APPENDIX B

ECONOMICS –

FLOOD RISK MANAGEMENT

APPENDIX B
ECONOMICS
FOR
DELTA ISLANDS AND LEVEES FEASIBILITY STUDY, CALIFORNIA

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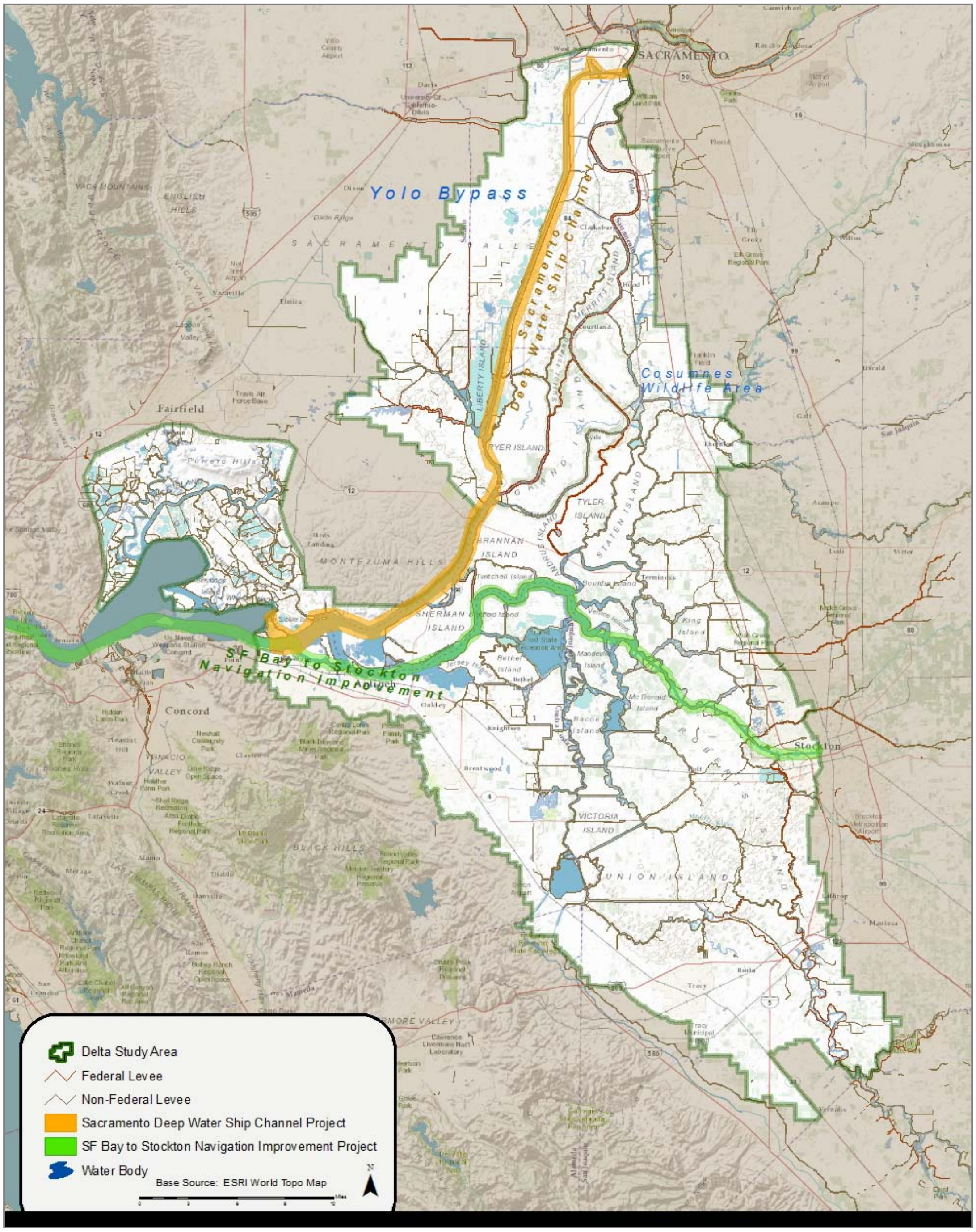
1.0 Background

The Sacramento – San Joaquin Delta (Figure 1) is part of the largest estuary on the west coast of the United States; is home to hundreds of species of fish, birds, mammals and reptiles; and has been named an Ecosystem of National Significance through the Environmental Protection and Biodiversity Conservation (EPBC) Act in 2011. Agricultural land irrigated by Delta water contributes billions of dollars in production for the nation. Two deep water ports serve as economic engines for the Central Valley, Northern California, and the western States and are reliant on Delta waters and Federal Deep Draft Navigation Channels and levees for navigation. Delta levees protect such critical infrastructure as state and interstate highways, National rail lines, natural gas fields, gas and fuel pipelines, water conveyance, drinking water pipelines, and numerous businesses and towns.

The Delta is a web of channels and reclaimed islands at the confluence of the Sacramento, San Joaquin, Cosumnes, Mokelumne, and Calaveras Rivers. Forty percent of California's land area is contained within the watersheds of these rivers. The Delta, which covers about 738,000 acres, interlaced with hundreds of miles of waterways, is legally defined by Section 12220 of California Water Code (CWC). Much of the land is below sea level and protected by a network of 1,100 miles of levees which have been constructed over the past 150 years to manage the flow of water through the Delta. The land behind the levees is predominantly agricultural (corn, wheat, vineyards, cattle) and waterways provide recreational outlets for nearby urban areas and essential habitat for fish and wildlife. The Delta is also the largest single source of California's water supply, providing 25 million Californians with drinking water and irrigating millions of acres of farmland in the Central Valley. In addition, more than 500,000 people live within the Delta and rely upon it for water, recreation, and livelihood. The majority of that population is in the greater Sacramento and Stockton areas and is the focus of other Corps FRM studies, though there are communities within the Delta. Several historic towns, known as "legacy communities," remain within the Delta, some of which are listed in the national registry of historic places.

Historically, the Delta was defined by tidal wetlands, primarily comprised of peat soils. The Swamp and Overflow Land Act of 1850 transferred ownership of all swamp and overflow land, including Delta marshes, from the federal government to the State. This Act began the reclamation of wetlands in the Delta through the construction of levees and drainage channels, typically by the new land owners. The majority of levees in the Delta are still privately owned and maintained. Nearly three fourths of the Delta is now in agriculture.

