APPENDIX D

ENGINEERING –

ECOSYSTEM RESTORATION

ENGINEERING APPENDIX

FOR

EXISTING CONDITION ANALYSIS FOR RISK INFORMED DECISION MAKING FOR PROJECT ALTERNATIVE SELECTION

DELTA ISLANDS AND LEVEES FEASIBILITY STUDY, CALIFORNIA

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Contents

1.0 INTRODUCTION AND BACKGROUND

1.1 Purpose

This document was created as an addendum to the Hydraulic Engineering Technical Memorandum (TM) for the Sacramento – San Joaquin Rivers Delta Island and Levees, California, Feasibility Study (Feasibility Study), in order to describe the engineer analysis conducted for the Ecosystem Restoration (ER) portion of the Tentative Selected Plan (TSP). The TM documents the hydraulic analysis work conducted for the Flood Risk Management (FRM) portion of the TSP report.

The TM indentified four potential locations within the study area, Bethel Island, Discovery Bay, Brannen Andrus Island and Walnut Grove, that would have provided the largest Benefit to Cost Ratio (BCR) for a potential FRM alternative. However, the FRM analysis showed that there was not enough Federal interest in FRM alternative for the Delta (benefit to cost ratio less than 1). The PDT decided to evaluate FRM alternatives which only contained ER components and alternatives.

The Project Delivery Team (PDT) qualitatively selected ER alternatives from an array of choices based on USACE Planning criteria and engineering judgment. This report does not support a recommendation, it only documents the work conducted to support for the selection of an ER alternative for the TSP report.

1.2 Background

The Central Valley of California, is defined by a watershed drainage area of 59,380 square miles, and includes the Sacramento River (27,580 square mile watershed) which flows south from the Sacramento Valley and the San Joaquin River (31,800 square mile watershed) which flows north from the San Joaquin Valley. The Calaveras and Mokelumne Rivers flow from the east into the Sacramento San Joaquin Delta.

The Sacramento - San Joaquin Delta (Delta) as defined for this study, extending east of the Carquinez Straight through Suisun Bay to the northeast along the Sacramento River to Freeport, southeast along the San Joaquin River to Vernalis, and through the network of islands and levees east to Stockton, as shown in Plate 1. The Delta is a controlled system of over 700 miles of interconnected waterways and islands protected by approximately 1,100 miles of levees that include approximately 400 miles of federal levees. The levees are aging and under threat from subsidence, animal burrowing, earthquakes, wind and wave action, floods, high tides, and sea level rise.

1.3 Data Sources

1.3.1 Bathymetric Data

The topographic and bathymetric datasets used to support the ER alternative analysis were supplied by the State of California Department of Water Resources (DWR), Bay Delta Office. Digital Elevation Models (DEM) consisting of 10 meter and 2 meter integrated elevation maps were developed by DWR. This product was developed based on synthesizing LiDAR, singleand multibeam sonar soundings and existing integrated maps collated from multiple sources. For additional information on the bathymetric data set please refer to the following DWR website:

http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/modelingdata/DEM.cfm

1.3.2 Salinity Impact Analysis

DWR has conducted water quality impact studies along various locations in the Delta, specifically looking at salinity, organic carbon, and mercury levels. DWR's report "Flooded Islands, Feasibility Study Baseline Report, 2005" documents potential project alternatives and their relative impacts on the salinity levels on Frank's Tract, Big Break and Lower Sherman Lake. The water quality impacts were assumed to be the same for USACE's ER alternatives for TSP selection. For additional information on the bathymetric data set please refer to the following DWR website:

http://www.water.ca.gov/Frank'stract/floodedislands.cfm

2.0 ECOSYSTEM RESTORATION ALTERNATIVE DEVELOPMENT

2.1 Formulation of Alternative Array

The formulations of the ER Alternative array address the ecological health of the Delta by re-establishing some of the critical ecosystem structure and functions. The alternatives, otherwise referred to as "measures" are defined as a feature or an activity that can be implemented at a geographic site to address one or more planning objectives. A detailed description of the ecosystem restoration strategy and measures can be found in the TSP report. A list of ecosystem restoration measures that were considered are given below:

- Restoration of native riparian habitat
- Creation of new channels to connect habitat
- Invasive species management
- Restoration of in-channel islands and floodplains
- Restoration of historic marshes
- Salinity Management
- Construction of habitat friendly levees
- Construction of setback levees
- Controlled flooding of appropriate subsided islands
- Creation of bypasses

2.2 Alternative Selection

The measures listed in the previous section were initially screened based on four criteria: likehood of opportunity, effectiveness, general efficiency, and general acceptability. A detailed description of the selection criteria can be found in the TSP report. A secondary screening, in which any measure that was already considered under the BDCP would be eliminated, also helped to truncate the alternatives array.

A list of ecosystem restoration measures that were considered are given below:

- Restoration of Intertidal Habitat with Subsidence Reversal at Big Break
- Restoration of Intertidal Habitat with Subsidence Reversal at Little Frank's Tract and Frank's Tract
- Restoration of Stream Connectivity and Riparian Habitat with Setback Levees at Steamboat and Sutter Sloughs
- Restoration of Riparian/Intertidal Habitat and Floodplain Access with Subsidence Reversal along the South Mokolumne River
- Restoration of Riparian/Intertidal Habitat and Floodplain Access with Subsidence Reversal at Medford Tract

These measures were again screened based on land availability concerns, likely effects to water rights, impacts to existing habitat, gross relative real estate cost and gross relative construction cost. A secondary screening, in which a measure already considered under the BDCP would be eliminated, further truncating the alternative array.

3.0 ENGINEERING ANALYSIS FOR FINAL ALTERNATIVE ARRAY

Restoring intertidal habitats at Big Break, Little Frank's Tract and Frank's Tract, Plate 2, it would provide an area for native aquatic and terrestrial species to survive, while also eliminating habitant for invasive non-native species. Previous USACE projects at Venice Cut and Donlon Island have shown that subsidence reversal is a viable method to restore intertidal marsh.

3.1 <u>Project Assumptions</u>

3.1.1 Salinity

Delta waters serve multiple purposes: providing habitat for important species of fish and other aquatic organisms, a water source for California's residents and for agricultural irrigation, all of which have specific water quality requirements. The threat to the Delta from salt-water intrusion is one of the main concerns of all who rely on the Delta.

DWR has conducted various studies to better capture a baseline condition of the salinity levels within the Delta. Specifically, DWR concentrated on three study areas in their report "Flood Island Baseline Report, State of California Department of Water Sources, 2005", Frank's Tract, Big Break and Sherman Island.

Frank's Tract is tidally connected to the San Joaquin River through the False River channel. Due to the levee breach locations along Frank's Track, the hydrodynamic forces trap saline water within the flooded area of the island. Modeling showed that the saline water entered through the breach along the western side of the island, False River, and exited into Old River through the levee breach on the east side, which degrades the source water by allowing the saline water to travel further upstream. For engineering purposes, it is assumed that a subsidence reversal measure would eliminate this pathway for saline water to travel further upstream the Delta. At a minimum, there would be no negative impacts to the salinity levels.

The flooded area within Big Break is shallower than Frank's Tract, so the hydrodynamic forces are not as complex. It is assumed for the TSP, that the salinity levels within the Delta would not be negatively affected with a subsidence reversal measure.

3.1.2 Hazardous, Toxics and Radioactive Waste Concerns

There are common potential environmental concerns for all alternatives evaluated in this study. There are Total Maximum Daily Load (TMDL) Basin Plan Amendments for organic enrichment and dissolved oxygen for portions of the San Joaquin Deep Water Ship Channel based on the current 303d Clean Water Act list for the Delta, however, the project alternatives are outside of impaired areas. There is also a TMDL for methyl mercury in the Delta, which includes wetland and open water sources in the proposed project area. Total mercury loads and potential methyl mercury loads are required to comply with the TMDL allocations.

