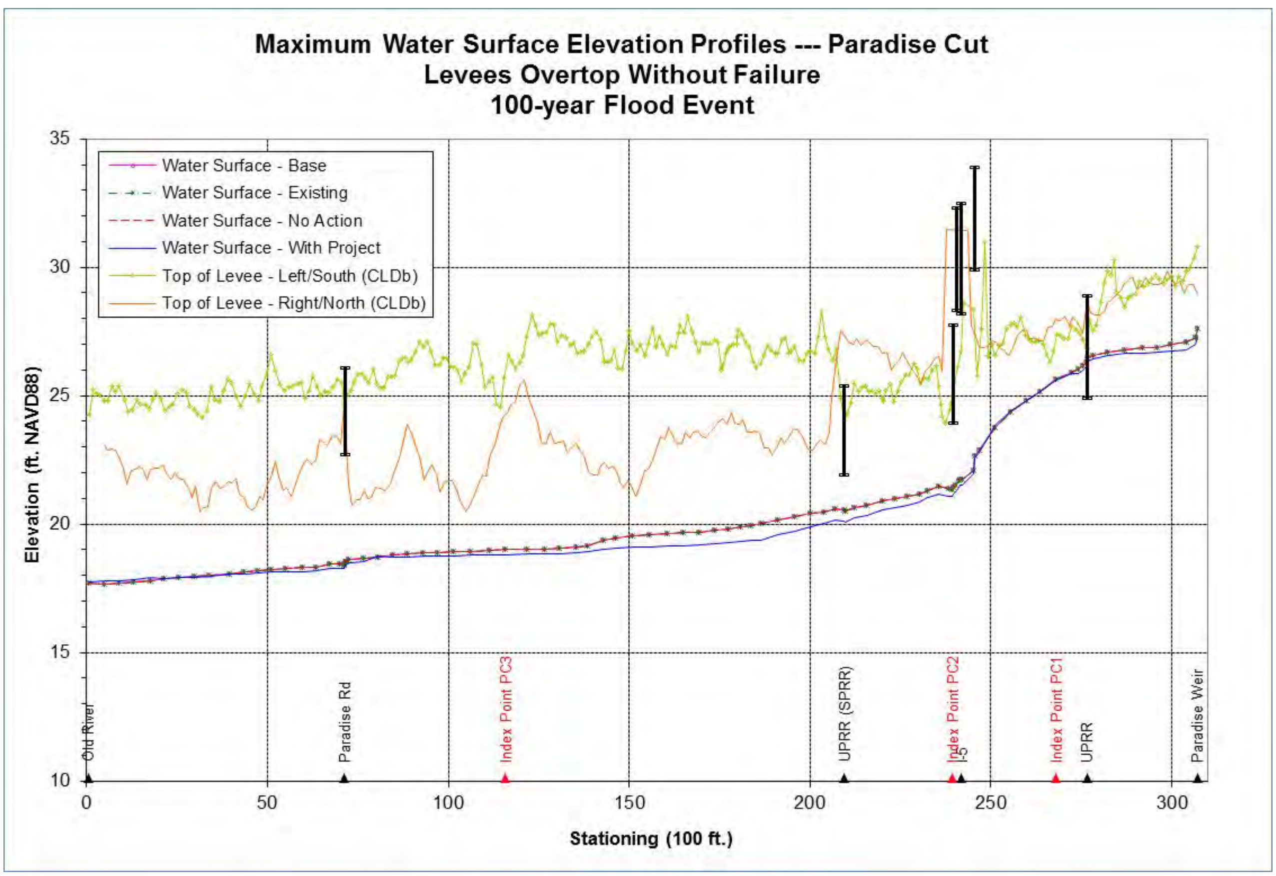
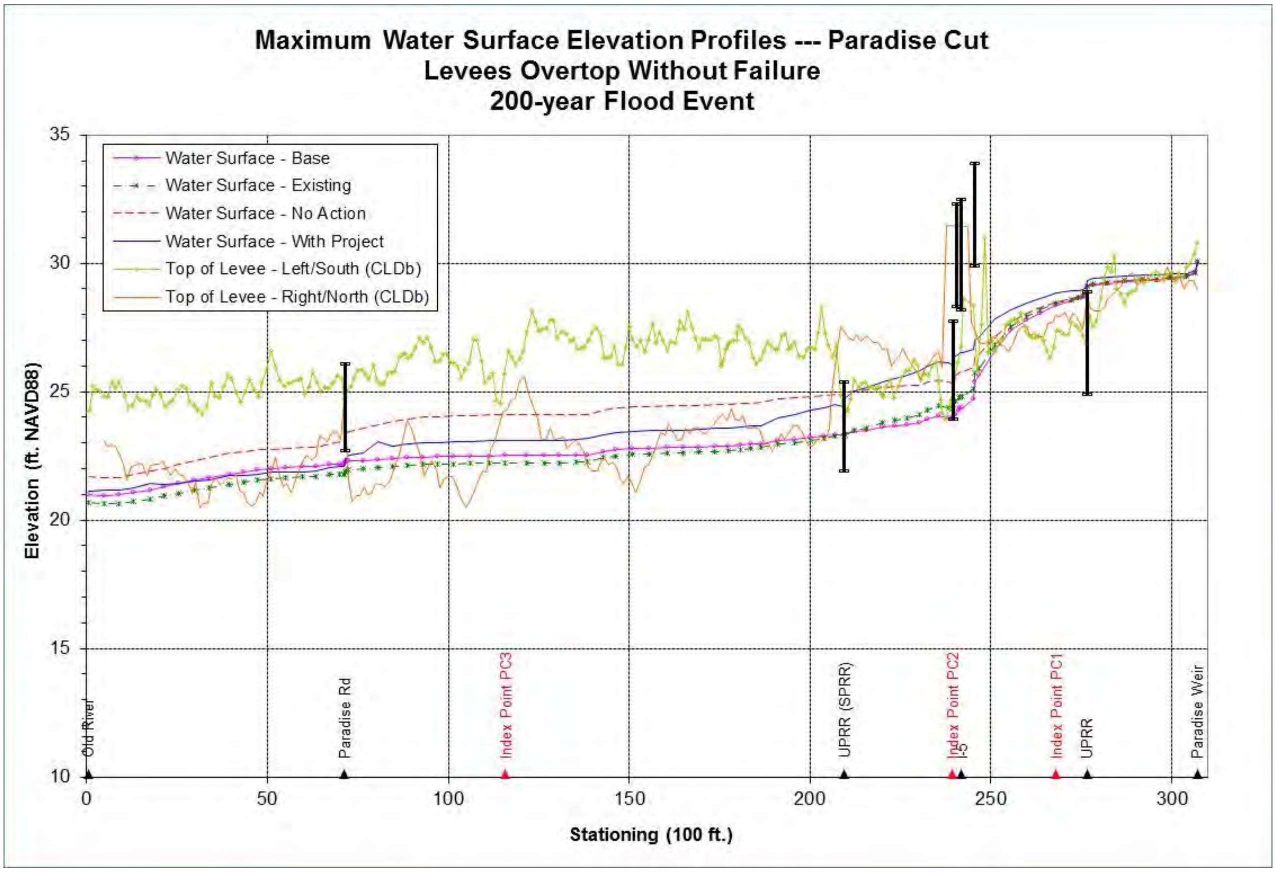


Figure H-6



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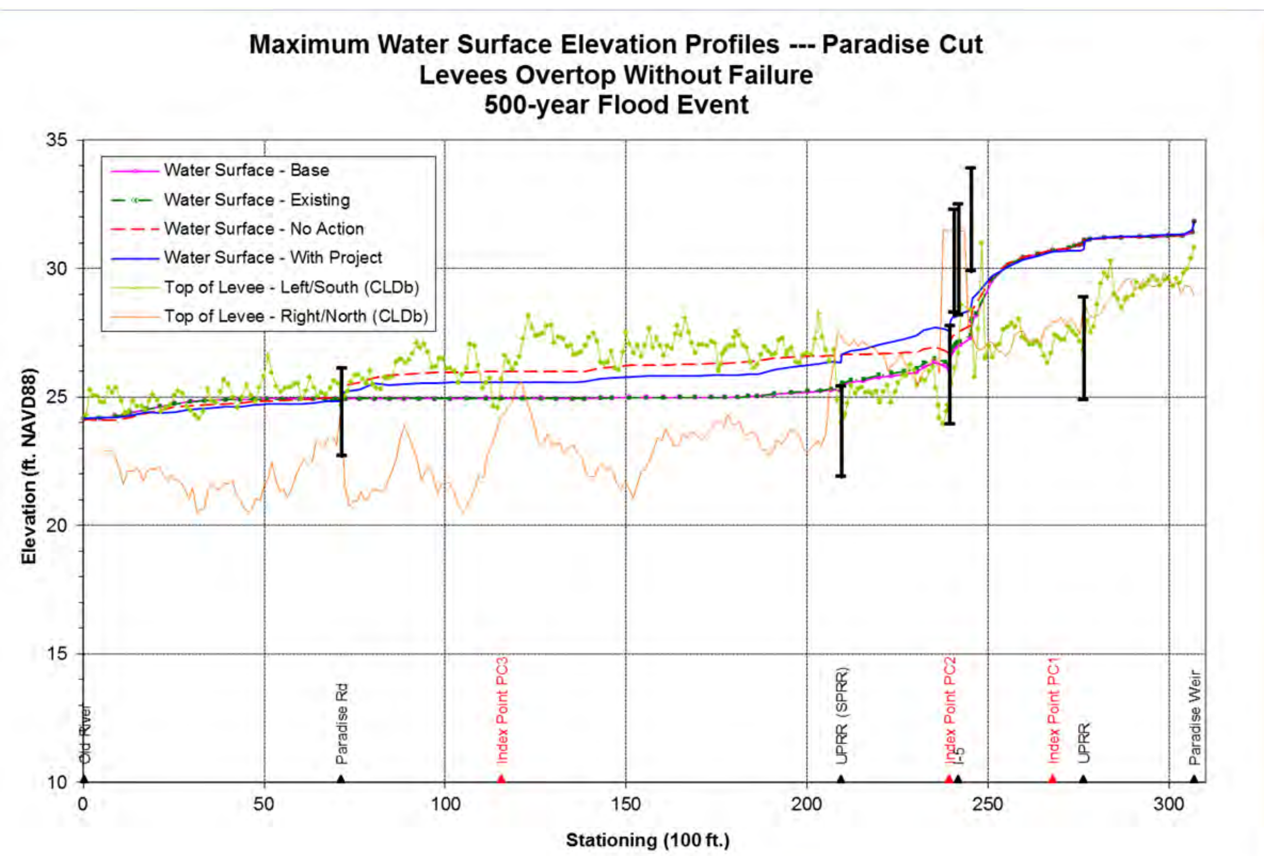

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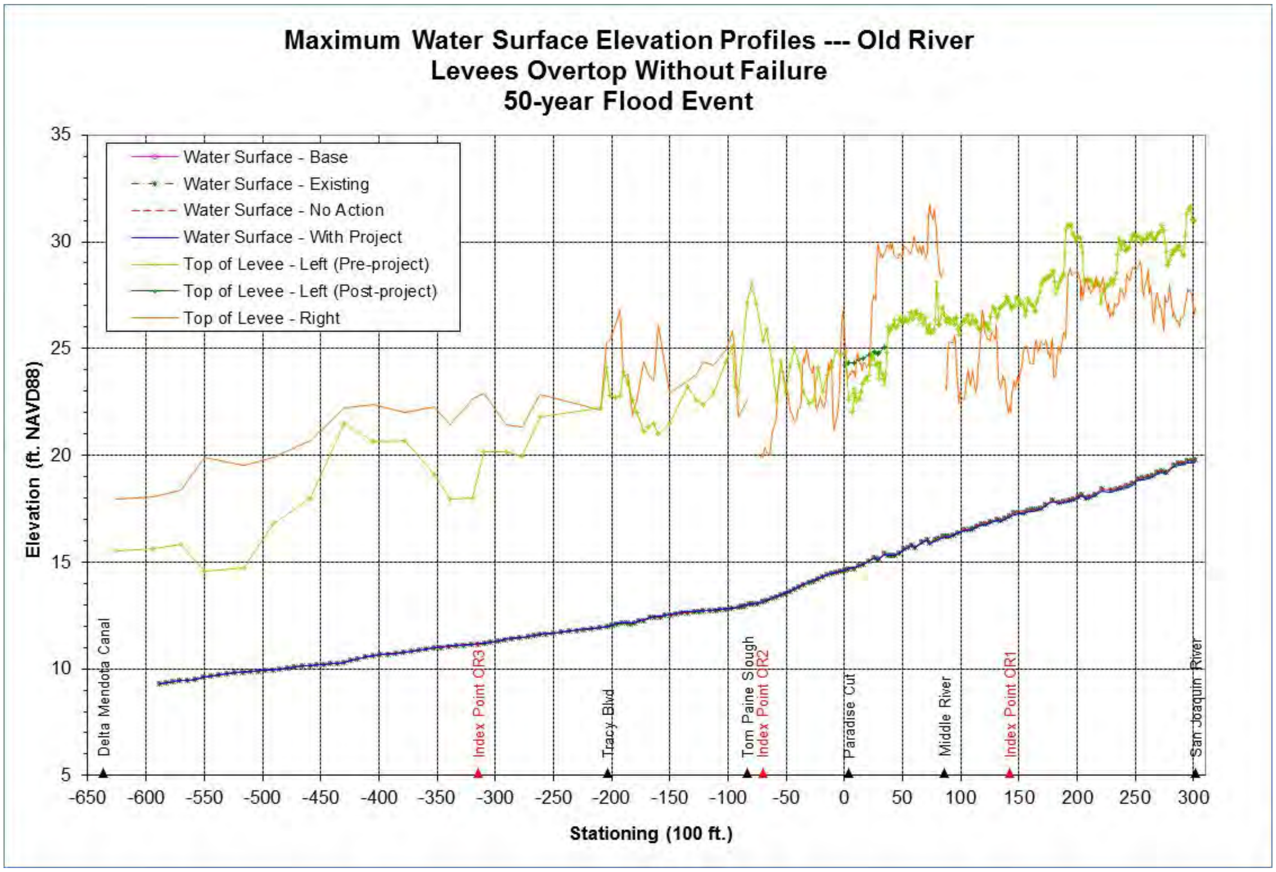