Figure 1 –Delta Study Area



2.0 Economic Analysis

The economic analysis was conducted in two phases: 1) screening phase and 2) analysis phase. In the screening phase, information contained in the Delta Risk Management Study (DRMS) was used to help determine which Delta Islands that have a high likelihood of meeting the study's FRM objectives. Based on the screening criteria described in the next section, the four Delta Islands which have the highest likelihood of meeting the objectives were analyzed in more detail in the analysis phase.

2.1 Screening Phase

All of the information used to conduct the screening phase of this economic analysis was obtained from various components of the DRMS. DRMS was developed by the California Department of Water Resources (DWR) and completed in two phases; Phase 1 assessed the performance of Delta and Suisun Marsh levees and evaluated the economic, environmental, and public health and safety consequences of levee failures to California as a whole; Phase 2 developed and evaluated risk reduction strategies. The use of DRMS information was chosen because it is the only recent comprehensive analysis on the local and statewide consequences of Delta levee failures. The screening criteria used to help refine Delta Islands Feasibility FRM measures for the screening phase include the following three components:

1. the ratio of total inundation repair costs to upgraded levee costs
2. life safety risk
3. significance of statewide importance

1. Ratio of Total Inundation Repair Costs to Upgraded Levee Costs

   To calculate the ratio of total inundation repair costs to upgraded levee costs, information was taken from both phases of the DRMS. The total inundation repair costs values are from the DRMS Phase 1 Impact to Infrastructure Technical Memorandum (IITM); these costs represent the repair cost for each asset on a particular Delta island, based on inundation depths, the percent damage incurred, and the original value of the asset. The assets considered in the IITM include: a) points assets: structures and buildings (and their contents), bridges, marinas, natural gas fields/storage areas, natural gas wells, commercial and industrial buildings, residences, and pump stations and b) linear assets: railroads, highways, shipping channels, transmission lines, aqueducts, and gas and petroleum pipelines. Since inundation repair costs are similar to the Corps concept of damages it was determined to be an appropriate numerator value for a screening criterion ratio. The upgraded levee costs were taken from DRMS Phase II report Upgraded Delta Levees (Section 4); these costs consist of upgrading non-project Delta Levees to PL 84-99 or Urban Project Levee (UPL) standards. In DRMS, levees protecting urban centers were selected for UPL upgrades and PL 84-99 upgrades for all other areas. The higher the relative ratio of total inundation repair costs to upgraded levee costs for a particular Delta island the higher the rating for this criterion.

2. Life Safety Risk

   Life safety risk is based entirely on Delta island population data obtained from the DRMS Economic Consequences Technical Memorandum (ECTM). Delta islands that have higher populations were considered to have a greater potential for life safely issues and thus a higher rating for this criterion.

3. Significance of Statewide Importance

   A measure's significance of statewide importance was determined qualitatively by using the findings contained in contained in the ECTM. If a Delta island contained an asset that would impact the region or state during and after a flood event, then that island was rated with a "Yes", otherwise the island was rated with a "NO." The categories of statewide significance include: deepwater ship channels, electric transmission lines, highways, natural gas transmission, Mokelumne Aqueduct, oil and gas wells, railroads, wastewater facilities, eight western islands, and legacy communities.

For criteria 1 and 2, each Delta island was assigned a rating of high, medium, or low. For criterion 3, each island was given a rating of Yes or No. The location measures that were assigned a "high" rating are generally populated areas with relatively higher economic values and therefore are likely to be included in the final array of measures as a more comprehensive, whole island levee improvement. The measures that were assigned a "medium" rating are generally somewhat populated with more limited economic values and therefore are likely to be included in the final array of measures as a more limited structural or non-structural solution. The measures that were assigned a "low" rating are sparsely populated areas with limited to no infrastructure/economic value and were therefore dropped from further considerations. This qualitative assessment was based on existing data from the DRMS and is summarized below in Table 1 and Figure 2. The green, yellow, and red areas in Figure 2 represent islands that were assigned a high, medium, and low ranking respectively.

Table 1: Location Screening of Flood Risk Management Measures

Island Name	Total Asset Repair Costs/Construction Costs[1]	Life Loss Risk	Assets of Statewide Importance
Sacramento Urban Area*	High	High	Yes
West Sacramento*	High	High	Yes
Elk Grove*	High	High	Yes
Shima Tract*	High	Medium	Yes
Boggs Tract*	High	Medium	Yes
Pescadero*	High	Medium	Yes
Pico Naglee Tract*	High	Medium	Yes
Sargent Barnhart Tract*	High	Medium	Yes
Lincoln Village*	High	Medium	Yes
Paradise Junction*	High	Medium	Yes
Bethel Island	High	Medium	Yes
Walnut Grove	High	Medium	Yes
Smith Tract*	High	Medium	Yes
Hotchkiss Tract	High	Medium	Yes
RD 17 (Mossdale)	High	Medium	Yes
Terminous Tract	High	Medium	Yes
Pierson District (aka Pearson)	High	Medium	Yes
New Hope Tract	High	Medium	Yes
Brannan-Andrus Island	High	Medium	Yes
Union Island	High	Medium	Yes
Bishop Tract	High	Medium	Yes
Tyler Island	High	Medium	No
King Island	High	Low	Yes
Walthall Tract	High	Low	Yes
Veale Tract	High	Low	Yes
Jones Tract	High	Low	Yes
Fabian Tract	High	Low	Yes
Canal Ranch	High	Low	No
Coney Island	High	Low	Yes
Rough and Ready Island*	High	Low	Yes
Little Egbert Tract	High	Low	Yes
Victoria Island	High	Low	Yes
Roberts Islands	Medium	Medium	Yes
Netherlands	Low	Medium	Yes
Discovery Bay	Low	Medium	Yes
Libby McNeil Tract	Low	Medium	Yes

[1] Total Asset Repair Costs (Damages) in the event of a flood and the estimated Construction Costs to improve the existing levees are based on estimates from the Delta Risk Management Strategy Phase 1 Report.
* These areas are included in other current USACE studies.