The dredged material obtained from Operations and Maintenance Dredging will be characterized prior to placement and habitat restoration. Similarly, previously placed dredged material will be characterized for mercury prior to placement in the restoration areas, and has already been characterized under the O&M dredging program for the past 13 years. Further, a control study will be developed to monitor mercury and methyl mercury concentrations in the habitat restoration areas following placement. All other environmental concerns will be addressed through the 401 Water Quality Certification process and subsequent monitoring program required under the 401 permit.

3.1.3 Hydraulic Impacts

Due to the geographic location of Big Break and Frank's Tract, it is assumed that any subsidence reversal measure would have little to no hydraulic impacts to the flood control system and deep water shipping channels.

3.2 <u>Subsidence Reversal Measure</u>

3.2.1 Target Elevation for Island Restoration

Based on the previous projects at Venice Cut and Donlon Island, it was determined that optimal wetland development occurs when the marsh habitat is restored to an elevation between -2.0ft to 0.5ft relative to mean water level. The mean water level elevation was based on data collected from DWR's gage along the Sacramento River at Rio Vista (RVB) for the year 2013. Since this effort was only for a TSP selection, the PDT determined that a period of record of one calendar year was enough data to get an estimate of the mean water level. Further refinement of the TSP would consider a longer period of record and account for potential sea level rise. The mean water level ranged from 2.8ft NAVD88 to 6.8ft NAVD88. An elevation of 4.8ft NAVD88 for mean water level was estimated from the gage data.

Given the mean water level of 4.8ft NAVD88, the ground elevation required for restoration of native habitat would range from 2.8ft to 5.3 ft NAVD88. Conservatively, the PDT choose to use an elevation of 4.5ft NAVD88 as the target elevation to estimate fill quantities.

3.2.2 Volume Calculations

The amount of material required to fill in Big Break, Little Frank's Tract and Frank's Tract was based on bathymetric data from DWR and data collected from previous USACE projects along Venice Cut and Donlon Island.

Multiple cross sections were cut along various locations for Big Break, Little Frank's Tract and Frank's Tract in order to determine a representative channel floor elevation. Plates 3 and 4 shows the cross section locations for Big Break, Little Frank's Tract and Frank's Tract. Cross sections were divided into sections of 100 meters and then the elevations were averaged together to get representative elevations. Table 3.1 below shows a summary of the target elevations, the Delta floor elevations, and the required depth to fill. Plates 5 through 15 show the cross section profiles.

Project Reach	Target Elev. (NAVD88)	Delta Floor Elev. (NAVD88)	Depth to Fill
Big Break	4.5 ft	-2.44 ft	6.94 ft
Little Frank's Tract	4.5 ft	-5.42 ft	9.92 ft
Frank's Tract	4.5 ft	-5.82 ft	10.32 ft

Table 3.1

Based on the depth to fill and the area, approximate acreage and total fill volumes were calculated. An extra 15% was added to the acreages due to the open water area at the edge of the existing island that the project may have to partially fill. An additional 10% fill lost factor was added as a contingency for estimation purposes. Table 3.2 below summarizes:

Project Reach	Acreage	Total Fill Required to Target Elevation (CY)
Big Break	1,064	12,685,575
Frank's Tract	2,470	42,647,982
Little Frank's Tract	273	4,567,363

Table 3.2

3.2.3 Error in Volume Calculations

An error was later found post district quality control for the total fill required to fill until reaching the target elevation. The difference was found to be less than 6%. Being that the change in volume was so minor, the PDT decided to update the volumes when the project reaches Pre-design Engineering and Design Phase. Table 3.3 below summarizes the differences:

Project Reach	Old Volume Required to Reach Target Elev. (CY)	New Volume Required to Reach Target Elev. (CY)	Δ (CY)	%
Big Break	12,685,575	13,104,420	418,844	3.2%
Frank's Tract	42,647,982	45,236,954	2,588,972	5.0%
Little Frank's Tract	4,567,363	4,806,080	238,717	5.7%

Table 3.3

3.2.4 Increment Selection

In order to optimize the subsidence reversal measure, the PDT divided each project reach into a grid system, with each grid approximately 1 acre. This allowed for the PDT to select smaller increments of the project area to fill in based on proximity of the area to available fill material. The grid outlines for Big Break, Frank's Tract and Little Frank's Tract are shown on plates 16, 17, and 18.

Big Break was divided into 7 different increments; Frank's Tract was broken into 3 increments, and Little Frank's Tract into 2 increments. The acreages were determined by the amount of material that could be placed at a specific site based on the volume of material available. Plates 19 through 20 show the increment breakdown and table 3.4 below describes the different increments:

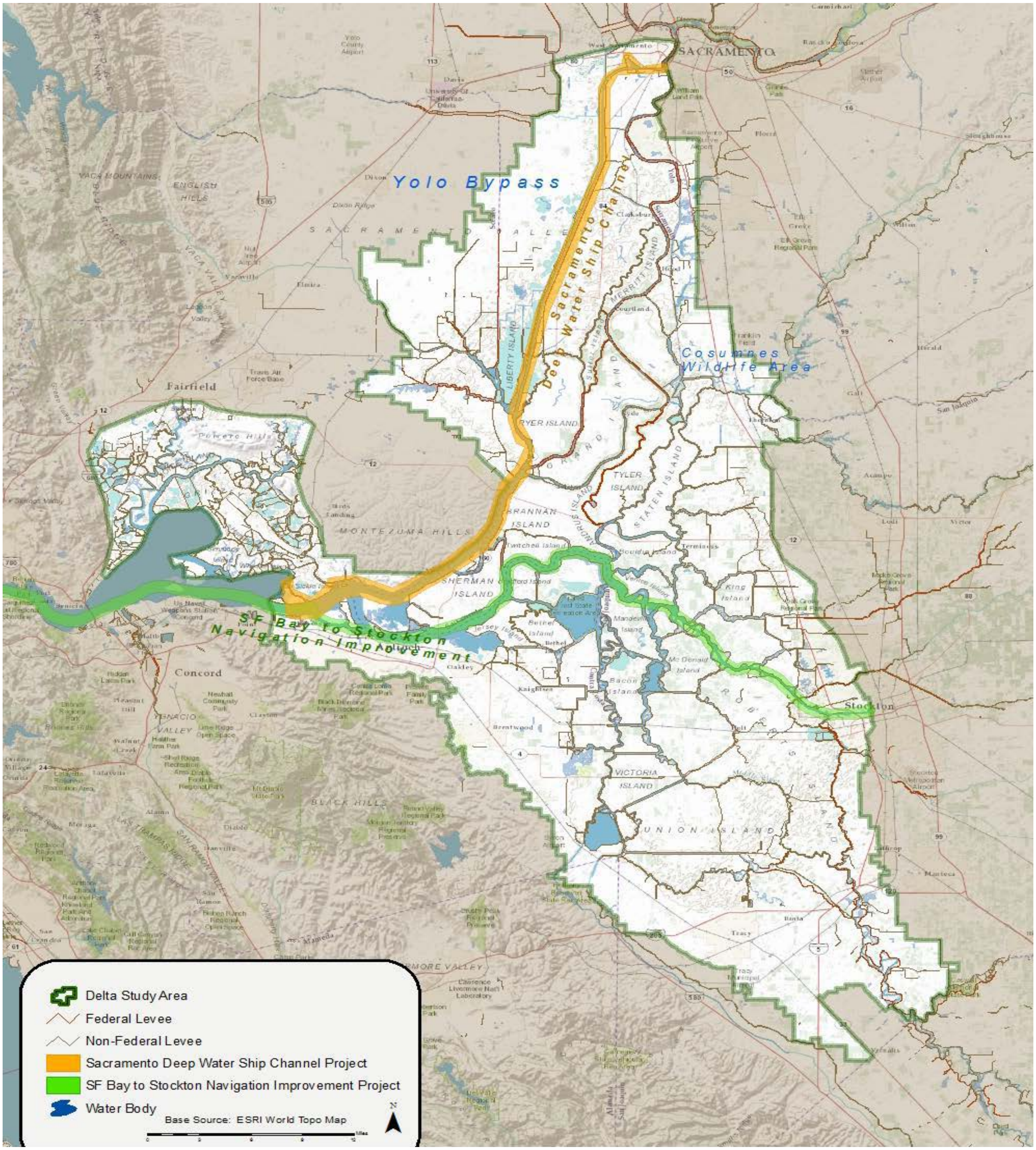
BIG BREAK				
INCREMENT	**ACREAGE**	**VOLUME (CY)**	**DEPTH (FT)**	**METHOD**
1	41.9	500,000	6.9	DIRECT PLACEMENT (O&M)
2	10.4	124,023	6.9	PUMPING
3	17.6	209,992	6.9	PUMPING
4	0.9	11,263	6.9	PUMPING
5	10.4	124,500	6.9	PUMPING
6	4.2	49,500	6.9	PUMPING
7	978.5	11,666,297	6.9	TRUCKING/BARGING
TOTAL SUM	1,064	12,685,575		
FRANK'S TRACT				
1	19.7	339,020	10.3	PUMPING
2	119.3	2,053,084	10.3	PUMPING
3	2,331.0	40,255,878	10.3	TRUCKING/BARGING
TOTAL SUM	2,470.0	42,647,982		
LITTLE FRANK'S TRACT				
1	9.2	153,115	9.9	PUMPING
2	263.9	4,414,248	9.9	TRUCKING/BARGING