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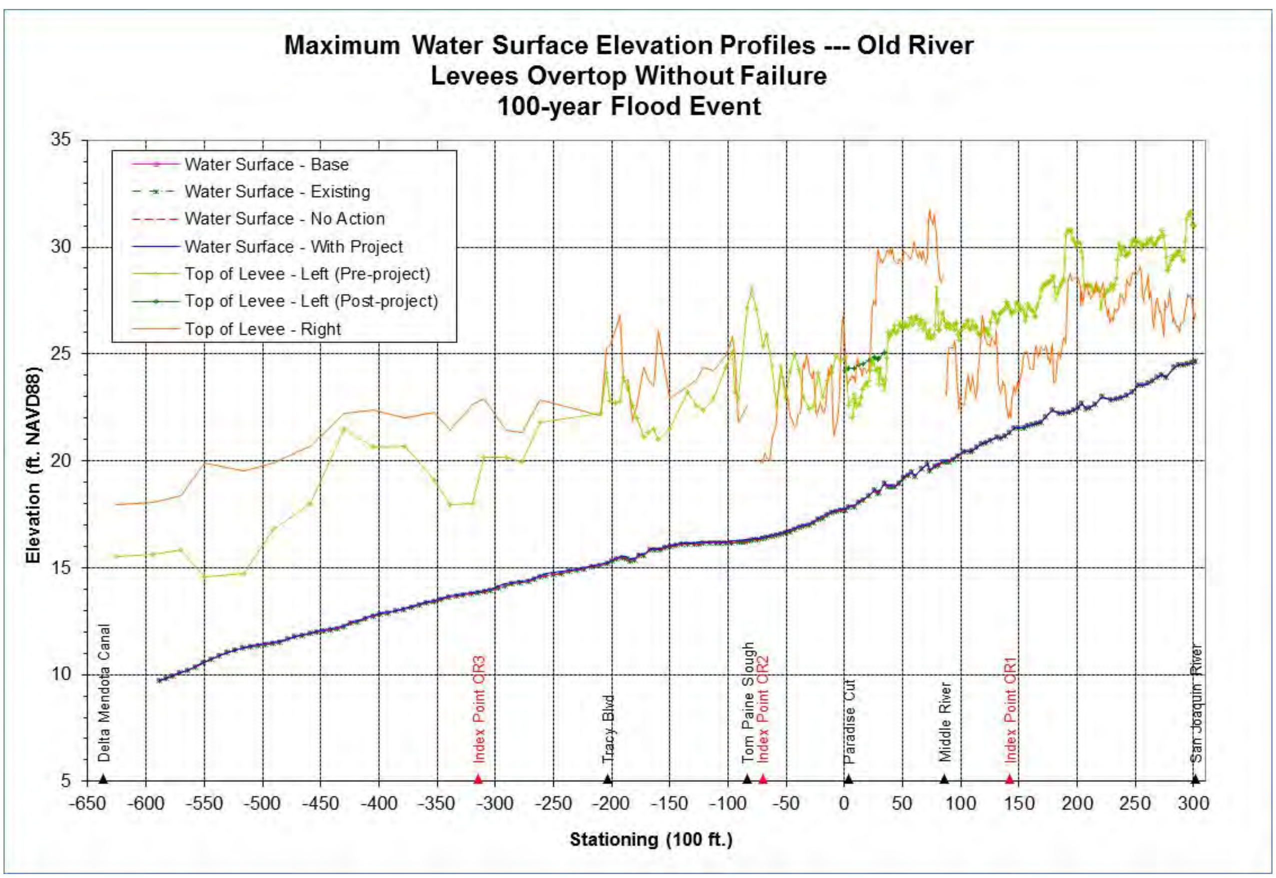

Figure H-10

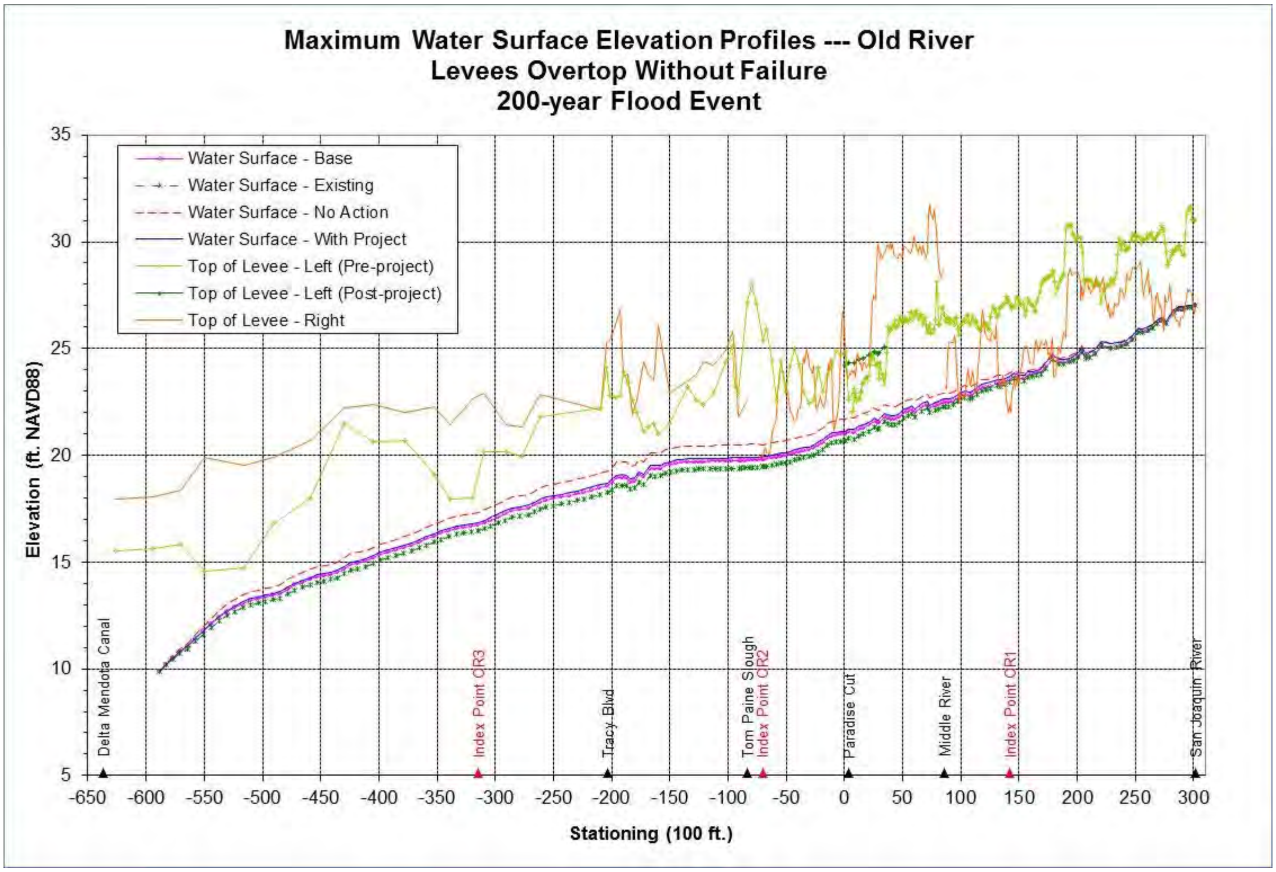

Figure H-11

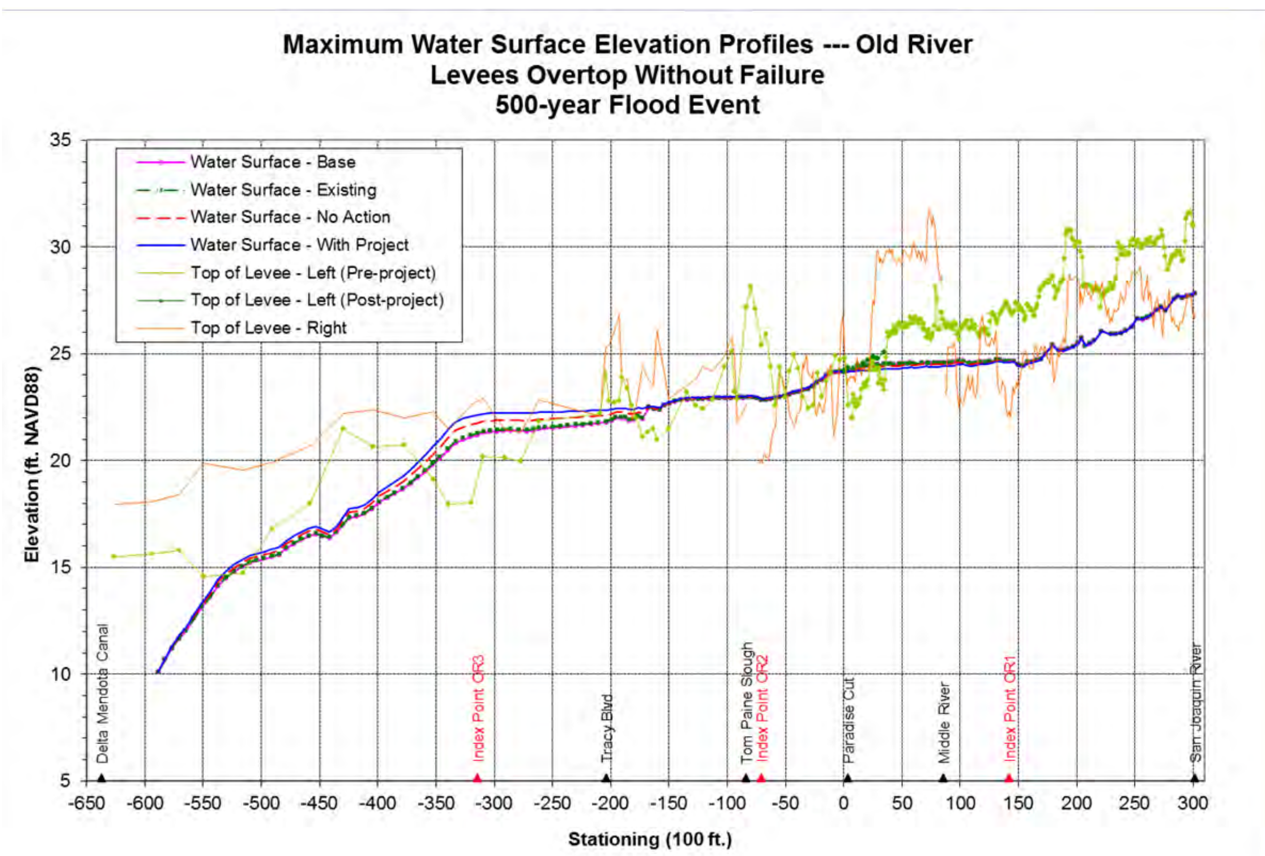

Figure H-12

Attachment I

Detailed Flood Inundation Maps, 200-year Flood Event

Figure I-1. Storage Area D and E 200-year inundation, Existing and With Project
Figure I-2. Detail of Storage Area D 200-year inundation, Existing and With Project (1 of 1)
Figure I-3. Storage Area F and G 200-year inundation, Existing and With Project
Figure I-4. Detail of Storage Area F and G 200-year inundation, Existing and With Project (1 of 2)
Figure I-5. Detail of Storage Area F 200-year inundation, Existing and With Project (2 of 2)
Figure I-6. Storage Area K, L, and M 200-year inundation, Existing and With Project
Figure I-7. Detail of Storage Area K 200-year inundation, Existing and With Project (1 of 1)
Figure I-8. Storage Area Z 200-year inundation, Existing and With Project
Figure I-9. Detail of Storage Area Z 200-year inundation, Existing and With Project (1 of 4)
Figure I-10. Detail of Storage Area Z 200-year inundation, Existing and With Project (2 of 4)
Figure I-11. Detail of Storage Area Z 200-year inundation, Existing and With Project (3 of 4)
Figure I-12. Detail of Storage Area Z 200-year inundation, Existing and With Project (4 of 4)
Figure I-13. Storage Area D and E 200-year inundation, No Action and With Project
Figure I-14. Detail of Storage Area D and E 200-year inundation, No Action and With Project (1 of 1)
Figure I-15. Storage Area F and G 200-year inundation, No Action and With Project
Figure I-16. Detail of Storage Area F and G 200-year inundation, No Action and With Project (1 of 2)
Figure I-17. Detail of Storage Area F and G 200-year inundation, No Action and With Project (2 of 2)
Figure I-18. Storage Area K, L, and M 200-year inundation, No Action and With Project
Figure I-19. Detail of Storage Area K, L, and M 200-year inundation, No Action and With Project (1 of 1)
Figure I-20. Storage Area Z 200-year inundation, No Action and With Project
Figure I-21. Detail of Storage Area Z 200-year inundation, No Action and With Project (1 of 4)
Figure I-22. Detail of Storage Area Z 200-year inundation, No Action and With Project (2 of 4)
Figure I-23. Detail of Storage Area Z 200-year inundation, No Action and With Project (3 of 4)
Figure I-24. Detail of Storage Area Z 200-year inundation, No Action and With Project (4 of 4)