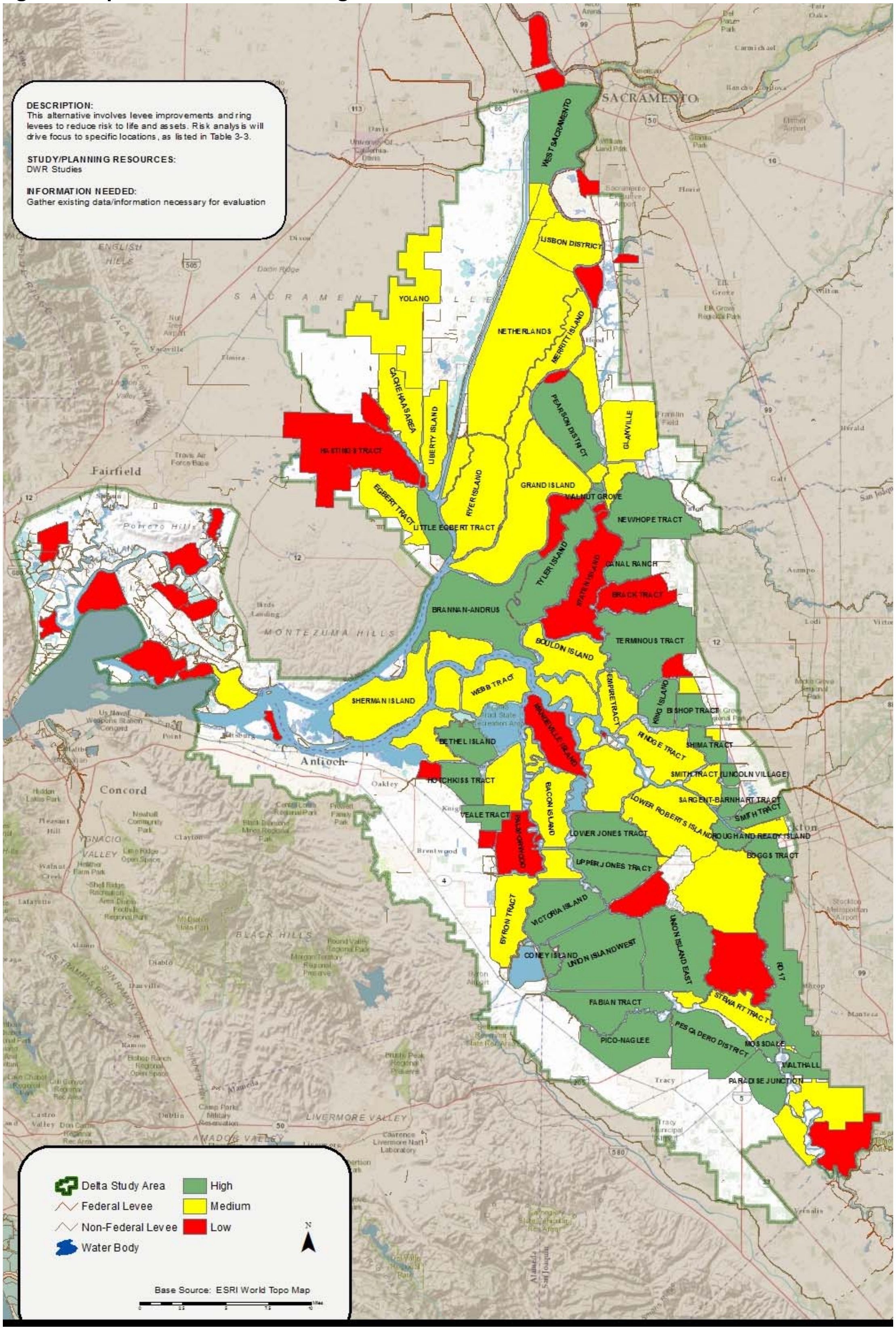
Island Name	Total Asset Repair Costs/Construction Costs[1]	Life Loss Risk	Assets of Statewide Importance
Twitchell Island	Medium	Low	Yes
Sherman Island	Medium	Low	Yes
Bacon Island	Medium	Low	No
Rindge Tract	Medium	Low	Yes
Woodward Island	Medium	Low	Yes
Glanville Tract	Medium	Low	Yes
Stark Tract	Medium	Low	Yes
McDonald Tract	Medium	Low	Yes
Empire Tract	Medium	Low	Yes
Bradford Island	Medium	Low	Yes
Grand Island	Low	Low	Yes
Merritt Island	Low	Low	Yes
Kasson District	Low	Low	Yes
Sutter Island	Low	Low	Yes
Prospect Island	Low	Low	Yes
Ryer Island	Low	Low	Yes
Webb Tract	Low	Low	Yes
McMullin Ranch-River Junction Tract	Low	Low	Yes
Hastings Tract	Low	Low	Yes
Lisbon District	Low	Low	Yes
Glide District	Low	Low	Yes
Lower Roberts Island	Low	Low	Yes
Byron Tract	Low	Low	Yes
Van Sickle Island	Low	Low	Yes
Stewart Tract	Low	Low	Yes
Palm Tract	Low	Low	Yes
Egbert Tract	Low	Low	Yes
Cache Haas Tract	Low	Low	Yes
Orwood Tract	Low	Low	Yes
Liberty Island	Low	Low	Yes
Middle Roberts Island	Low	Low	Yes
Decker Island	Low	Low	Yes
Medford Island	Low	Low	Yes
Holland Tract	Low	Low	Yes
Bouldin Island	Low	Low	Yes
Rio Blanco Tract	Low	Low	Yes
Wright-Elmwood Tract	Low	Low	Yes
Venice Island	Low	Low	Yes
Jersey Island	Low	Low	Yes
McCormack Williamson Tract	Low	Low	Yes
Mandeville Island	Low	Low	Yes

Island Name	Total Asset Repair Costs/Construction Costs[1]	Life Loss Risk	Assets of Statewide Importance
Quimby Island	Low	Low	Yes
Atlas Tract	Low	Low	Yes
Chipps Island	Low	Low	Yes
Weber Tract	Low	Low	Yes
Wetherbee Lake	Low	Low	Yes
Holt Station	Low	Low	Yes
Stewart-Mossdale	Low	Low	Yes
Ehrheardt Club	Low	Low	Yes
Yolano	Low	Low	Yes
Zone 122	Low	Low	No
SM-132	Low	Low	No
Zone 162	Low	Low	No
Zone 206	Low	Low	No
Water Zone 5	Low	Low	No
Zone 148	Low	Low	No
Zone 197	Low	Low	No
Zone 216	Low	Low	No
SM-202	Low	Low	No
Simmons-Wheeler Island	Low	Low	No
SM-49, SM-50	Low	Low	No
Water Zone 1	Low	Low	No
SM-48, SM-49	Low	Low	No
SM-43	Low	Low	No
SM-54	Low	Low	No
SM-60	Low	Low	No
SM-199	Low	Low	No
SM-198	Low	Low	No
SM-53	Low	Low	No
SM-84	Low	Low	No
SM-124	Low	Low	No
Zone 75	Low	Low	No
Zone 31	Low	Low	No
Zone 33	Low	Low	No
Bixler Tract	Low	Low	No
Zone 160	Low	Low	No
Water Zone 4	Low	Low	No
Water Zone 2	Low	Low	No
Water Zone 3	Low	Low	No
Holland Land	Low	Low	No
Pittsburg	Low	Low	No
Zone 38	Low	Low	No