TOTAL SUM	273.0	4,567,363		

Table 3.4

4.0 CONCLUSION

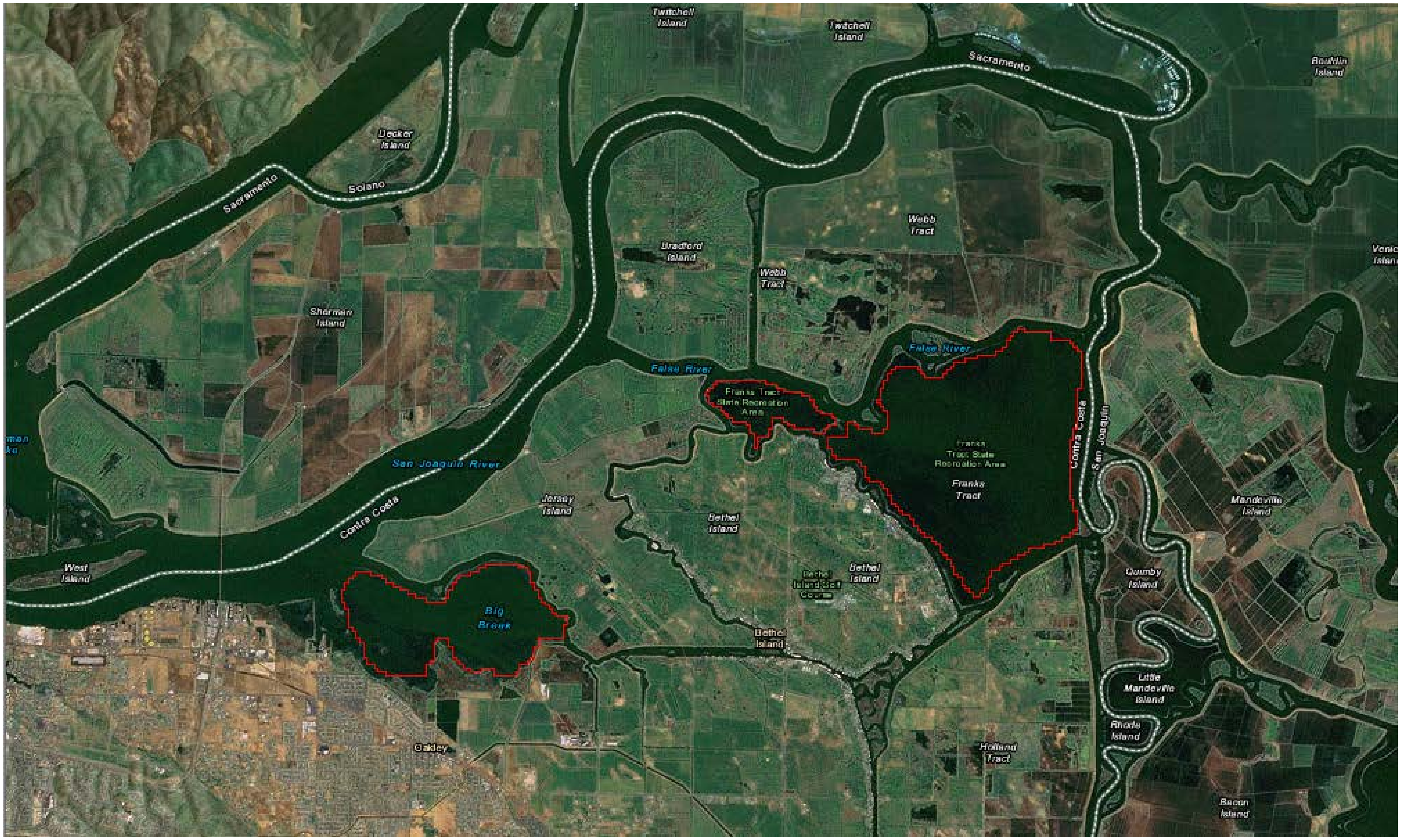
The Tentatively Selected Plan includes Big Break increment 1, 2, 3, 5 and Little Frank's Tract increment 1. The selected grids to be filled in are shown on plates 22 and 23. Big Break Increment 1 would be filled in with dredged material from Operation and Maintenance dredging along the Stockton Deep Water Ship channel for a period of 5 years, assuming that an average of 100,000 CY of material is available annually. The remaining sites would be filled in by pumping available material from various nearby placement sites.