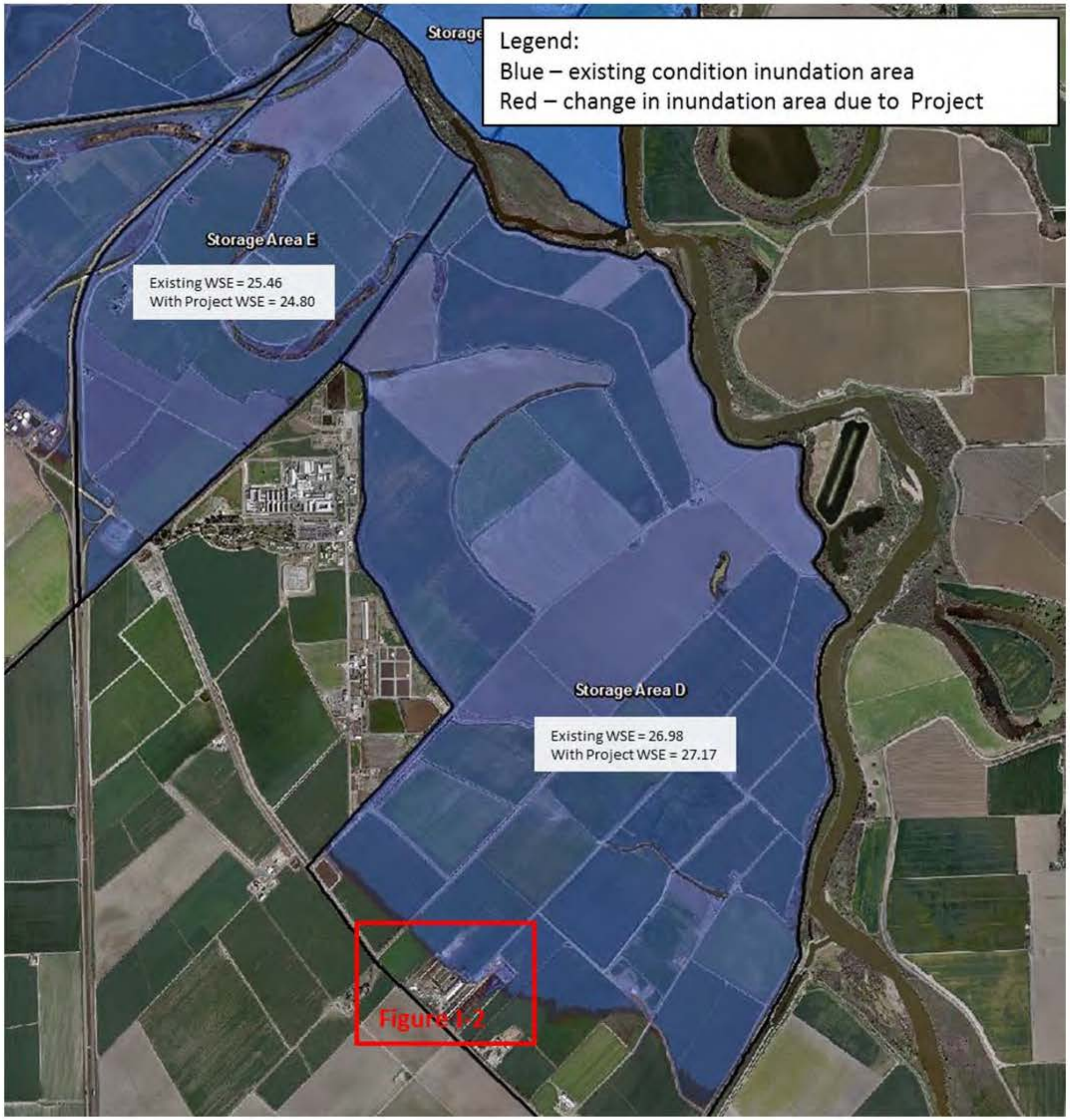

Figure I-1. Storage Area D and E 200-year inundation, Existing and With Project

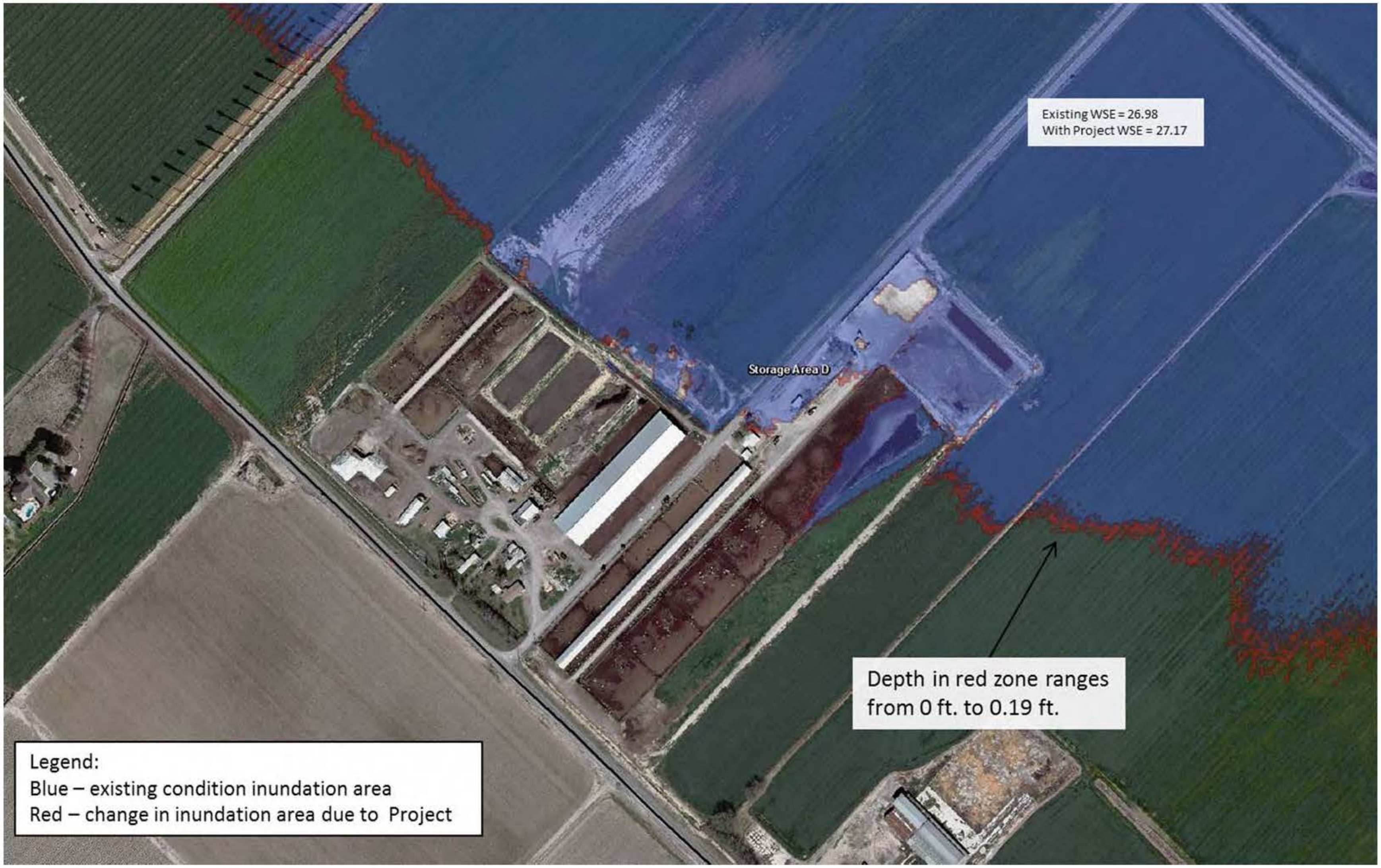

Figure I-2. Detail of Storage Area D 200-year inundation, Existing and With Project (1 of 1)