Island Name	Total Asset Repair Costs/Construction Costs[1]	Life Loss Risk	Assets of Statewide Importance
Zone 64	Low	Low	No
Zone 78	Low	Low	No
Zone 120	Low	Low	No
Schafter-Pintail Tract	Low	Low	No
Zone 185	Low	Low	No
SM-59	Low	Low	No
Zone 158 (Smith Tract 2)	Low	Low	No
SM-52	Low	Low	No
SM-44	Low	Low	No
SM-55	Low	Low	No
Zone 37	Low	Low	No
Yolo Bypass	Low	Low	No
SM-123	Low	Low	No
SM-57	Low	Low	No
Zone 77	Low	Low	No
SM-46	Low	Low	No
Zone 36	Low	Low	No
Clifton Court Forebay Water Assets	Low	Low	No
Zone 81	Low	Low	No
Zone 69	Low	Low	No
SM-40	Low	Low	No
SM-58	Low	Low	No
Zone 65	Low	Low	No
SM-56	Low	Low	No
Fay Island	Low	Low	No
SM-39	Low	Low	No
Zone 79	Low	Low	No
Zone 207	Low	Low	No
Zone 80	Low	Low	No
Zone 90	Low	Low	No
Zone 74	Low	Low	No
Zone 171	Low	Low	No
SM-85-Grizzly Island	Low	Low	No
Honker Bay Club	Low	Low	No
SM-42	Low	Low	No
SM-41	Low	Low	No
Zone 155	Low	Low	No
Zone 82	Low	Low	No
Water Canal	Low	Low	No
Zone 14	Low	Low	No
Zone 186	Low	Low	No

Island Name	Total Asset Repair Costs/Construction Costs[1]	Life Loss Risk	Assets of Statewide Importance
Zone 214	Low	Low	No
Peter Pocket	Low	Low	No
Brack Tract	Low	Low	No
Staten Island	Low	Low	No
Shin Kee Tract	Low	Low	No
Dead Horse Island	Low	Low	No
Browns Island	Low	Low	No
Little Holland Tract	Low	Low	No
SM-133	Low	Low	No
SM-134	Low	Low	No
SM-47	Low	Low	No
SM-51	Low	Low	No

Figure 2: Specific Flood Risk Management Measures Considered – Locations



2.2 Analysis Phase

The three Delta Islands with the highest ratio of total asset repair costs to total construction costs (from DRMS data) and not included in a current Corps study were considered for further screening level benefit-cost analysis; the three islands include: Bethel Island, Walnut Grove, the City of Isleton (on Brannon-Andrus Island). Based on suggestions from the local sponsor and its high population, a fourth island, Discovery Bay, was also considered for further analysis; these islands are highlighted in Figure 3.

The main analytical tool used to perform the economic analysis in the analysis phase was the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software (version 1.2.5). This program uses engineering data (hydrologic, hydraulic, and geotechnical) and economic data (structure/content inventory and depth-percent damage curves) to model flooding risk management problems and potential solutions in the study area. Through integration of the engineering and economic relationships HEC-FDA computes expected annual damages (EAD) and performance statistics. EAD is the metric used to describe the consequences of flooding on an annual basis considering a full range of flood events – from high frequency/small events to low frequency/large events over a long time horizon. The following two sections describe the economic and engineering data that was used the HEC-FDA analysis.