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

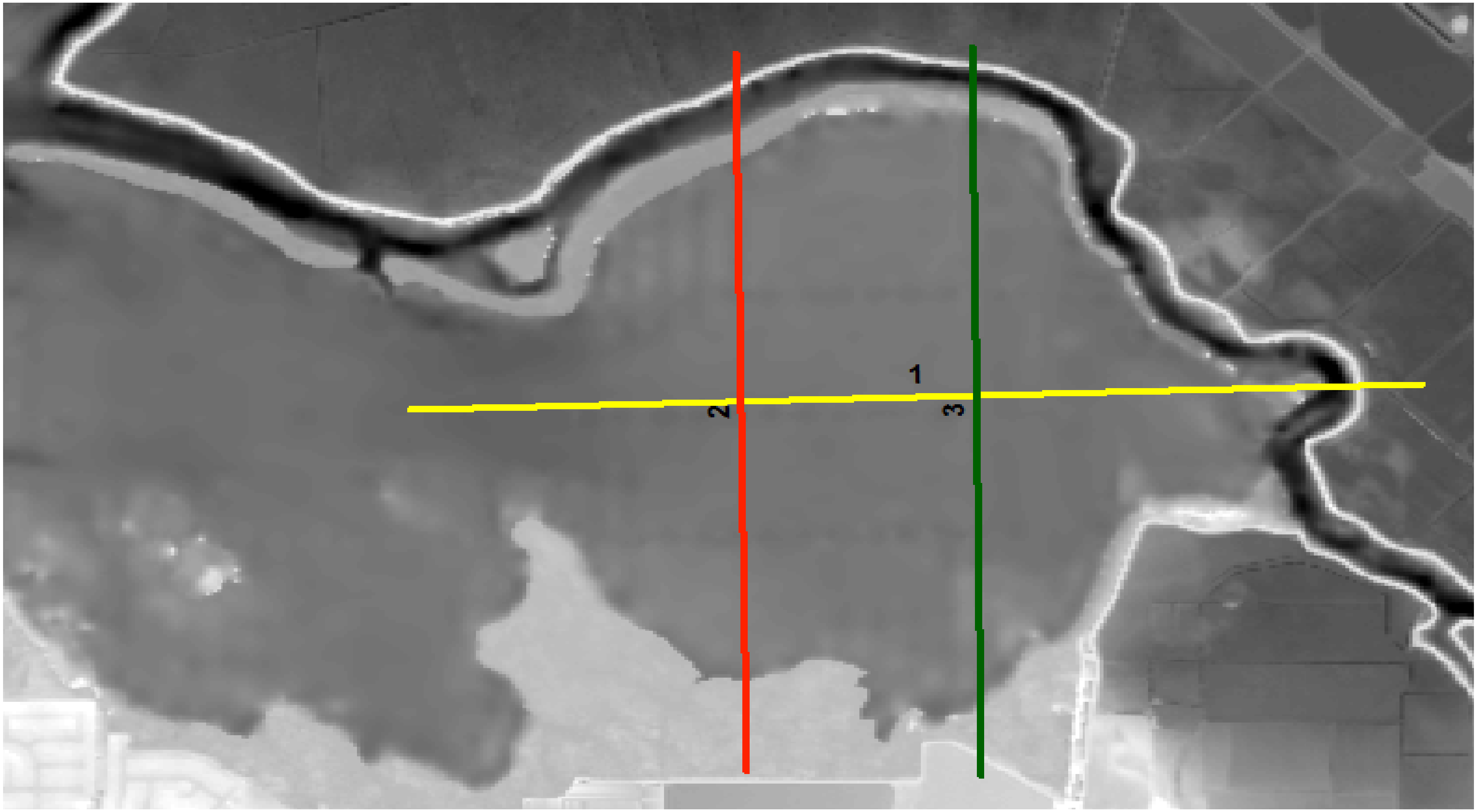
DELTA STUDY AREA

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY **ENGINEERING HYDRAULIC APPENDIX**
BIG BREAK, FRANK'S TRACT & LITTLE FRANK'S TRACT STUDY ARE
U.S ARMY CORPS OF ENGINEERS **SACRAMENTO DISTRICT**