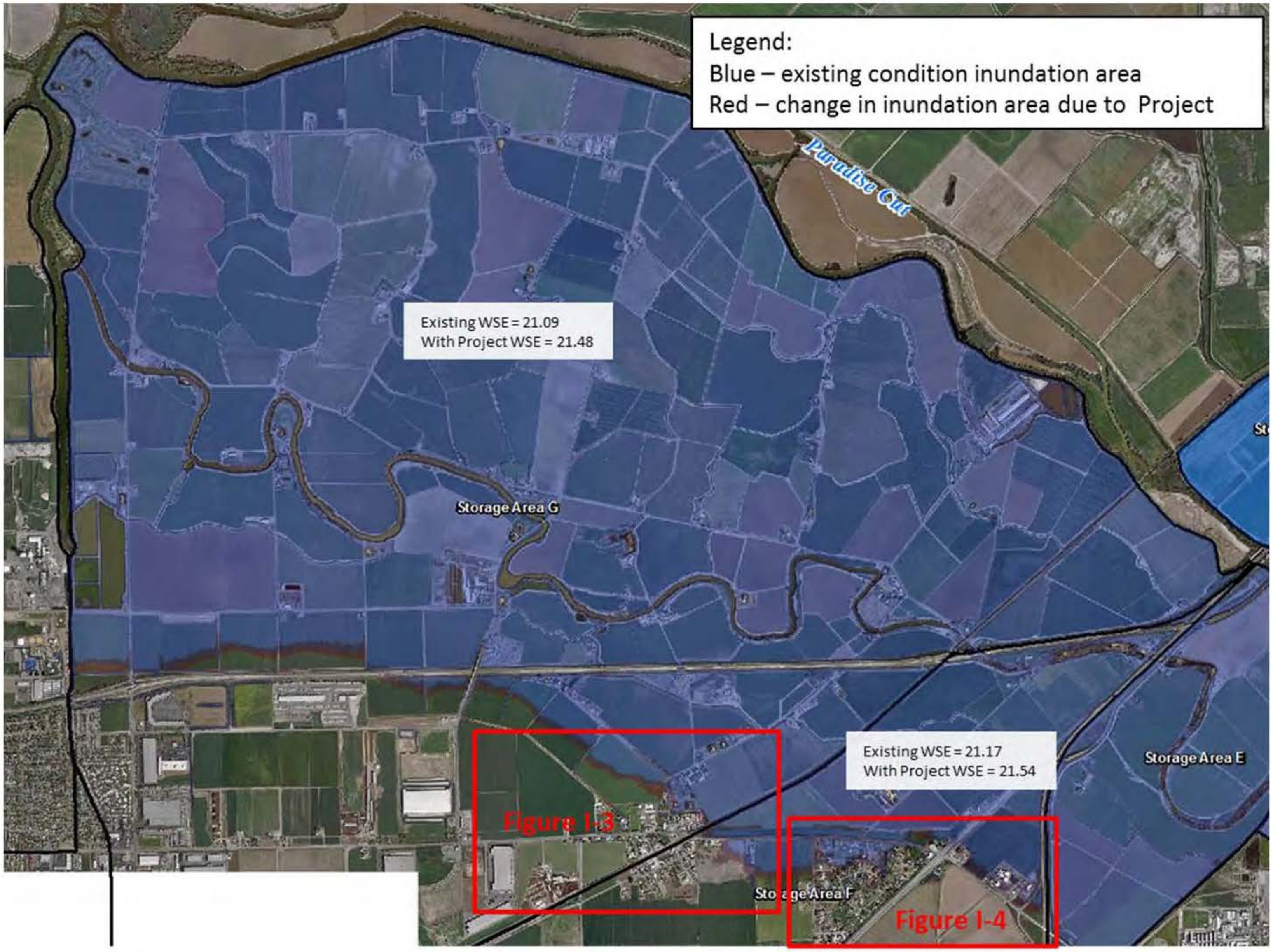

Figure I-3. Storage Area F and G 200-year inundation, Existing and With Project

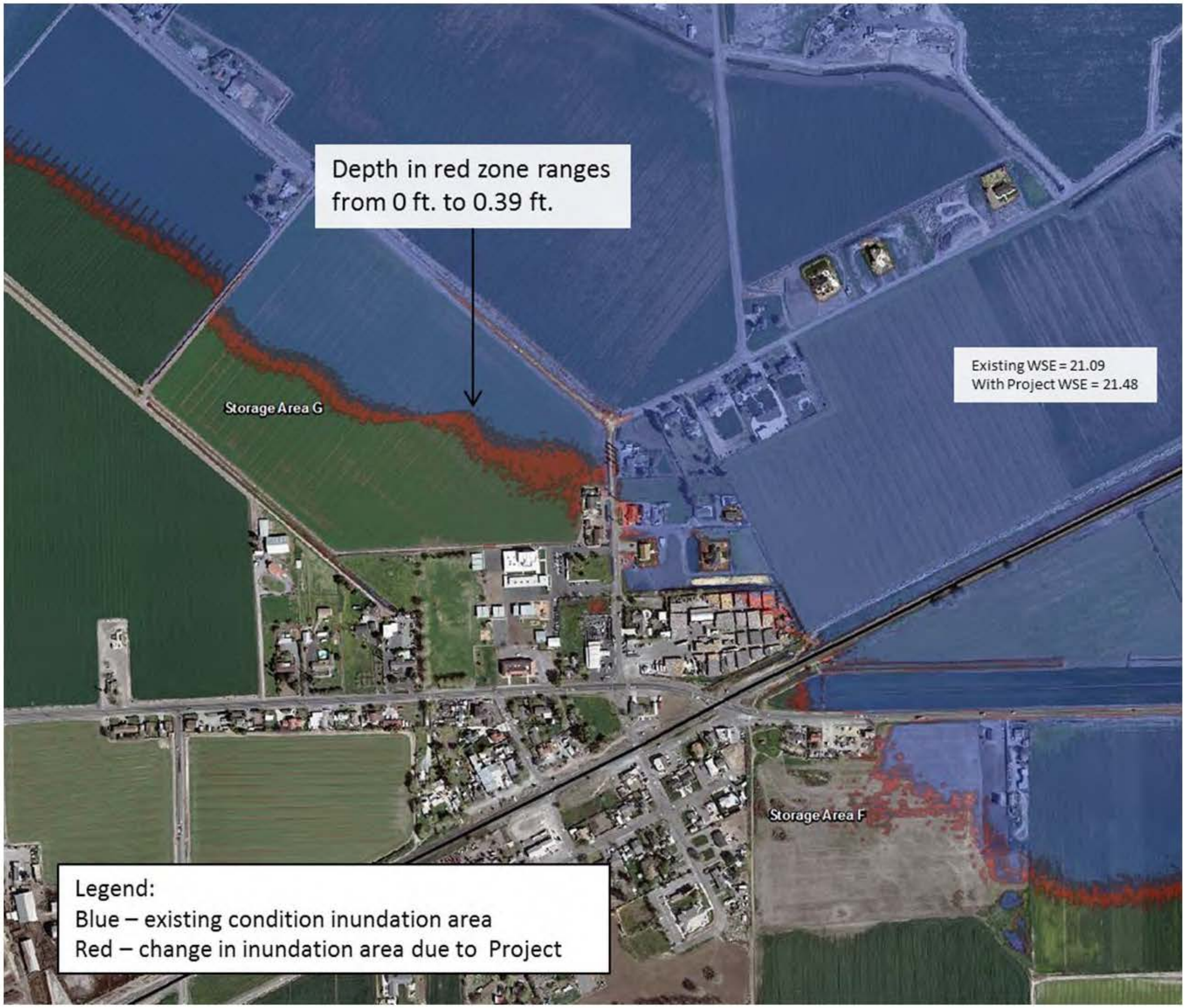

Figure I-4. Detail of Storage Area F and G 200-year inundation, Existing and With Project (1 of 2)

Figure I-5. Detail of Storage Area F 200-year inundation, Existing and With Project (2 of 2)

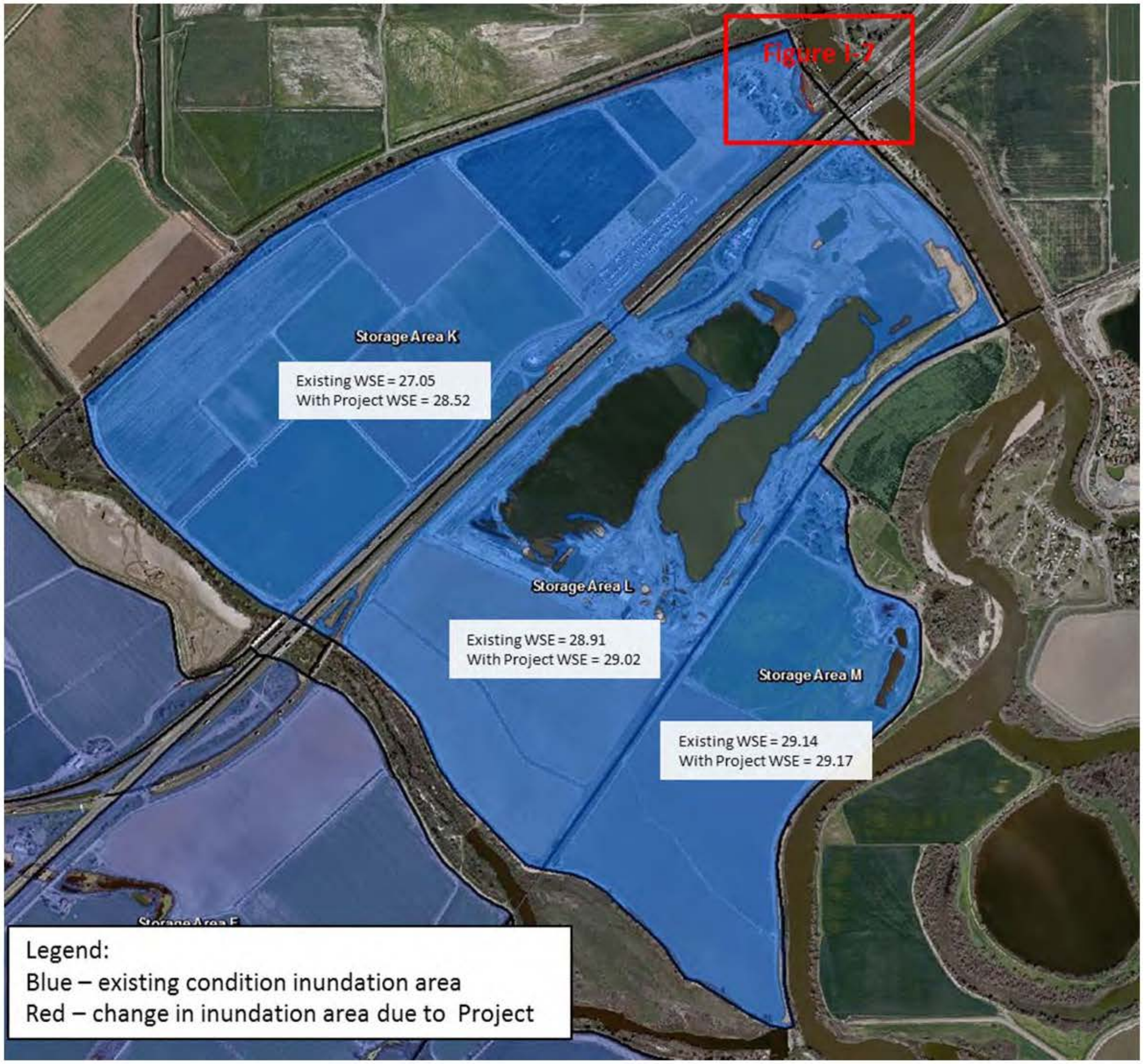

Figure I-6. Storage Area K, L, and M 200-year inundation, Existing and With Project

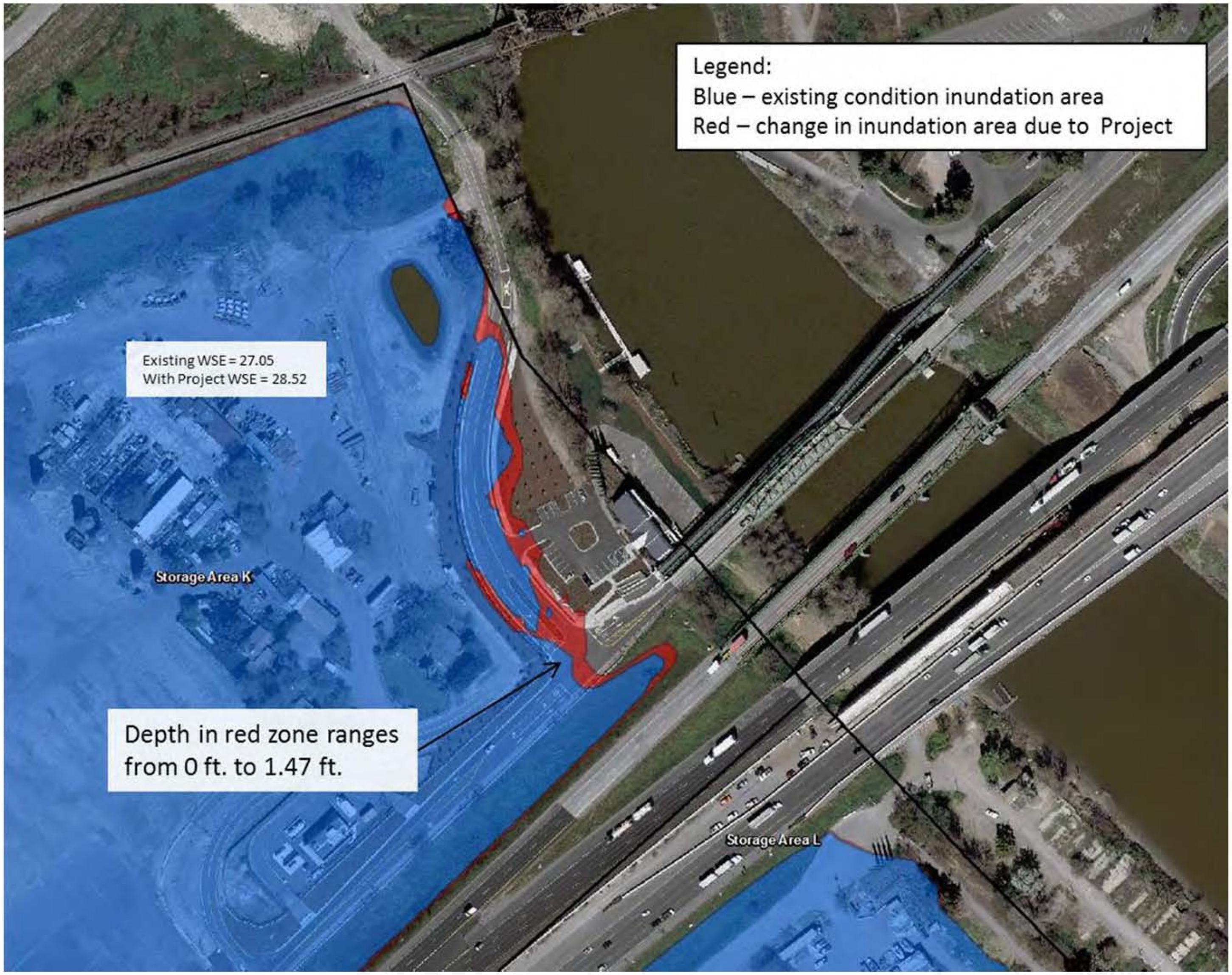

Figure I-7. Detail of Storage Area K 200-year inundation, Existing and With Project (1 of 1)