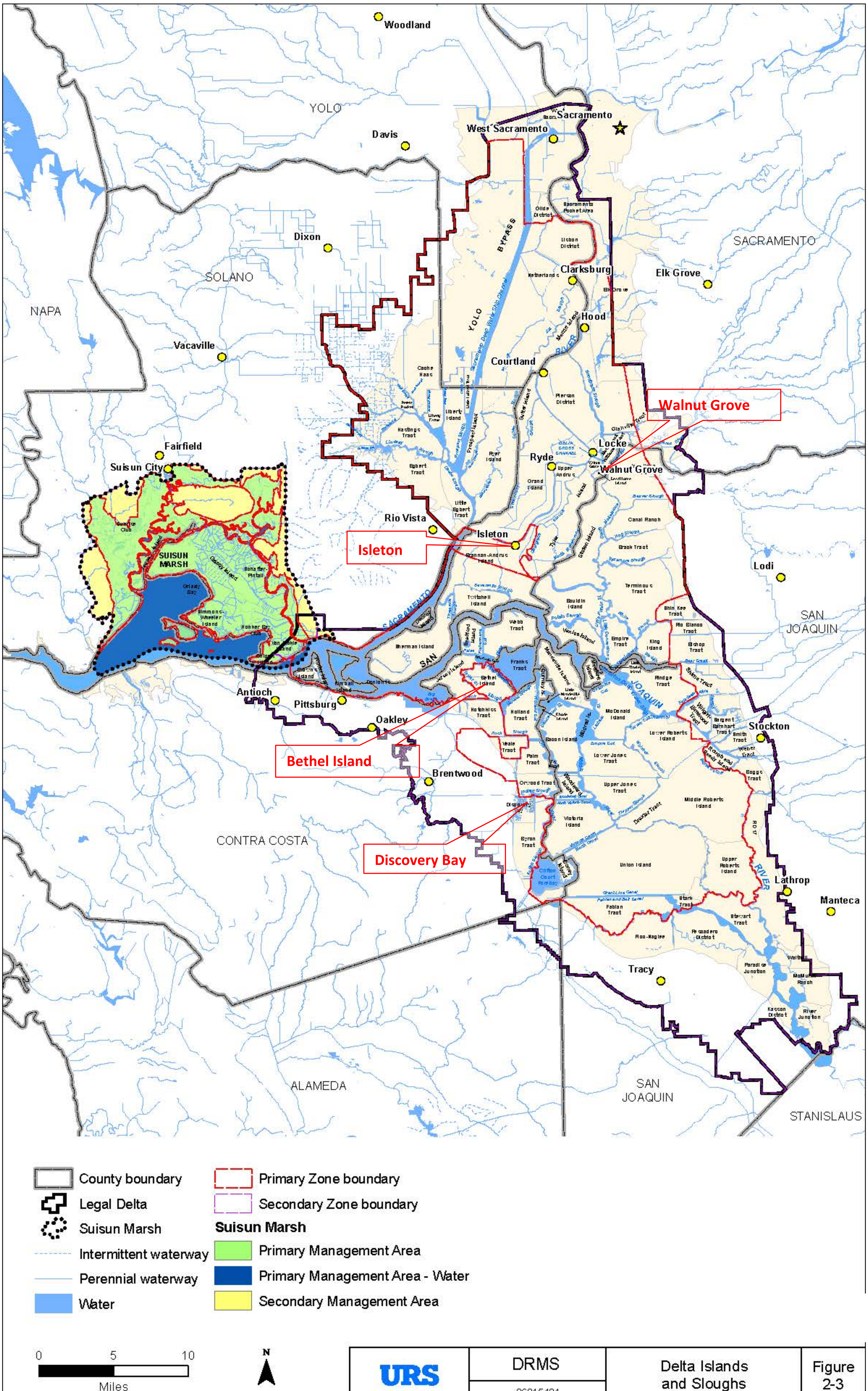
2.2.1 Economic Data

2.2.1.1 Structure and Contents Inventory and Valuation

Structure values were based on overall average values that were developed for the Lower San Joaquin River Feasibility Study (LSJRFS). Each residential structure's value was assumed to be equal to the average LSJRFS residential structure value. Residential content value was assumed to be equal to 50 percent of the structure value. Non-residential structure values were estimated by multiplying the Marshall and Swift calculator valuation per square foot value by the average LSJRFS non-residential structure square footage value for each business classification. Non-residential content values were taken from an expert elicitation that was performed to develop content values and content depth-percent damage curves for specific occupancy types for the 2008 American River Watershed, Folsom Dam Raise and Modification Economic Reevaluation Report (ERR). Although the values and curves were developed specifically for structures in the American River Watershed study area, the results of the expert elicitation were extended to the Delta study area in light of its proximity to Sacramento and the similarity of its structure types/construction types to those in Sacramento.

The number of structures for the study area was determined by Sacramento (Walnut Grove, Isleton) and Contra Costa (Bethel Island, Discovery Bay) county level GIS parcel data. Structure type (e.g., commercial, industrial, public and residential) was determined by GIS attribute codes and cursory checks using Google Earth. Automobiles were also included in the analysis and it was assumed one automobile would be subjected to flooding per residential structure; automobile values were determined for average used cars ($7,988) based on information from the U.S. Department of Transportation, Bureau of Transportation.

Figure 3: Delta Islands and Sloughs



2.2.1.2 Depth-Percent Damage Curves

The depth of flooding is the primary factor in determining potential damages to structures, contents, and automobiles. Depth-percent damage functions were used in the HEC-FDA models to estimate the percent of value lost for these categories. Residential depth-damage curves (structures and contents) were taken from Economic Guidance Memorandum (EGM) 01-03, Generic Depth-Damage Relationships, Non-residential structure curves were based on revised Federal Emergency Management Agency (FEMA) Flood Insurance Administration (FIA) curves. Non-residential content depth-percent damage curves for were taken from expert elicitation that were completed for previously mentioned American River studies. The depth-percent damage functions for automobiles were based on averages from curves developed by the Institute for Water Resources (IWR) and provided in EGM 09-04, Generic Depth-Damage Relationships for Vehicles.

2.2.1.3 Economic Uncertainty

In HEC-FDA, there are three areas of economic uncertainty that were considered for this study; valuation (structure and contents), depth damage curves (structure and contents), and foundation height. Values for structure valuation uncertainty were taken the 2012 Napa LRR Economic Appendix; content value uncertainties were based on data from expert elicitation from the previously mentioned American River Study. Residential structure and content depth-percent damage curves are normally distributed and uncertainty is measured as standard deviations of percent damages. Non-residential structure and content depth-percent damage curves are triangularly distributed and include a minimum, most likely, and maximum percent damage by depth of flooding. The uncertainty value for residential foundation height was assumed to be 0.5 feet; which is typical for SPK studies.

2.2.2 Engineering Data

2.2.2.1 Hydrologic and Hydraulic Analysis

The hydrologic and hydraulic data that was input into HEC-FDA include: floodplain data, stage-probability relationships, and period of record length (a hydrologic uncertainty measure). Floodplain data includes depths of flooding associated with the 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, and 0.2% annual chance exceedance (ACE) events; the floodplain data along with stage-probability curves were provided by SPK's Hydraulic Analysis Section. The data used for stage, frequency, and uncertainty event analysis originated from the 1992 Hydrology Office Report of the Sacramento-San Joaquin Delta Special Study by the Sacramento District (1992 Office Report). The 1992 Office Report was selected as the source for the hydraulic data and determined to be sufficient for this analysis as it is contains the most recent comprehensive hydrologic and hydraulic analysis of the Delta. To model the consequences of a flood event a simplified inundation model for analysis in the form of a constant water surface elevation, or stage, across the entire island was assumed. The stage values were taken from the 1992 Office Report. Table 2 shows the 1992 Office Report chart that was applied to each of the four islands along with the corresponding stage for each ACE. The uncertainty associated with the data will be evaluated using the appropriate period of record which is also listed the Table 2. See Appendix C- Engineering (Flood Risk Management) for a more detailed analysis and discussion on Delta: risk, hydrology and hydraulics.

Table 2: Stage Frequency Values and Period of Records

Island	Chart from 1992 Office Report	Datum Conversion to NAVD'88	Stage in Feet (NAVD'88) Annual Chance Exceedance								Period of Record (Years)
			50%	20%	10%	4%	2%	1%	0.5%	0.2%	
Bethel Island	Chart 12	2.36	7.3	8.1	8.5	8.9	9.2	9.4	9.6	9.7	30
Walnut Grove	Chart 5	2.39	11.4	13.8	14.9	15.9	16.7	17.3	17.8	18.4	43
Isleton (Brannan-Andrus)	Chart 4	2.47	7.5	8.3	9.0	9.7	10.5	10.9	11.2	11.5	30
Discovery Bay	Chart 12	2.36	7.3	8.1	8.5	8.9	9.2	9.4	9.6	9.7	30

2.2.2.2 Geotechnical Analysis

Levee fragility curve data was provided by SPK's Geotechnical Branch; a levee fragility curve shows the probabilities of failure at different water surface elevations against a levee. Fragility curves are a main component of the economic modeling and in determining the economic damages of flood events. For this analysis, fragility curves were developed for Bethel Island, Walnut Grove and Isleton using information contained in the DRMS Levee Vulnerability Technical Memorandum. Please see Appendix C- Engineering (Flood Risk Management) for additional geotechnical information.