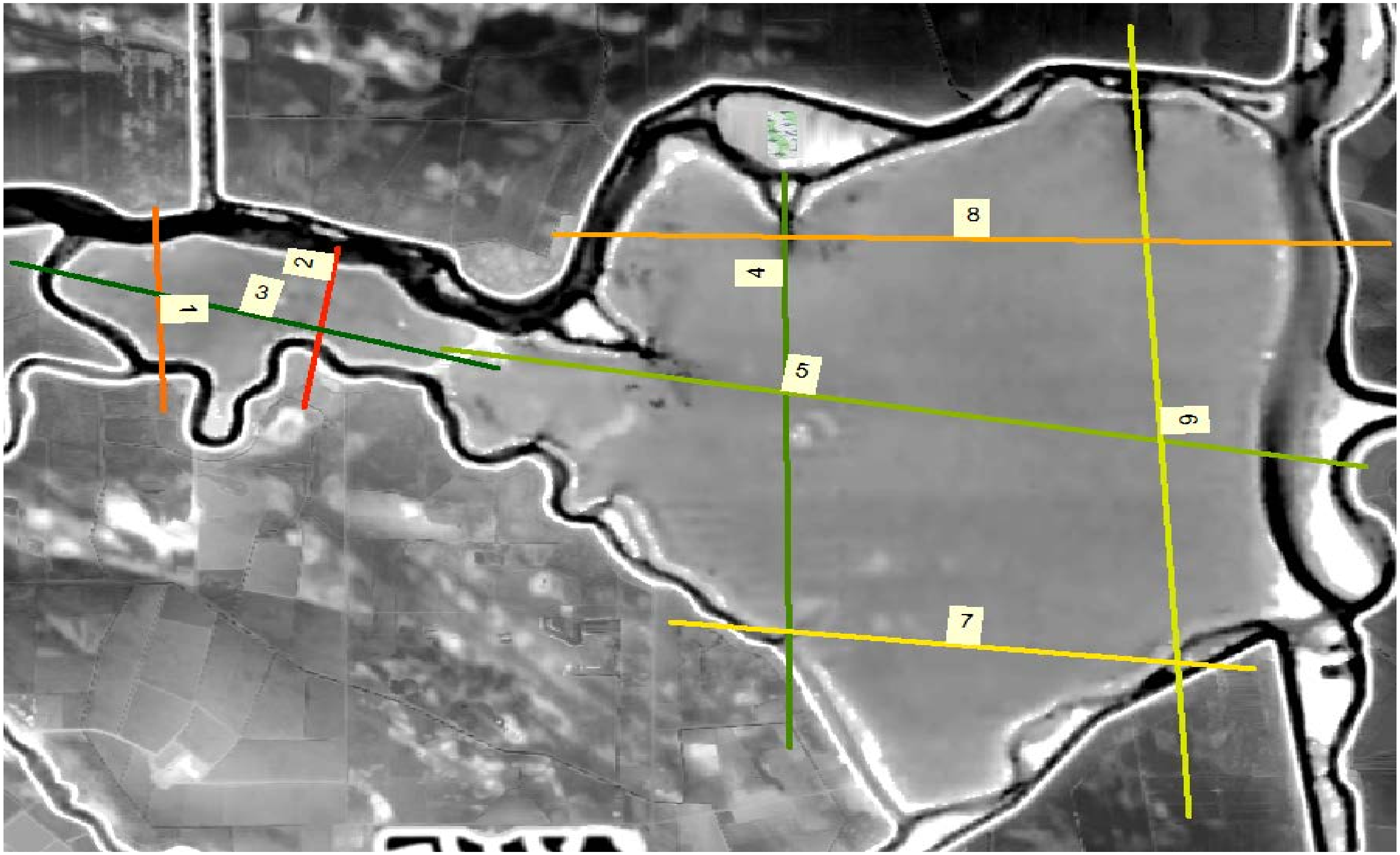
PLATE 2



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

REPRESENTATIVE CROSS SECTIONS FOR BIG BREAK

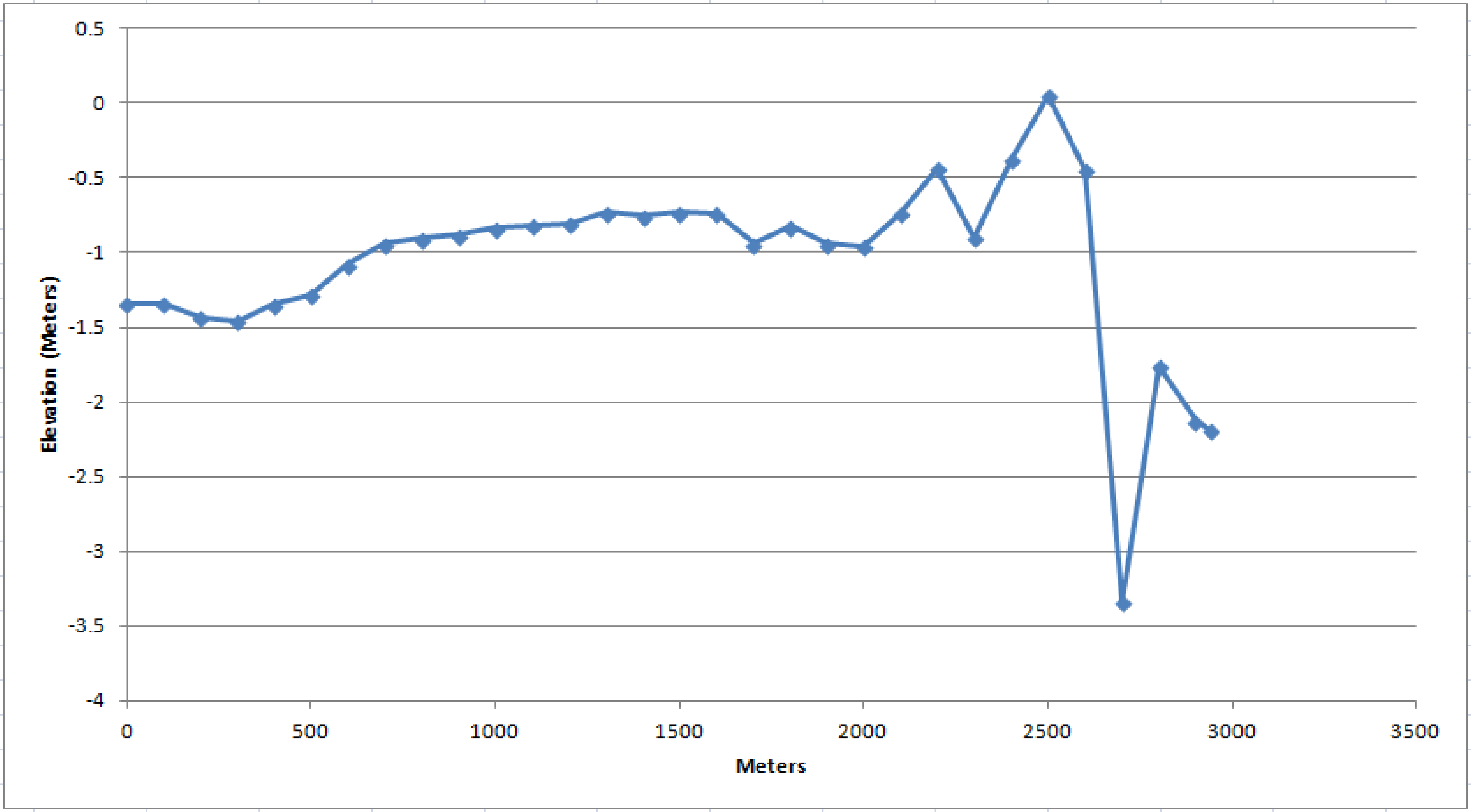
U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

REPRESENTATIVE CROSS SECTIONS FOR FRANK'S TRACT & LITTLE FRANK'S TRACT

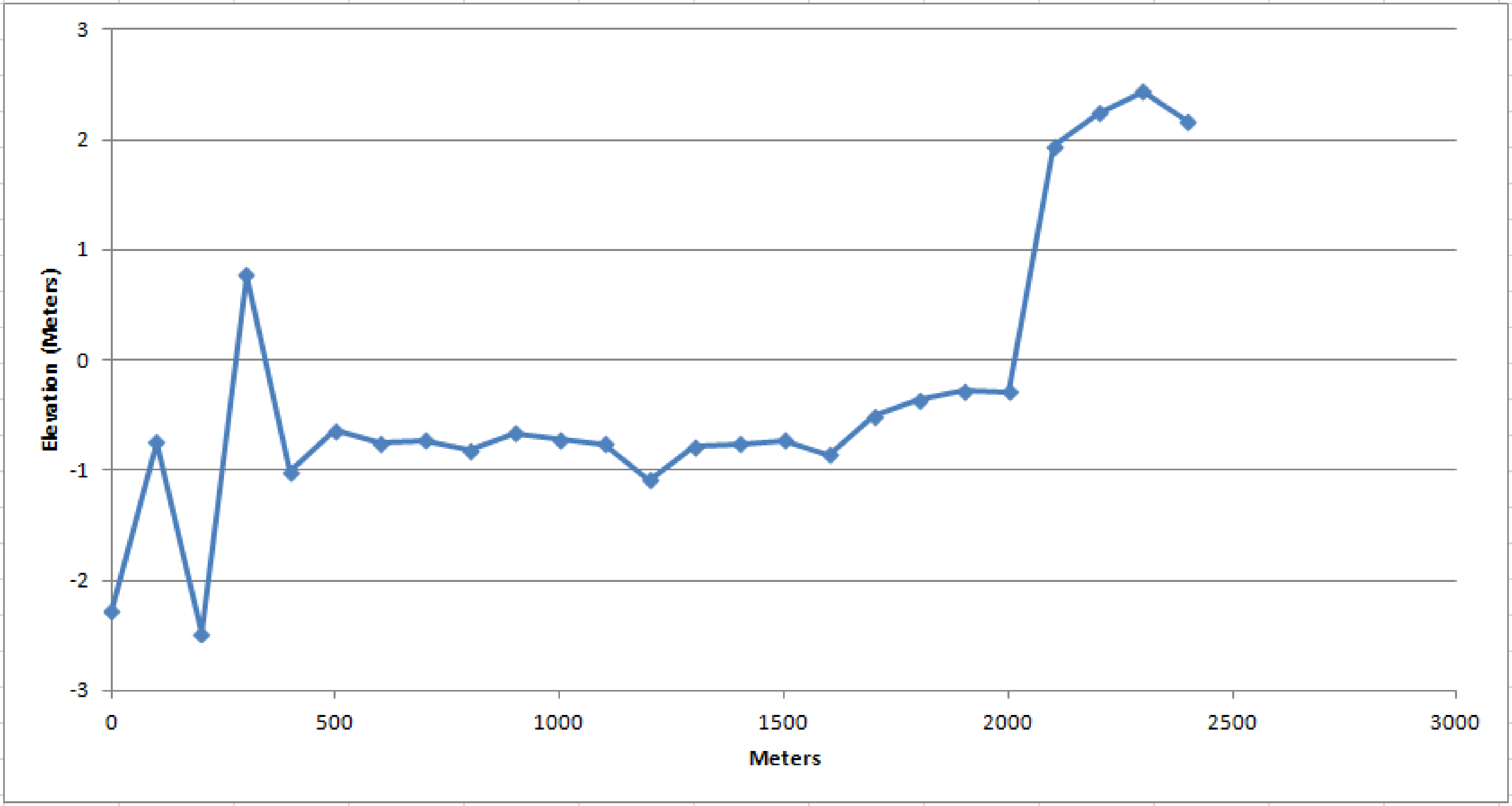
U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