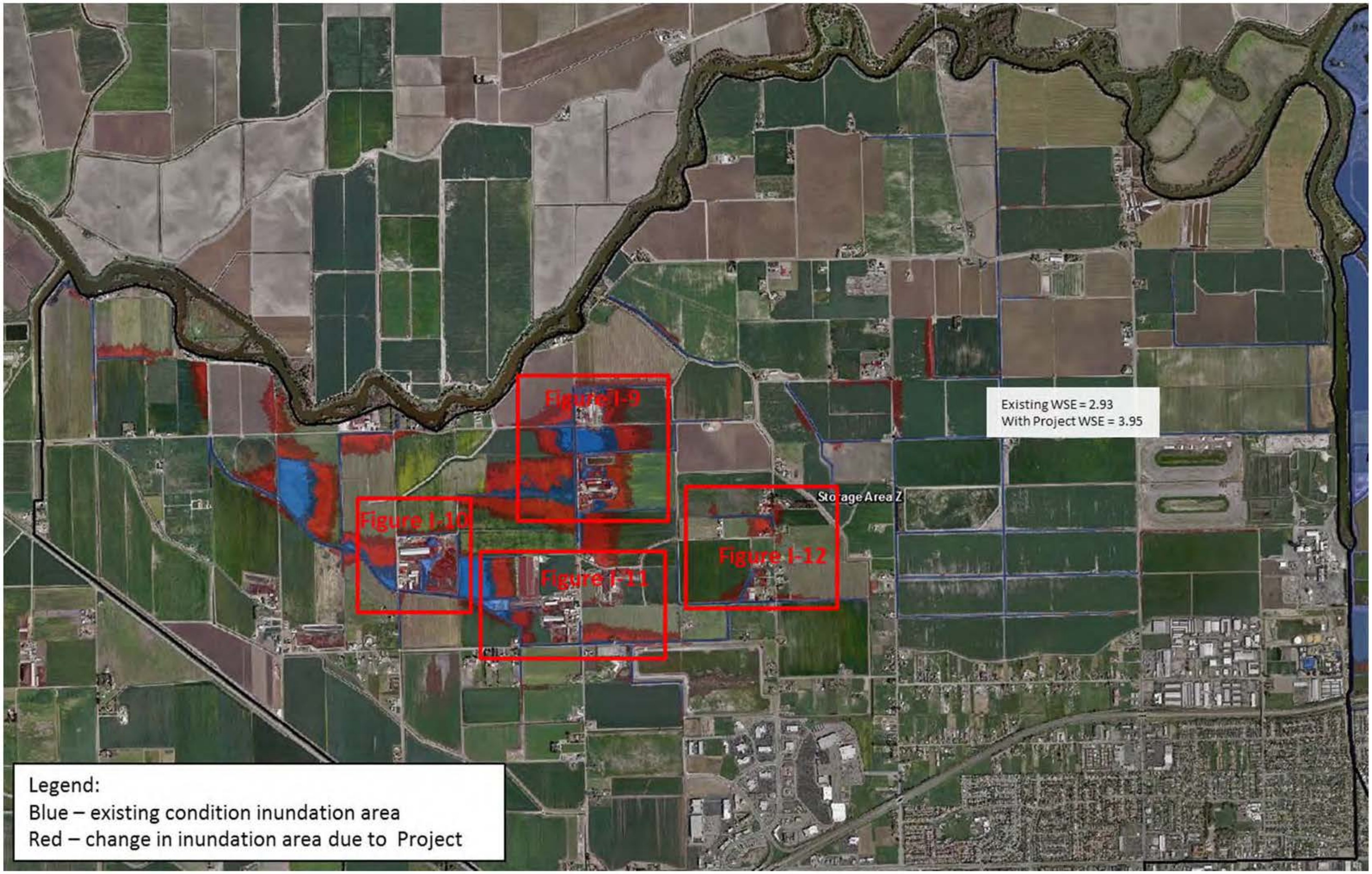

Figure I-8. Storage Area Z 200-year inundation, Existing and With Project

Figure I-9. Detail of Storage Area Z 200-year inundation, Existing and With Project (1 of 4)

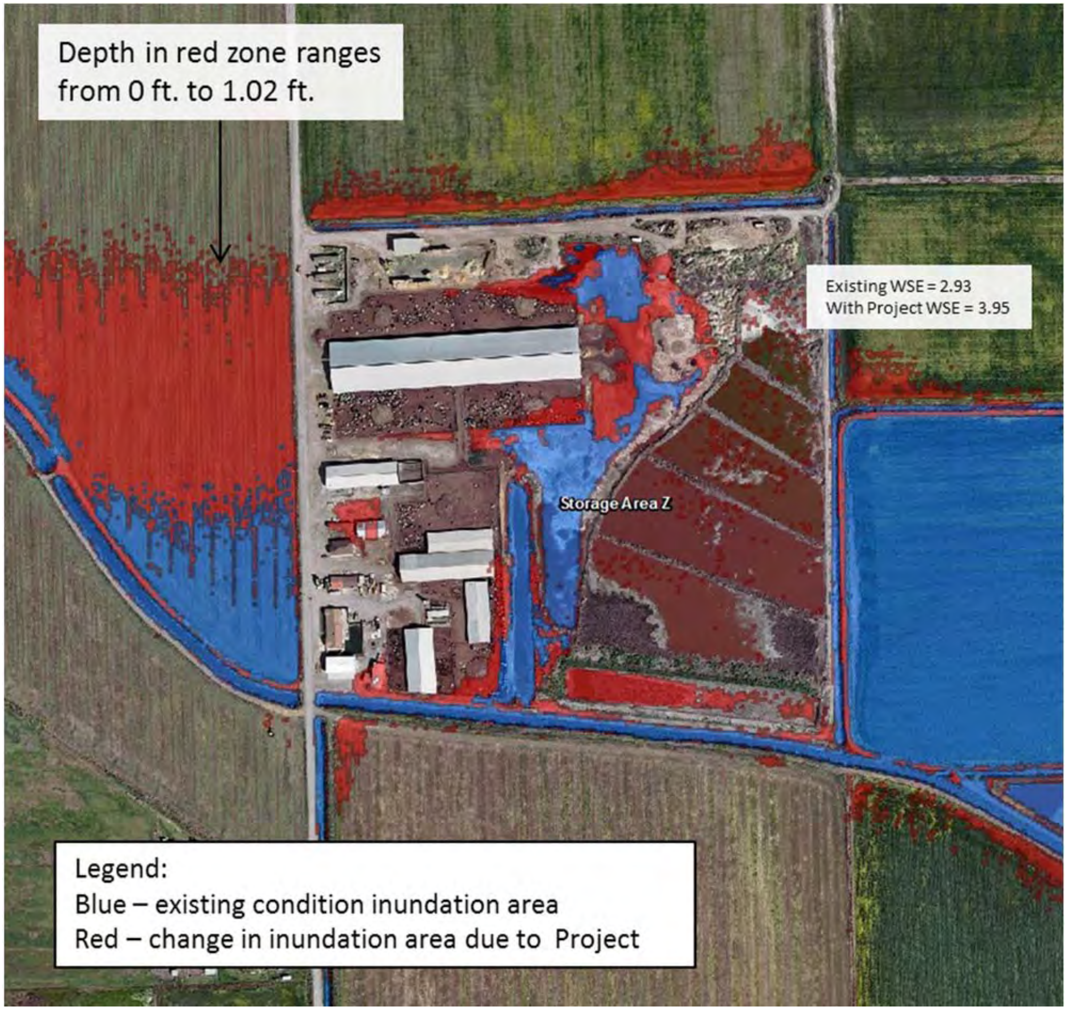

Figure I-10. Detail of Storage Area Z 200-year inundation, Existing and With Project (2 of 4)

Figure I-11. Detail of Storage Area Z 200-year inundation, Existing and With Project (3 of 4)

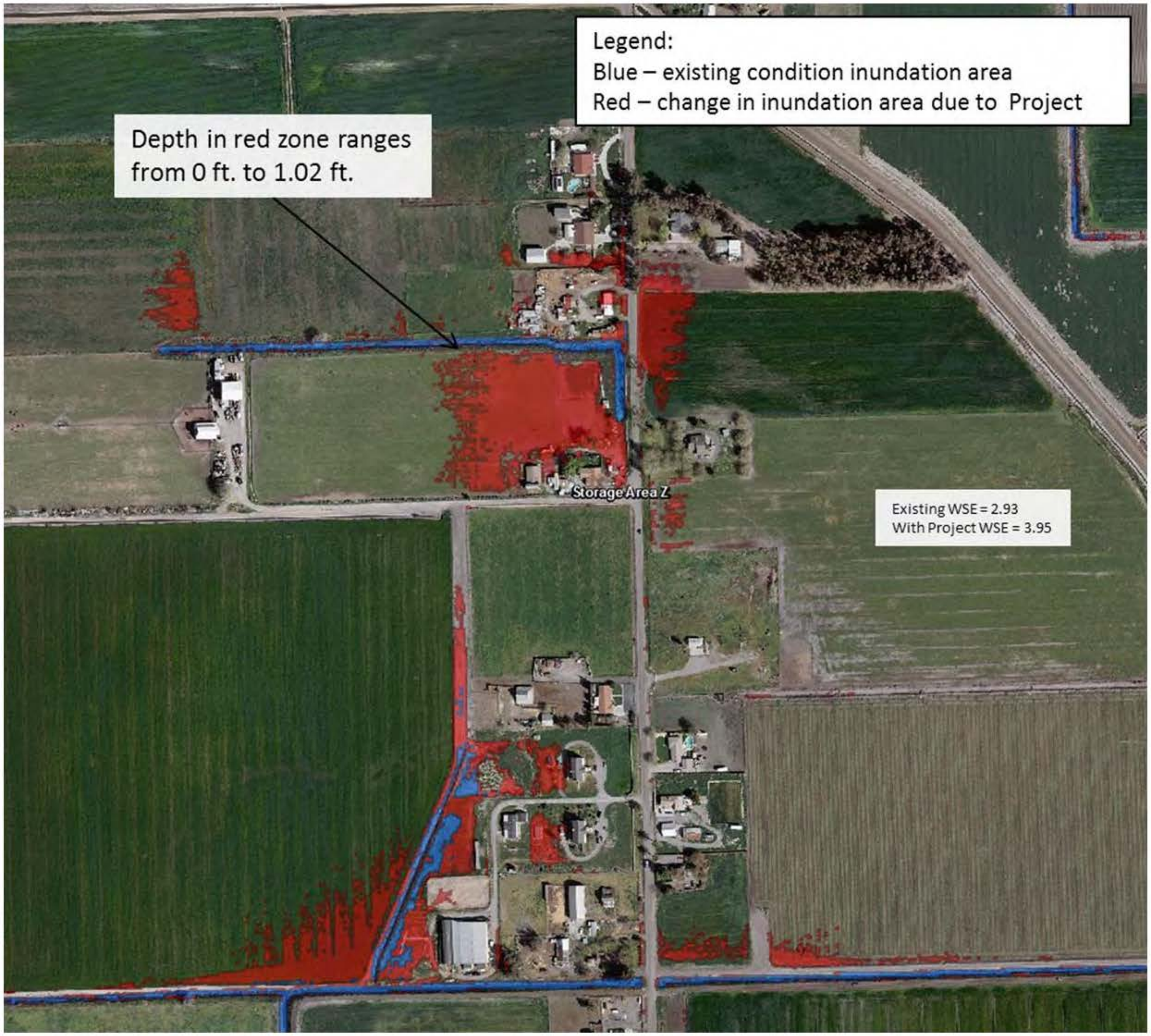

Figure I-12. Detail of Storage Area Z 200-year inundation, Existing and With Project (4 of 4)