2.3 Benefit Cost Analysis

Values listed in this section are based on an October 2012 price level. Annualized benefits and costs were computed using a 50-year period of analysis and a federal water resource discount rate of 3.750% as this was the current rate during the development of the flood risk management (FRM) and multipurpose economic analysis.

2.3.1 Without Project Analysis

The future without project condition assumed that the capital features of DWR's Bay Delta Conservation Plan (BDCP) will be in place. Solutions under consideration by the BDCP include a dual water conveyance system, which would create options that would move water through the Delta's interior or around the Delta through an isolated conveyance facility (tunnel). As such, any potential flood damages to existing Delta water conveyance features are not included in the without project analysis as the BDCP conveyance features will provide a means to convey water through or around the Delta. In addition, there are no structural FRM measures to protect existing Delta water conveyance features considered in the with-project analysis. See the Main Report for a more detailed discussion regarding the future without project condition.

Structure counts for the four main building categories are listed by island in Table 3a, and represent those structures falling within the 500-year floodplain. Without project EAD by major damage area and population at risk (2010 census) are reported in Tables 3b and 4 respectively.

Table 3a: Number of Structures by Category in 0.2% Annual Chance Exceedance Floodplain

Island	Commercial	Industrial	Public	Residential	Total
Bethel Island	13	1	3	914	**931**
Walnut Grove	39	11	3	123	**176**
Isleton	74	7	6	392	**479**
Discovery Bay	19	2	7	5,028	**5,056**

Table 3b: Without-Project Expected Annual Damages (EAD) ($1,000, 2012 Prices)

Island	Autos	Commercial	Industrial	Public	Residential	Total
Bethel Island	1,497	208	96	132	15,526	**17,459**
Walnut Grove	37	209	233	113	544	**1,136**
Isleton	356	1,040	443	476	4,573	**6,888**
Discovery Bay	85	5	2	2	1,472	**1,566**

Table 4: Population at Risk

Island	Population at Risk
Bethel Island	2,137
Walnut Grove	1,542
Isleton	804
Discovery Bay	13,352

2.3.2 Annual Exceedance Probability

Annual exceedance probability (AEP) is a statistic used to describe the chance of flooding in any given year within a designated area. AEP is computed in HEC-FDA using engineering data; AEPs for the four islands are reported in Table 5a.

Table 5a: Annual Exceedance Probability- Without-Project Condition

Island	AEP
Bethel Island	0.2840
Walnut Grove	0.0481
Isleton	0.1596
Discovery Bay	0.1640

2.3.3 Assurance

Assurance, describes the likelihood of a stream/river being able to pass a specific flow event, for example the 100-year flow. The assurance statistics provide relevant information to decision makers in that it helps describe both how well the flood system currently performs and how well the system could potentially perform under various with-project scenarios.

The assurance statistics for each island under the without-project condition are listed in Table 5b. Taking Bethel Island for example, the information indicates there is a 66% chance of passing the 10% flow event and 60% chance of passing the 1% flow event.

Table 5b: Assurance Results by Island

Island	ASSURANCE (%)					
	10%	4%	2%	1%	0.40%	0.20%
Bethel Island	66	63	62	60	58	57
Walnut Grove	92	90	88	86	83	82
Isleton	81	77	75	72	70	68
Discovery Bay	99	88	70	50	32	24

2.4 With Project Analysis

For this screening level analysis, there were no floodplains or other engineering data developed for with-project conditions. To develop estimates for with-project damages, two scenarios were considered; 1) Zero with-project damages (or best case scenario), the Corps project would yield no residual damages, and 2) 25 percent remaining damages (or a typical case scenario); the Corps project would eliminate 75 percent of without-project damages. The zero with-project damages scenario is the highest level of flood risk management (FRM) performance any Corps project could expect to yield; whereas, the 25 percent remaining with-project damages are more in line with the FRM performance of a typical Corps project. The with-project EADs for both scenarios are reported in Tables 6 and 7.

Table 6: With-Project Expected Annual Damages - Zero Remaining Damages ($1,000, 2012 Prices)

Island	Autos	Commercial	Industrial	Public	Residential	Total
Bethel Island	0	0	0	0	0	**0**
Walnut Grove	0	0	0	0	0	**0**
Isleton	0	0	0	0	0	**0**
Discovery Bay	0	0	0	0	0	**0**

Table 7: With-Project Expected Annual Damages - 25% Remaining Damages ($1,000, 2012 Prices)

Island	Autos	Commercial	Industrial	Public	Residential	Total
Bethel Island	374	52	24	33	3,882	**4,365**
Walnut Grove	9	52	58	28	136	**284**
Isleton	89	260	111	119	1,143	**1,722**
Discovery Bay	21	1	1	1	368	**392**

2.5 FRM Benefits

Average annual FRM benefits for the each island were determined by taking the difference between without-project EAD and with-project EAD. These results for both with project assumptions are shown in Tables 8 and 9.

Table 8: Expected Annual FRM Benefits - Zero Remaining Damages ($1,000, 2012 Prices)

Island	Autos	Commercial	Industrial	Public	Residential	Total
Bethel Island	1,497	208	96	132	15,526	**17,459**
Walnut Grove	37	209	233	113	544	**1,136**
Isleton	356	1,040	443	476	4,573	**6,888**
Discovery Bay	85	5	2	2	1,472	**1,566**

Table 9: Expected Annual FRM Benefits - 25% Remaining Damages ($1,000, 2012 Prices)

Island	Autos	Commercial	Industrial	Public	Residential	Total
Bethel Island	1,123	156	72	99	11,645	**13,094**
Walnut Grove	28	157	175	85	408	**852**
Isleton	267	780	332	357	3,430	**5,166**
Discovery Bay	64	4	2	2	1,104	**1,175**

2.6 FRM Costs

Cost estimates for each island and measure were provided by the SPK's Cost Engineering Section. Total and annual FRM construction costs are shown in Table 10. All costs are annualized based on the fiscal year 2013 federal water resource discount rate of 3.75 percent. The costs reported in Table 10 do not include interest during construction. See Appendix E - Cost Engineering for additional measure descriptions and cost information.