REPRESENTATIVE CROSS SECTIONS #1
FOR BIG BREAK

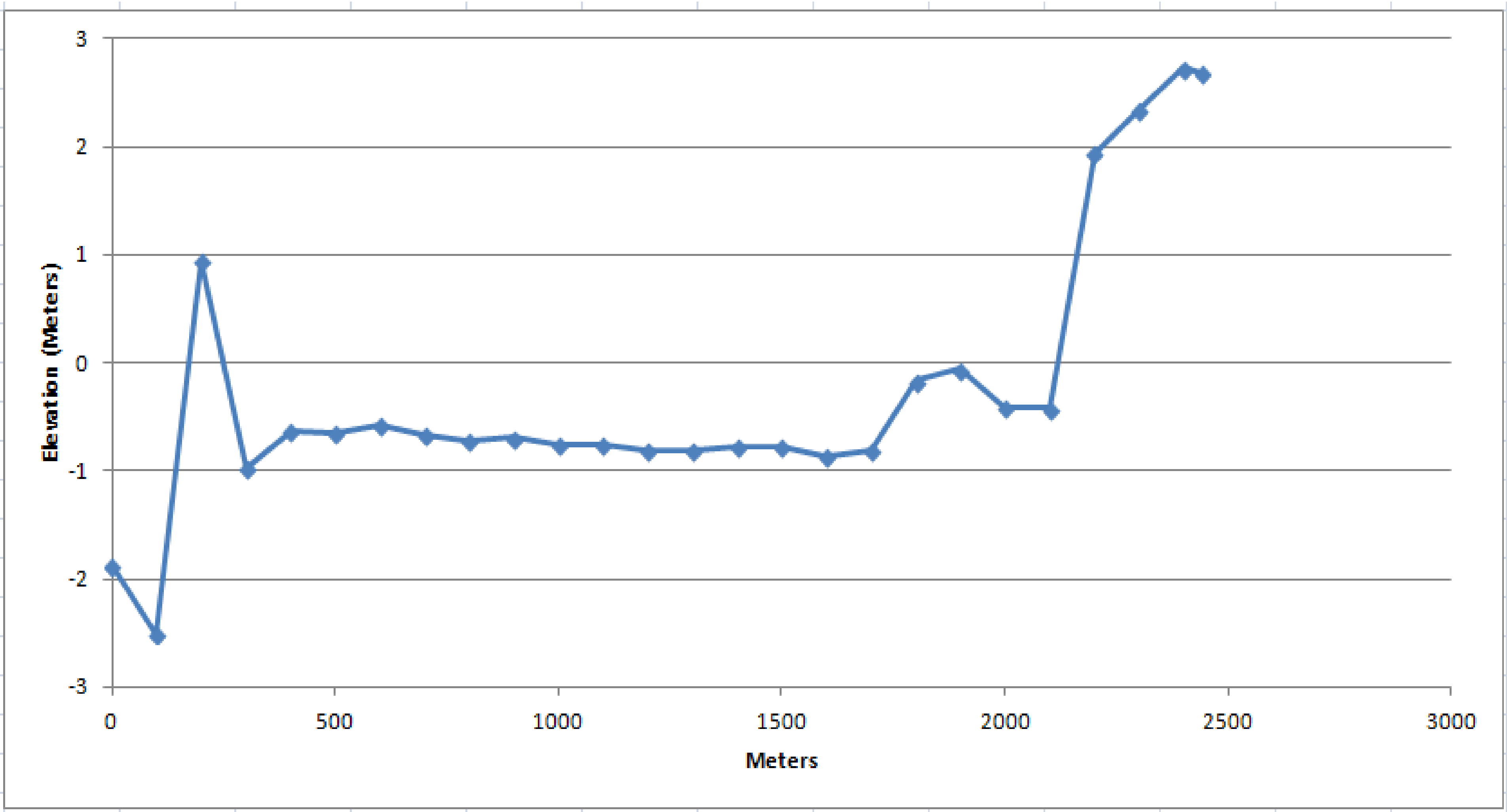
U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

REPRESENTATIVE CROSS SECTIONS #2
FOR BIG BREAK

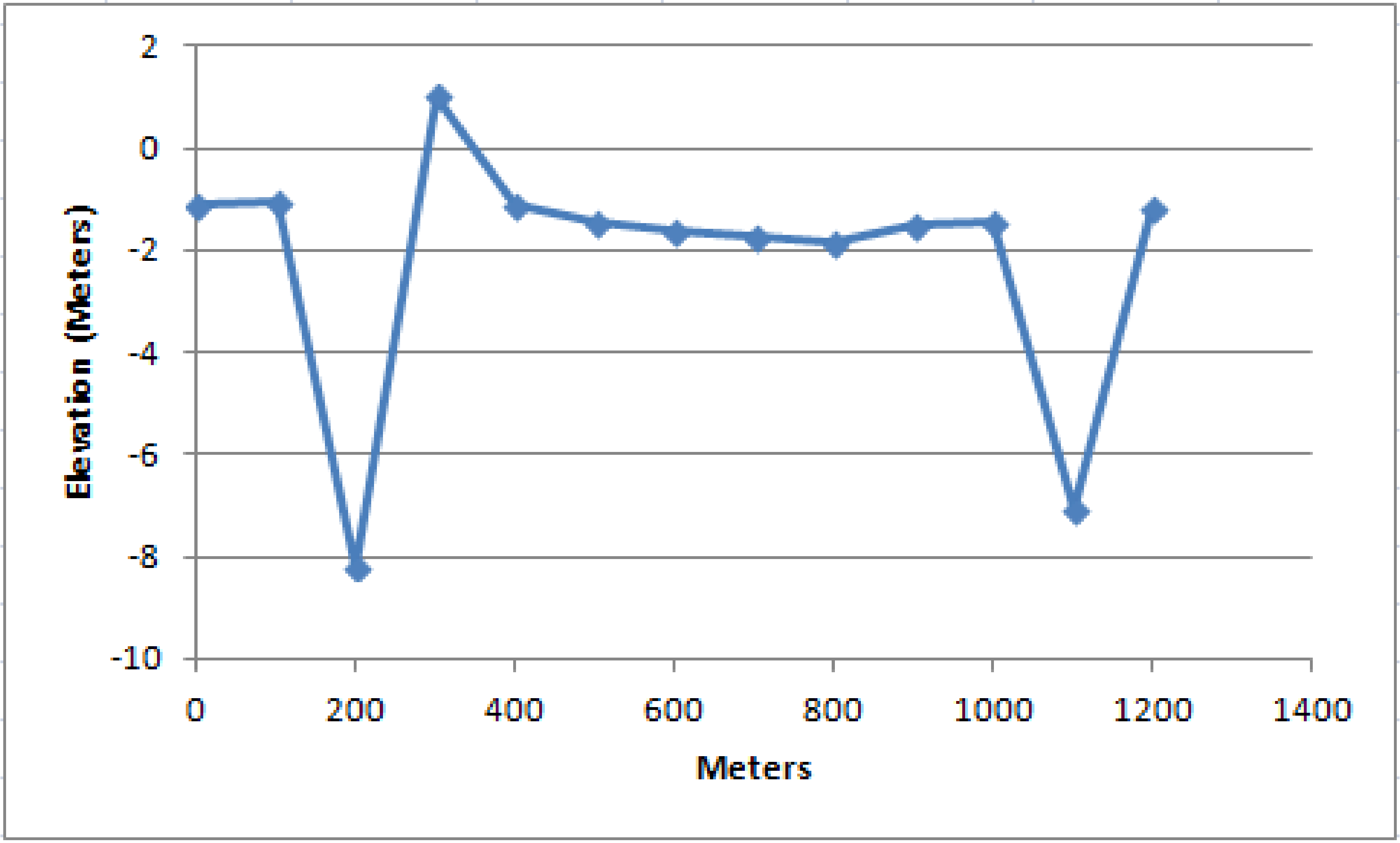
U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