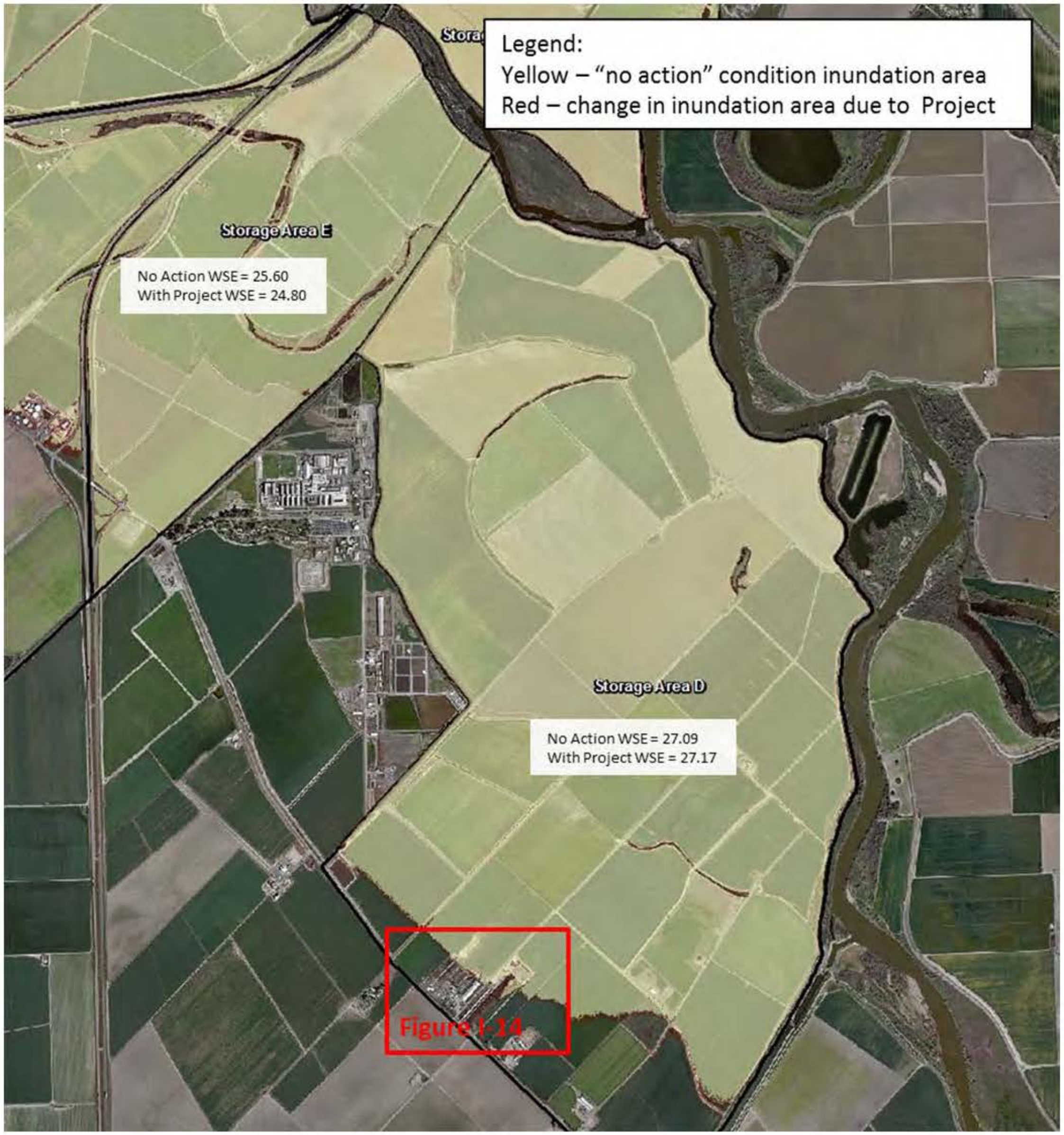

Figure I-13. Storage Area D and E 200-year inundation, No Action and With Project

Figure I-14. Detail of Storage Area D and E 200-year inundation, No Action and With Project (1 of 1)

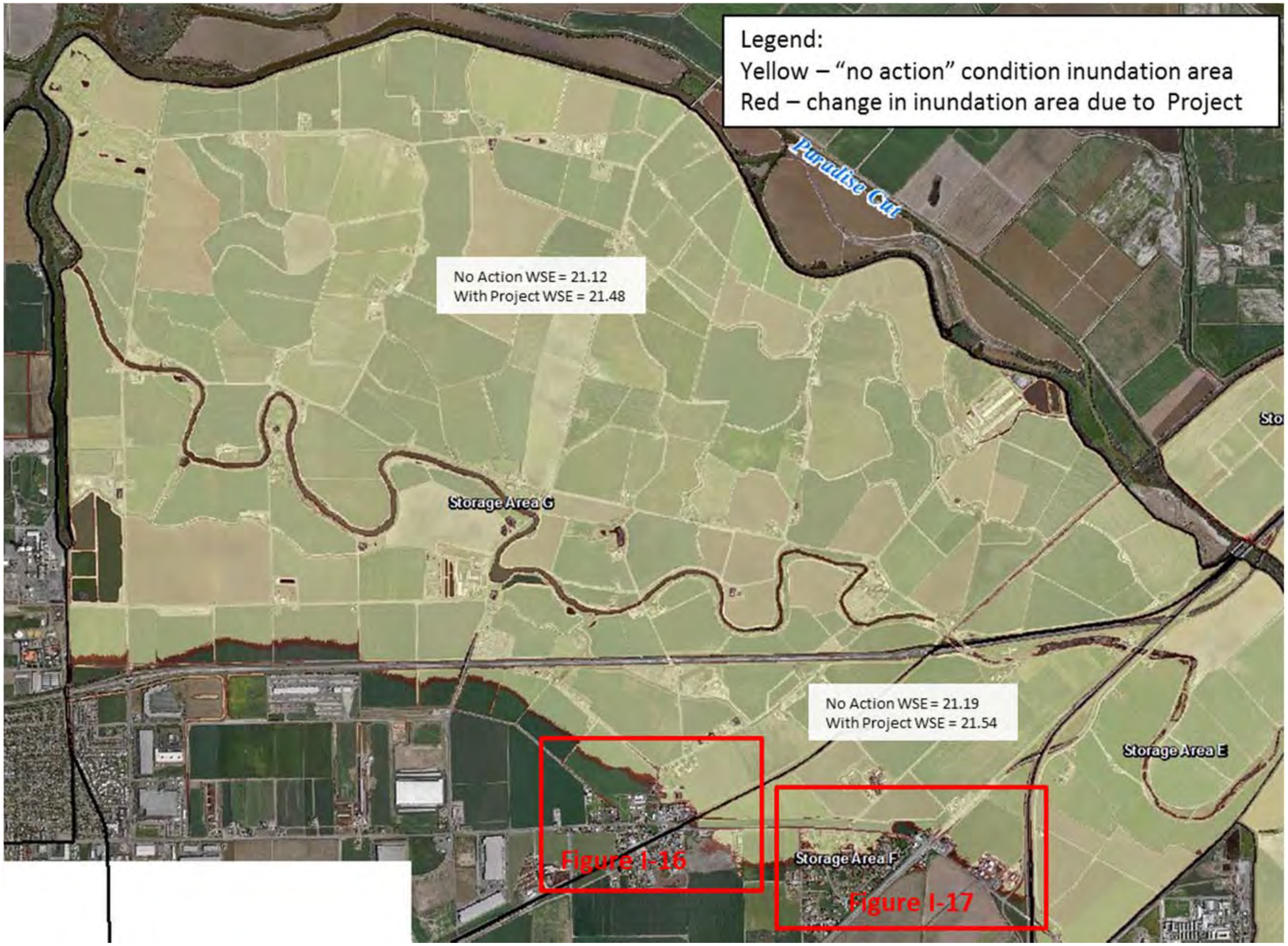

Figure I-15. Storage Area F and G 200-year inundation, No Action and With Project

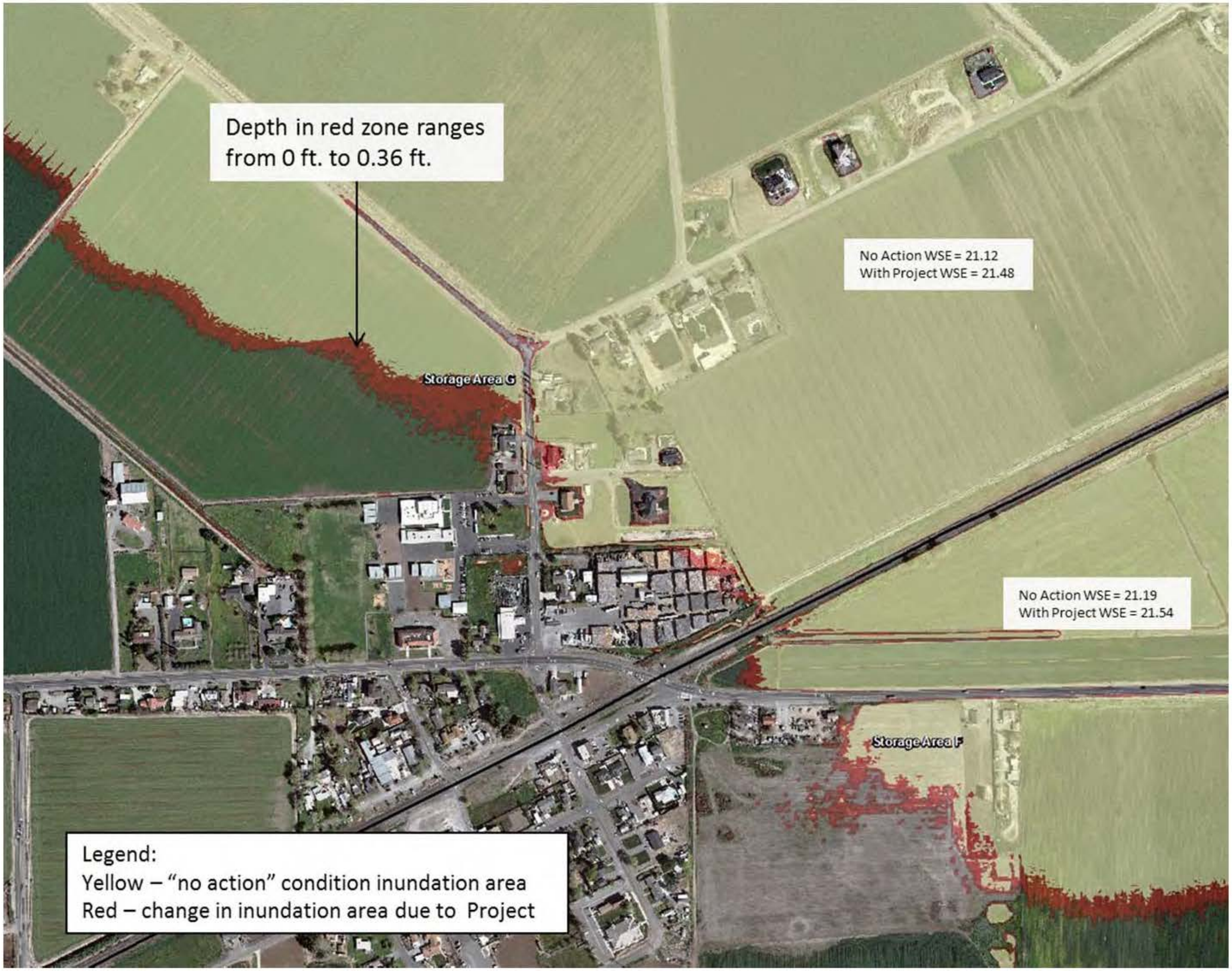

Figure I-16. Detail of Storage Area F and G 200-year inundation, No Action and With Project (1 of 2)

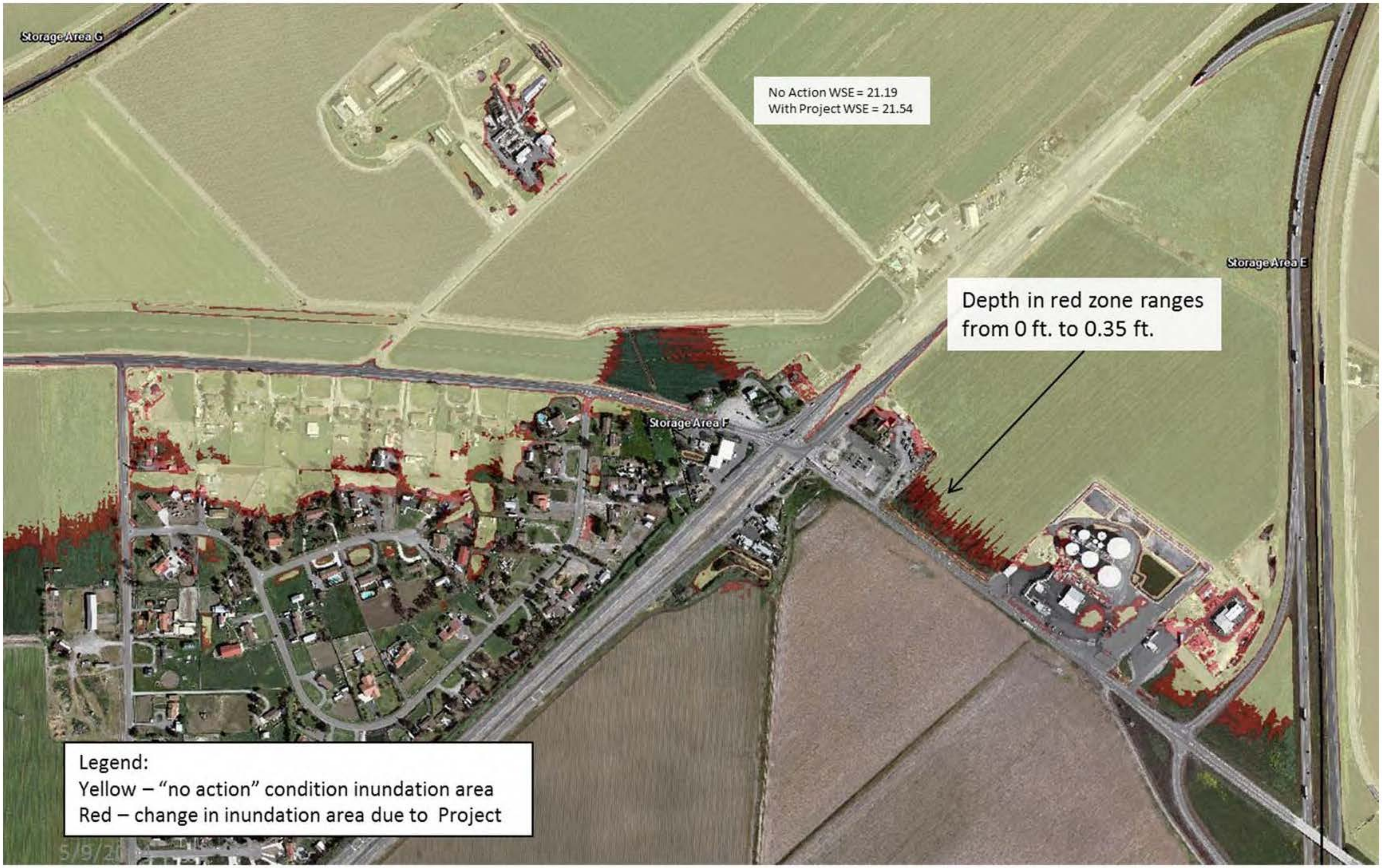

Figure I-17. Detail of Storage Area F and G 200-year inundation, No Action and With Project (2 of 2)