Table 10: Total and Annual FRM Costs ($1,000, 2012 Prices)

Island/Alternative	Total Costs	Annual Costs
Bethel Island- Measure A	682,558	30,424
Walnut Grove- Measure A	98,895	4,408
Walnut Grove- Measure B	104,646	4,665
Isleton- Measure A	203,705	9,080
Discovery Bay- Measure A	128,718	5,737

2.7 Net Benefits

Net benefits are determined as the difference between the annual benefits and the annual costs. The net benefits and BCRs for each island and alternative under both with-project scenarios are shown in Table 11. All island alternatives have negative net benefit; also, there is no island alternative that has a BCR above unity; the highest valued BCR is 0.76 for the Isleton Alternative A under the Zero Percent Remaining Damages with-project scenario.

Table11: Delta Islands Annual FRM Net Benefits and BCRs ($1,000)

Island/Measure	Net Benefits Zero Percent Remaining Damages	Net Benefits 25 Percent Remaining Damages	BCR Zero Percent Remaining Damages	BCR 25 Percent Remaining Damages
Bethel Island- A	-12,965	-17,330	0.57	0.43
Walnut Grove- A	-3,272	-3,529	0.26	0.19
Walnut Grove- B	-3,556	-3,813	0.24	0.18
Isleton- A	-2,192	-3,914	0.76	0.57
Discovery Bay- A	-4,171	-4,563	0.27	0.20

2.8 FRM Summary

All Delta island FRM measures have negative net benefits BCRs considerably below unity.

3.0 Multi-Purpose Analysis

As there was no overlap in the geographic footprints of the ER and FRM measures, opportunities do not exist to simply combine measures into multi-purpose measures. However, opportunities may exist to incorporate smaller scale ER measures in some of the higher ranking FRM areas. Of the highest ranking FRM areas, the two best candidates for multi-purpose measures were found to be Bethel Island and Walnut Grove. The opportunity to include ecosystem restoration into these FRM areas was largely based on land use; portions of the island were used solely for agriculture and could contribute to ER objectives if reconnected to the waterways. In order to determine if it was warranted to further pursue these measures, an economic analysis was first completed on the FRM elements, as described below.

3.1 Multipurpose Economic Analysis

There were two multipurpose measures considered for further screening level analysis: 1) Bethel Island Measure A (see Figure 3) and 2) Walnut Grove Measure B (see Figure 4). Both of these measures would restore sustainable ecosystem functions in the Delta while improving FRM for developed areas. A benefit-cost analysis was performed to determine if a multipurpose measure could be economically feasible based on FRM specific benefits and FRM separable costs. If a multipurpose measure's FRM benefits are less than the FRM separable costs, then that multipurpose measure will not be economically justified regardless of the level ecosystem restoration benefits. Under USACE policy, ecosystem restoration benefits cannot be used to justify FRM separable costs.

Table 12 contains the FRM separable costs for the two multipurpose measures; the costs in this table only include FRM separable costs and do not include joint costs. FRM separable costs are the costs that are required only for the FRM benefits of the measure, whereas joint costs are required for both FRM and ecosystem restoration benefits. In Figure 3, the FRM separable costs of the Bethel Island Measure A are the costs to construct levee feature BI_A_2 (orange line) while the joint costs are the costs to construct setback levee feature BI_A_1 (or green line). In Figure 4, the FRM separable costs of Walnut Grove Measure B are the costs to construct levee features WG_B_1 (red line), WG_B_3 (orange line) and WG_B_4 (yellow line), whereas the joint costs are the costs to construct setback levee feature WG_B_2 (blue line).

Table 12: Annual Separable FRM Costs (In 1,000s, Oct 2012 Price Level)

Island/Measure	Annual Separable FRM Costs
Bethel Island- Measure A	28,237
Walnut Grove- Measure B	3,821