REPRESENTATIVE CROSS SECTIONS #3
FOR BIG BREAK

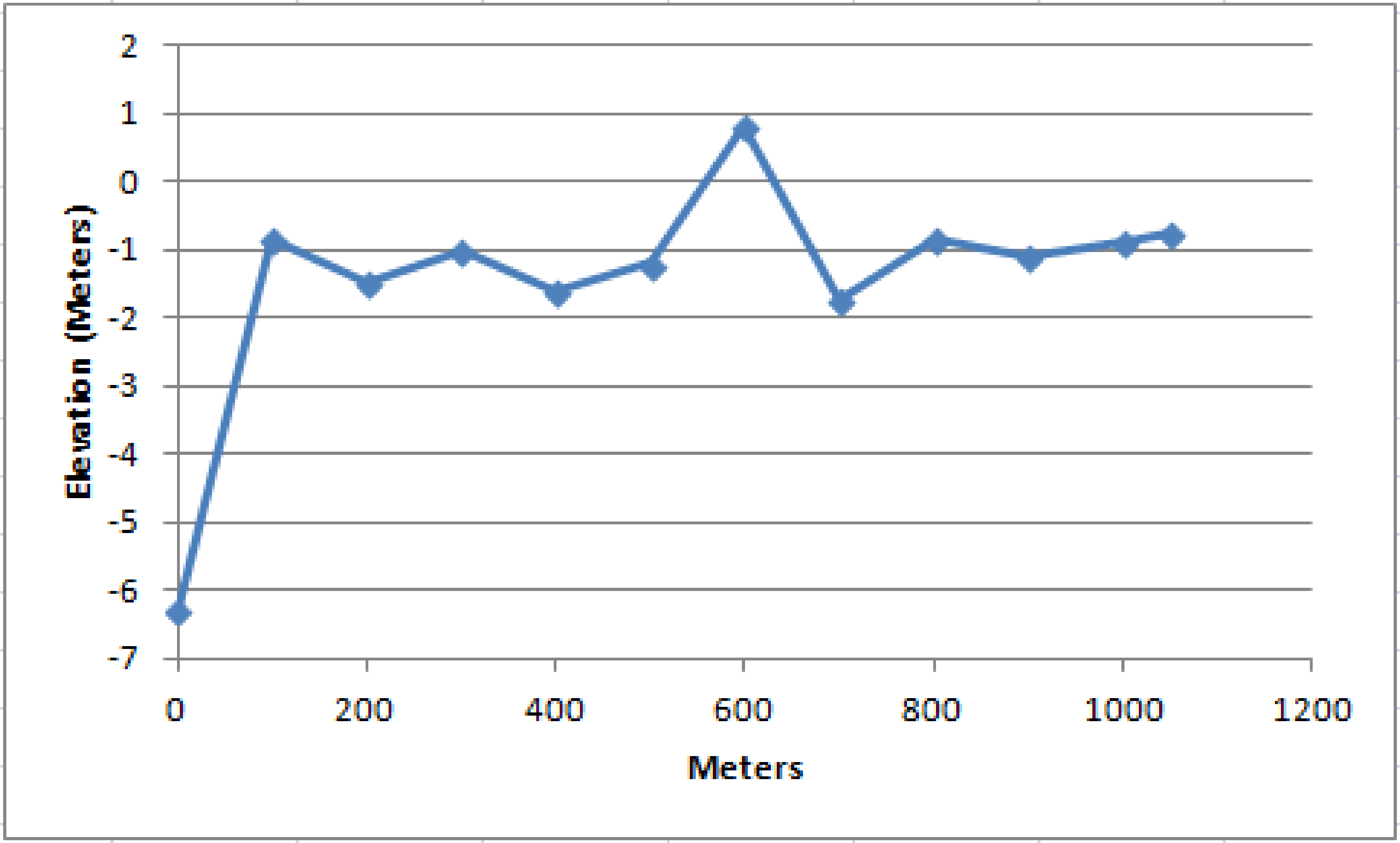
U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

REPRESENTATIVE CROSS SECTIONS #1
FOR LITTLE FRANK'S TRACT

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

REPRESENTATIVE CROSS SECTIONS #2
FOR LITTLE FRANK'S TRACT

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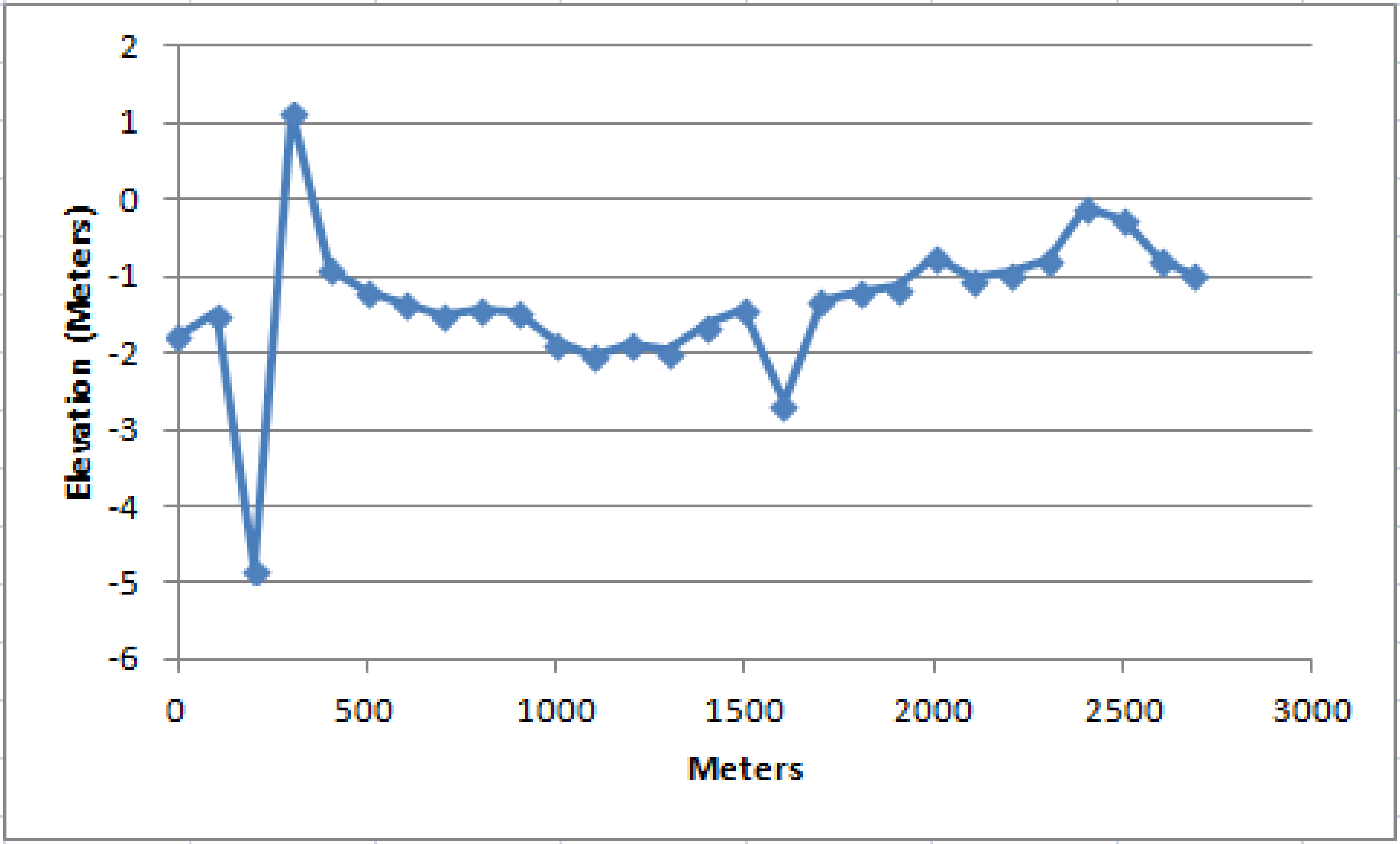
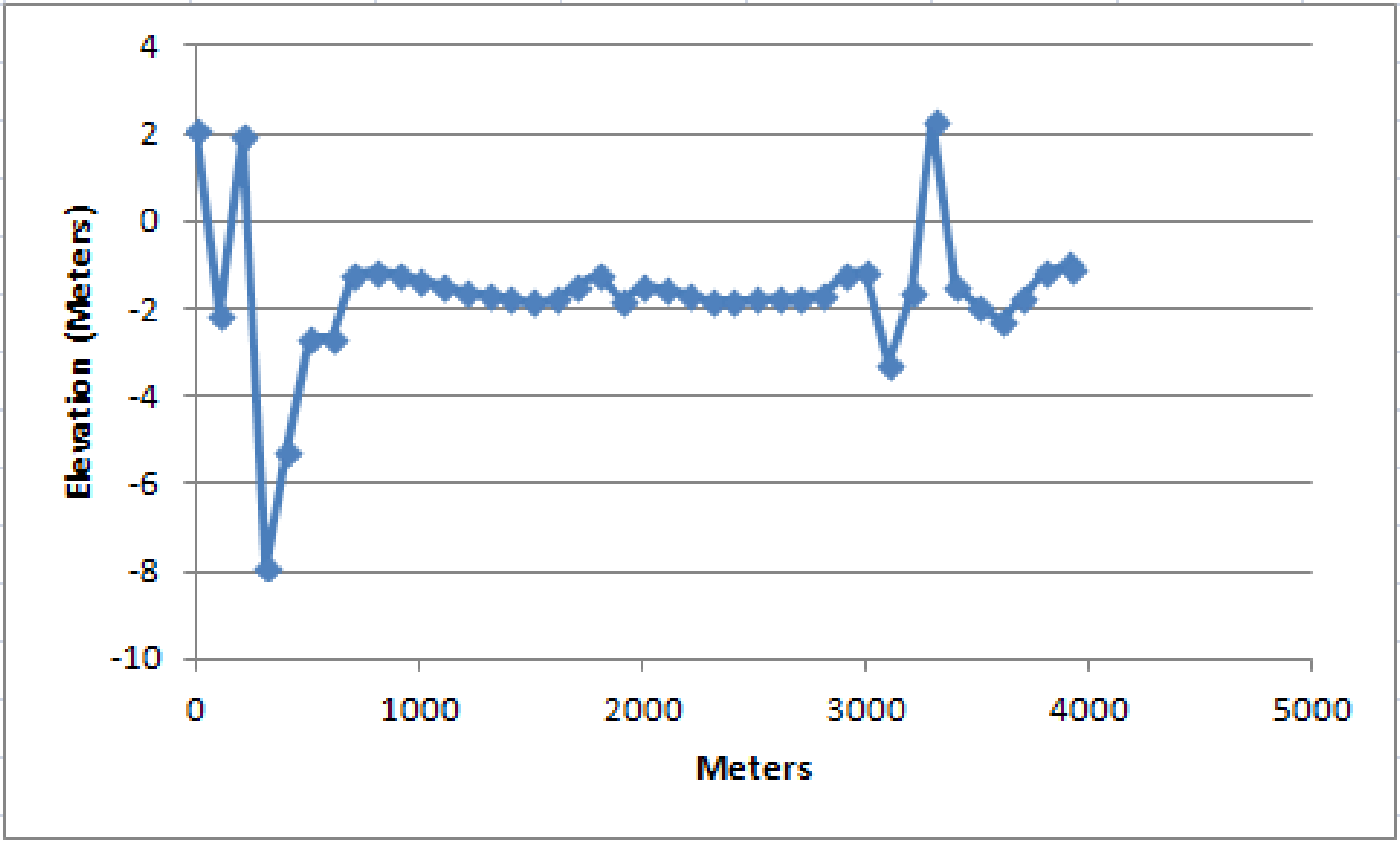
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