Figure I-18. Storage Area K, L, and M 200-year inundation, No Action and With Project

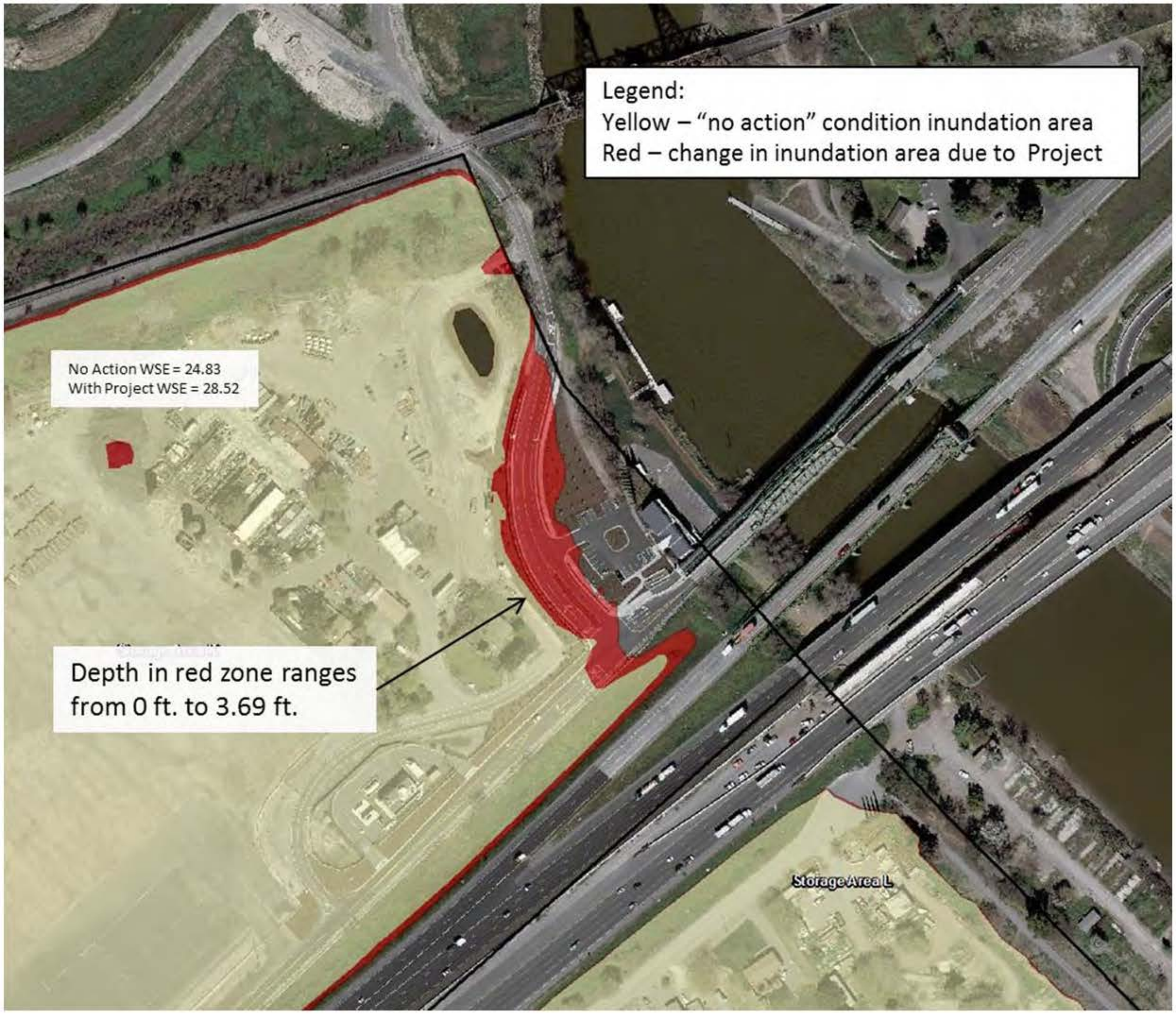

Figure I-19. Detail of Storage Area K, L, and M 200-year inundation, No Action and With Project (1 of 1)

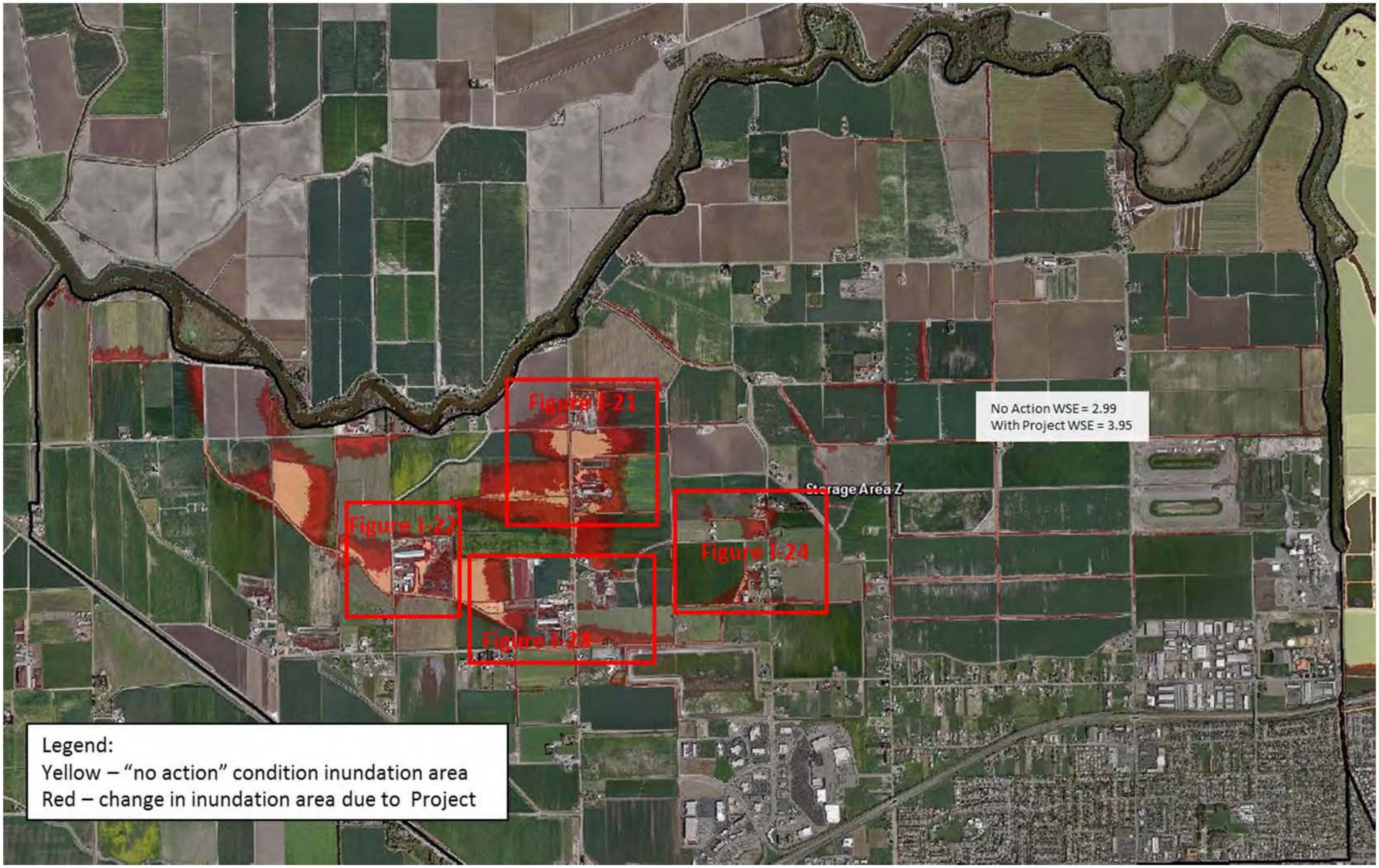

Figure I-20. Storage Area Z 200-year inundation, No Action and With Project

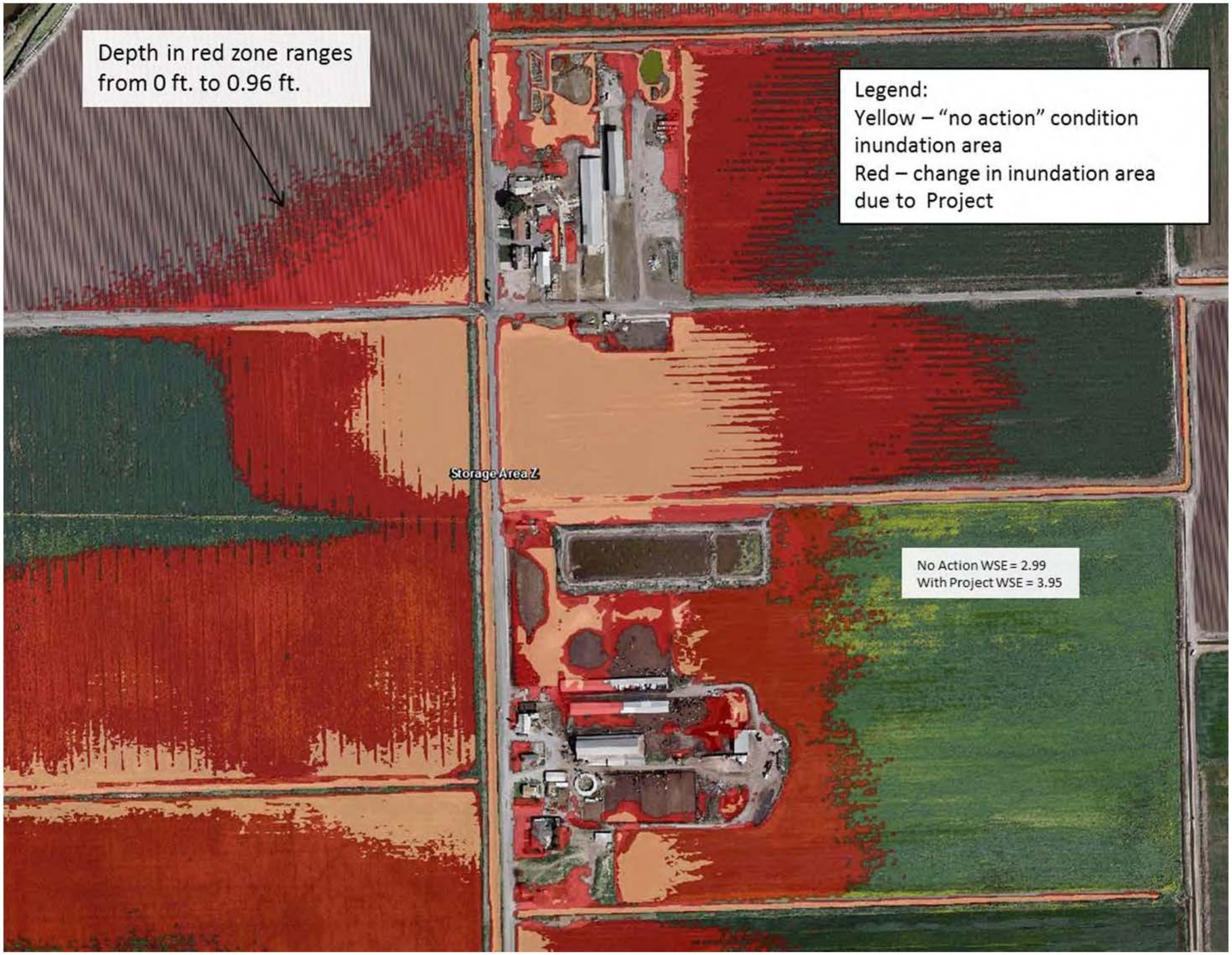

Figure I-21. Detail of Storage Area Z 200-year inundation, No Action and With Project (1 of 4)