Figure 3: Bethel Island Multipurpose Measure A

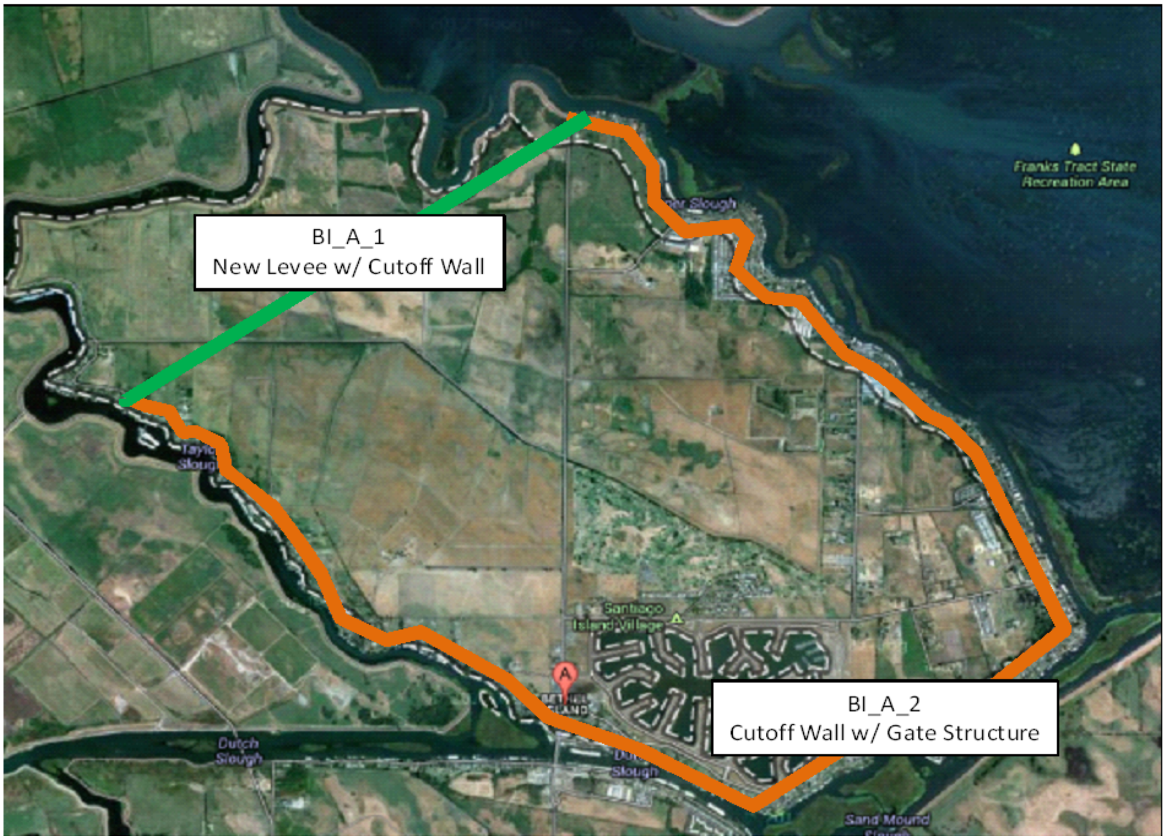
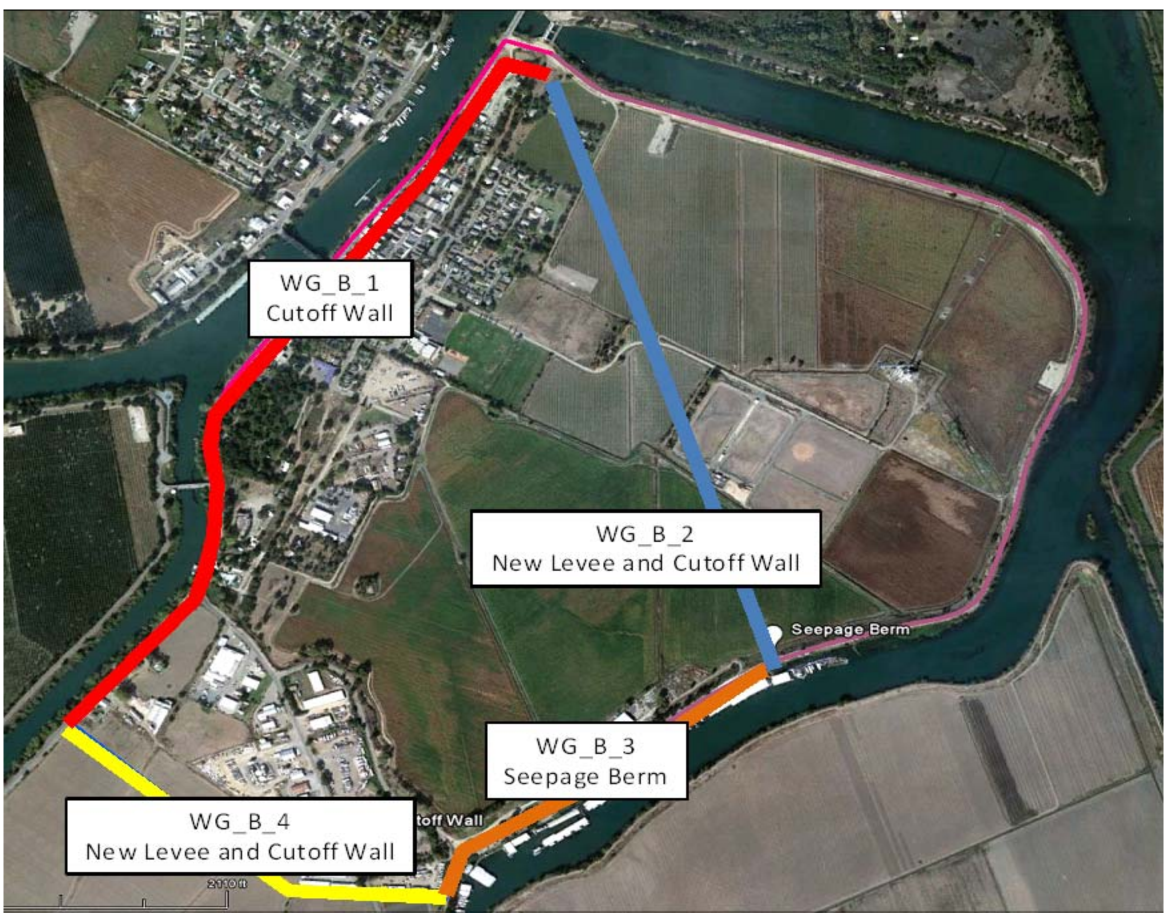


Figure 4: Walnut Grove Multipurpose Measure B



The FRM benefits for these multipurpose measures are the same as previously discussed and for convenience are repeated in Tables 13 and 14.

Table 13: Expected Annual FRM Benefits - Zero Remaining Damages ($1,000, 2012 Prices)

Island/Measure	Total Benefits
Bethel Island	**17,459**
Walnut Grove	**1,136**

Table 14: Expected Annual FRM Benefits - 25% Remaining Damages ($1,000, 2012 Prices)

Island	Total Benefits
Bethel Island	**13,094**
Walnut Grove	**852**

3.2 Multipurpose Objective Net Benefits

The FRM specific net benefits and BCRs of the two multipurpose measures are shown in Table 15. As a best-case scenario, the FRM benefits were assumed to be equal to the total without-project FRM damages (i.e., a zero percent remaining damages with-project scenario). The two measures would have negative net benefits and BCRs below unity even under that best-case scenario. The highest BCR is 0.62 for Bethel Island Measure A under the zero percent remaining damages with-project scenario. Since each multipurpose measure has a FRM negative net benefit, which indicates FRM specific benefits are less than the FRM separable costs, these multipurpose measures cannot be economically justified as ecosystem restoration benefits and costs are added.

Table15: FRM Net Benefits and BCRs for Multipurpose Alternatives (In 1,000s, Oct 2012 Price Level)

Island/Alternative	Net Benefits Zero Percent Remaining Damages	Net Benefits 25 Percent Remaining Damages	BCR Zero Percent Remaining Damages	BCR 25 Percent Remaining Damages
Bethel Island- Measure A	-10,778	-15,143	0.62	0.46
Walnut Grove- Measure B	-2,685	-2,969	0.30	0.22

3.3 Multipurpose Summary

FRM and multipurpose alternatives were found to be economically infeasible, therefore structural FRM alternatives were not evaluated further. However, there may still be non-structural measures to reduce risk within the study area as further described within the main report.

For information on the ecosystem restoration (single objective) alternative descriptions and cost effective-incremental cost analysis see the Main Report and Appendix F.