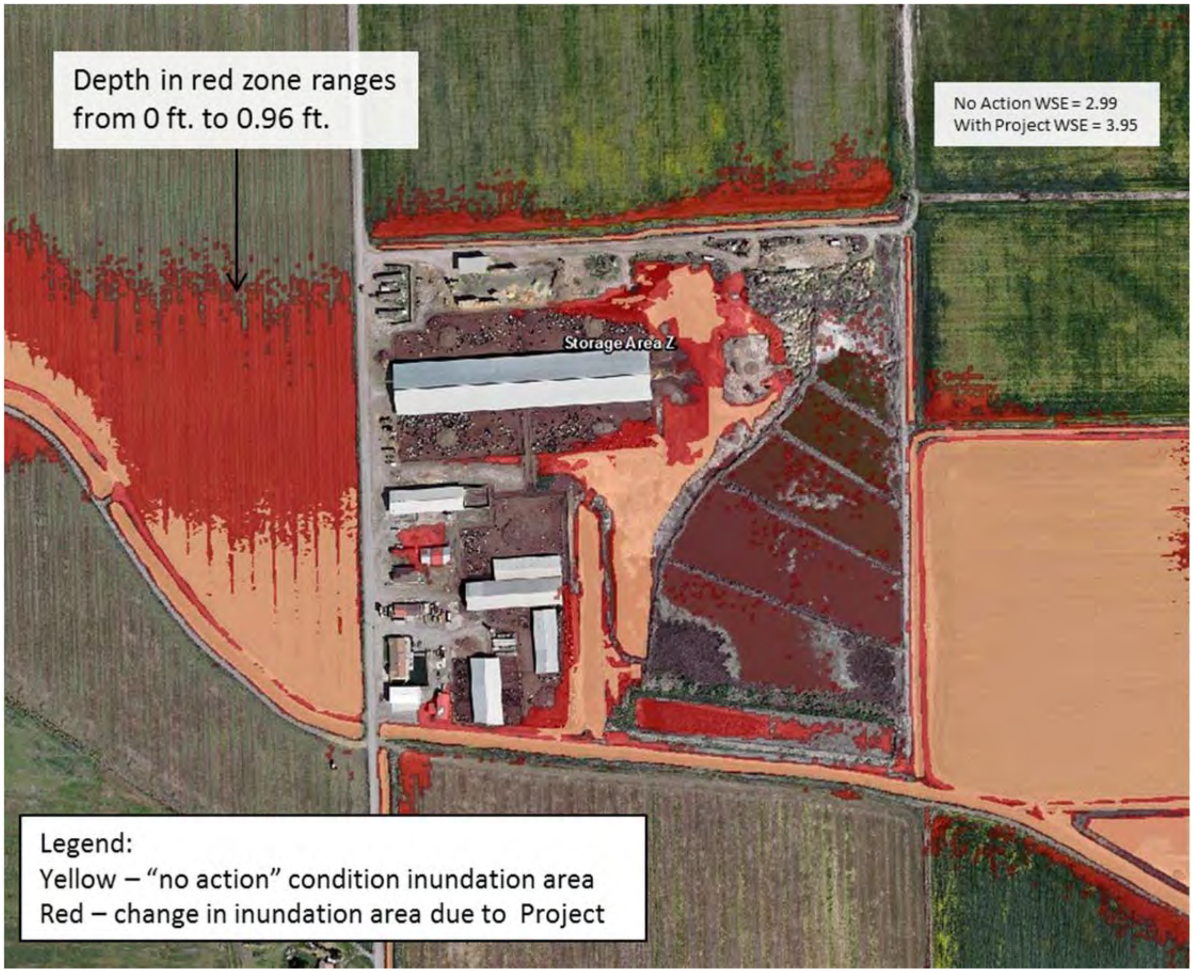

Figure I-22. Detail of Storage Area Z 200-year inundation, No Action and With Project (2 of 4)

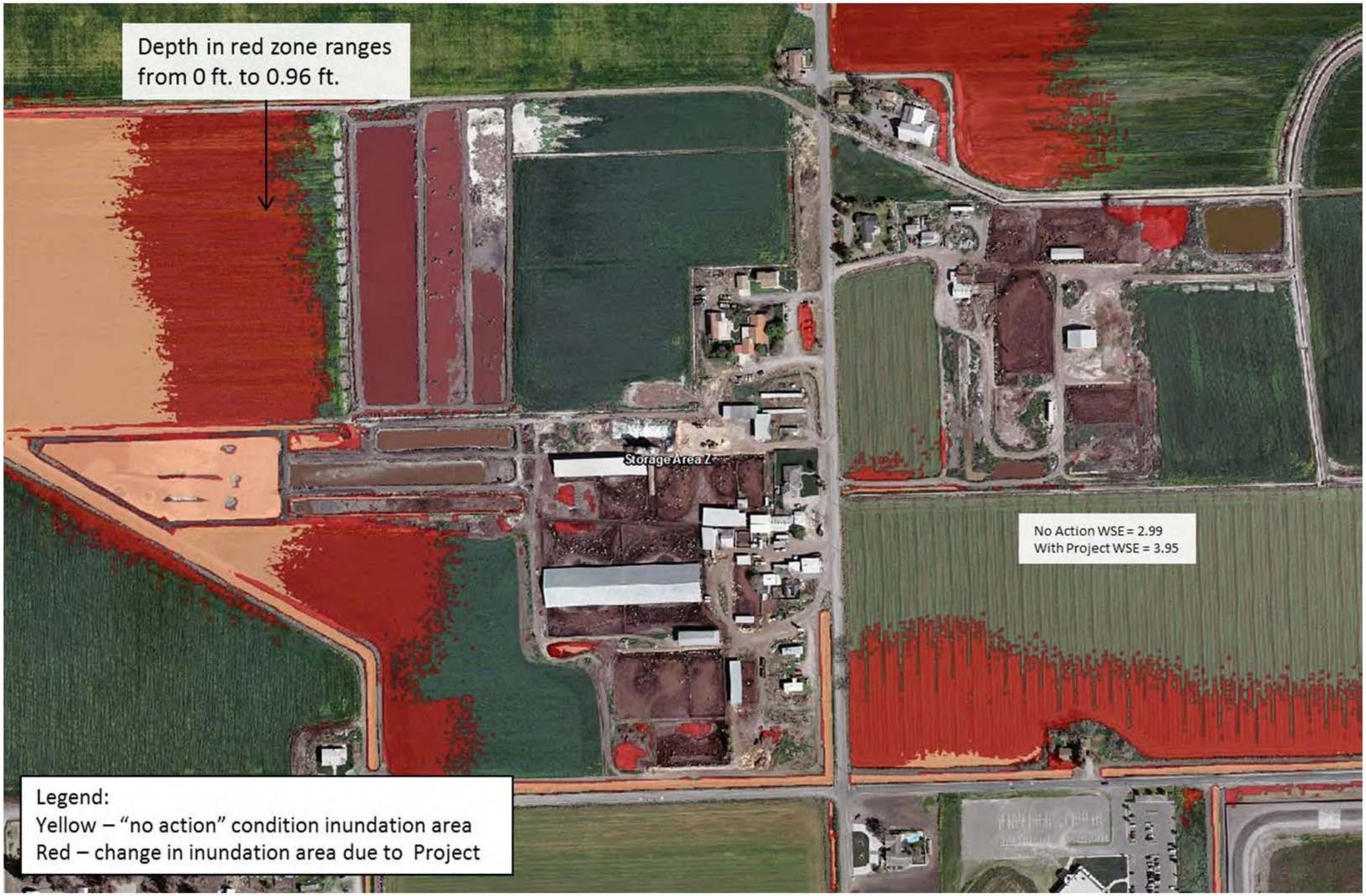

Figure I-23. Detail of Storage Area Z 200-year inundation, No Action and With Project (3 of 4)

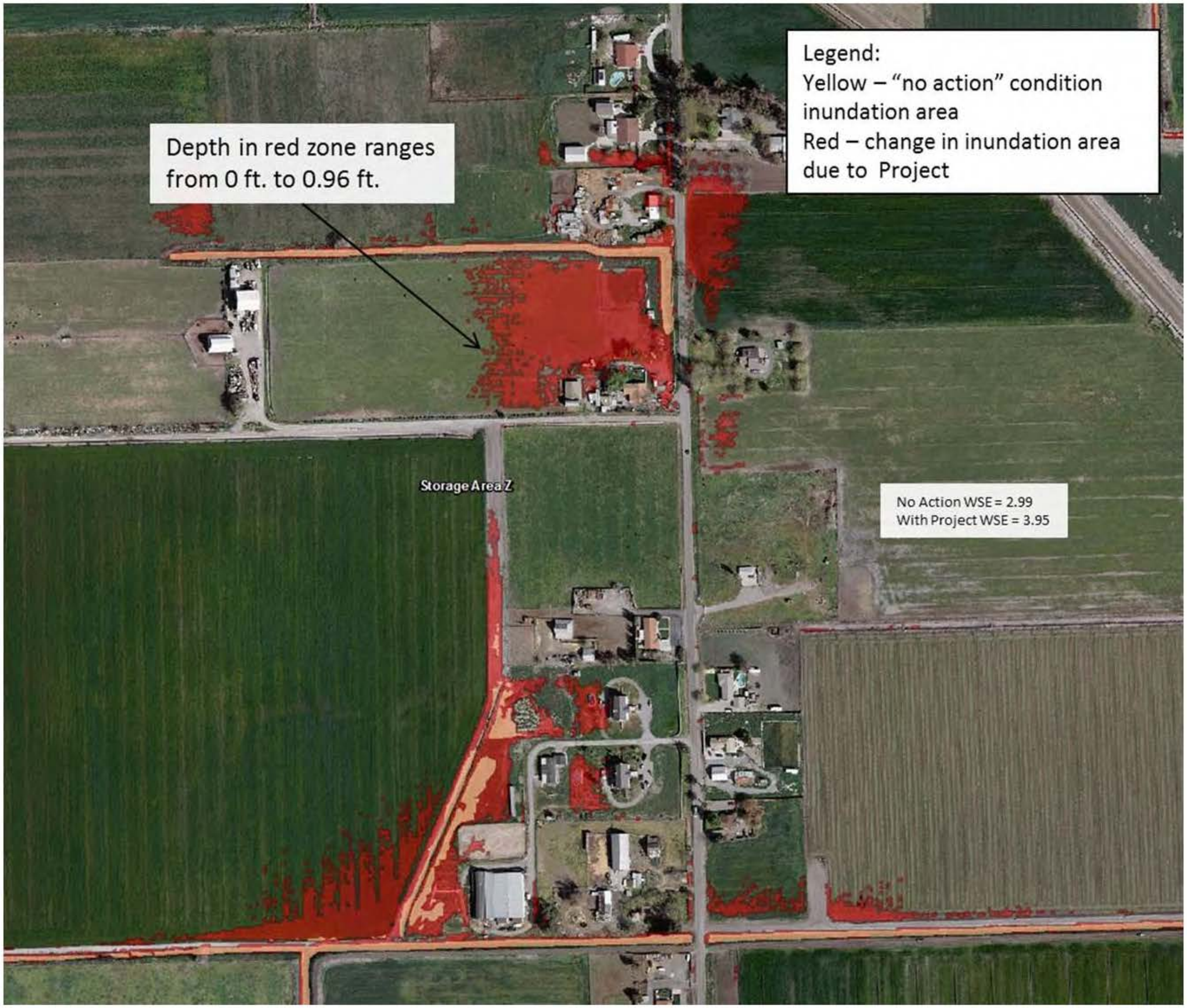

Figure I-24. Detail of Storage Area Z 200-year inundation, No Action and With Project (4 of 4)

Attachment J

Internal Quality Control Certification

MBK ENGINEERS

Internal Quality Control Certification

River Islands at Lathrop Hydraulic Impact Analysis, March 16, 2012.

MBK Engineers has completed a hydraulic impact analysis for the River Islands at Lathrop project. The undersigned verifies that the work performed complies with established policy, principles and procedures, and reflects the use of justified and verified assumptions. The technical review included verification of project criteria; review of assumptions, methods, procedures, and material used in analyses; review of the appropriateness of data used; and reasonableness of the results, including whether the product meets the needs of River Islands at Lathrop consistent with State and federal laws and regulations.

All concerns resulting from internal technical review of the project have been addressed.

Don Trieu, P.E.
MBK Engineers

3-29-12
Date