REPRESENTATIVE CROSS SECTIONS #3
FOR LITTLE FRANK'S TRACT

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

REPRESENTATIVE CROSS SECTIONS #4
FOR FRANK'S TRACT

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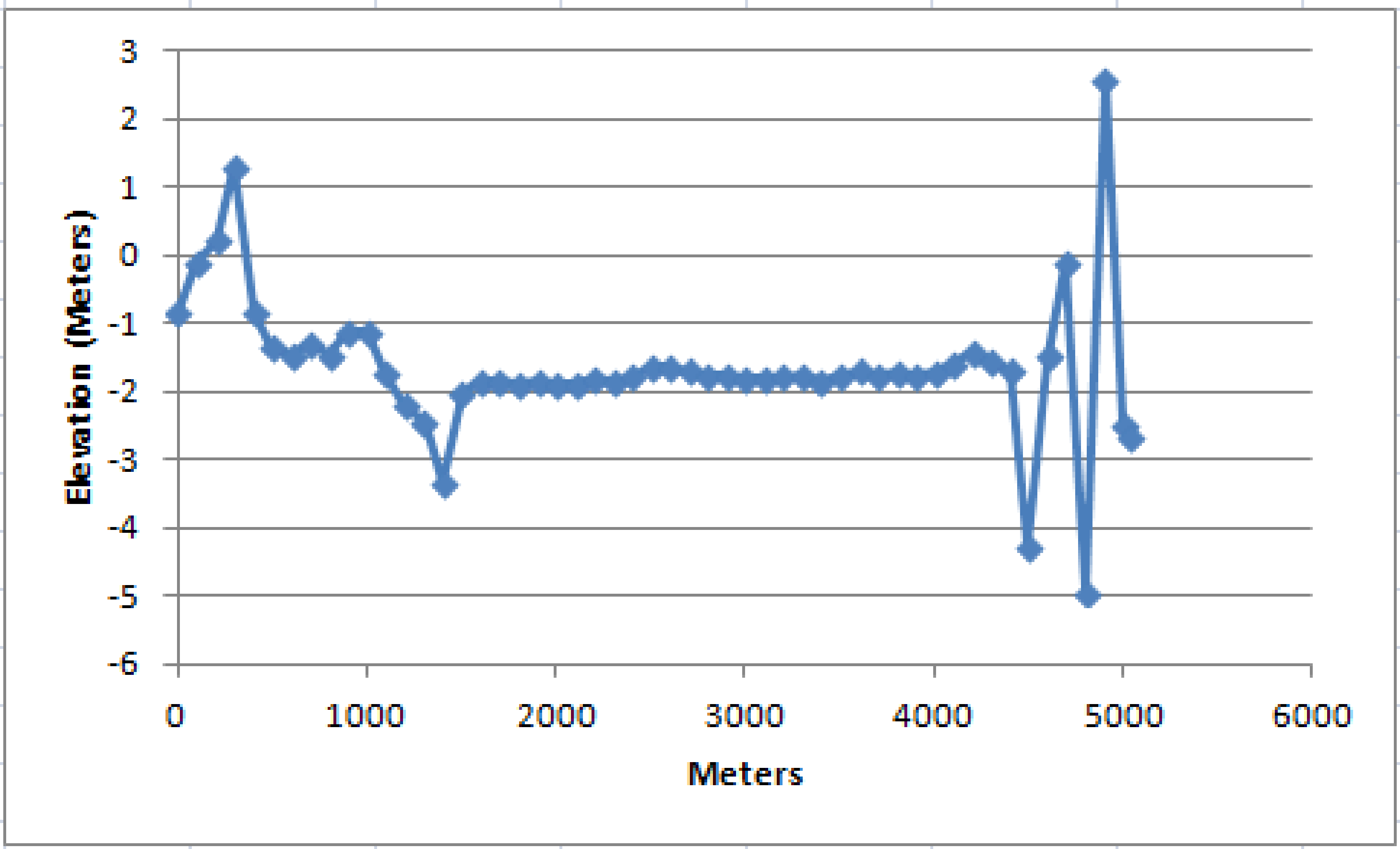
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

REPRESENTATIVE CROSS SECTIONS #5 FOR FRANK'S TRACT

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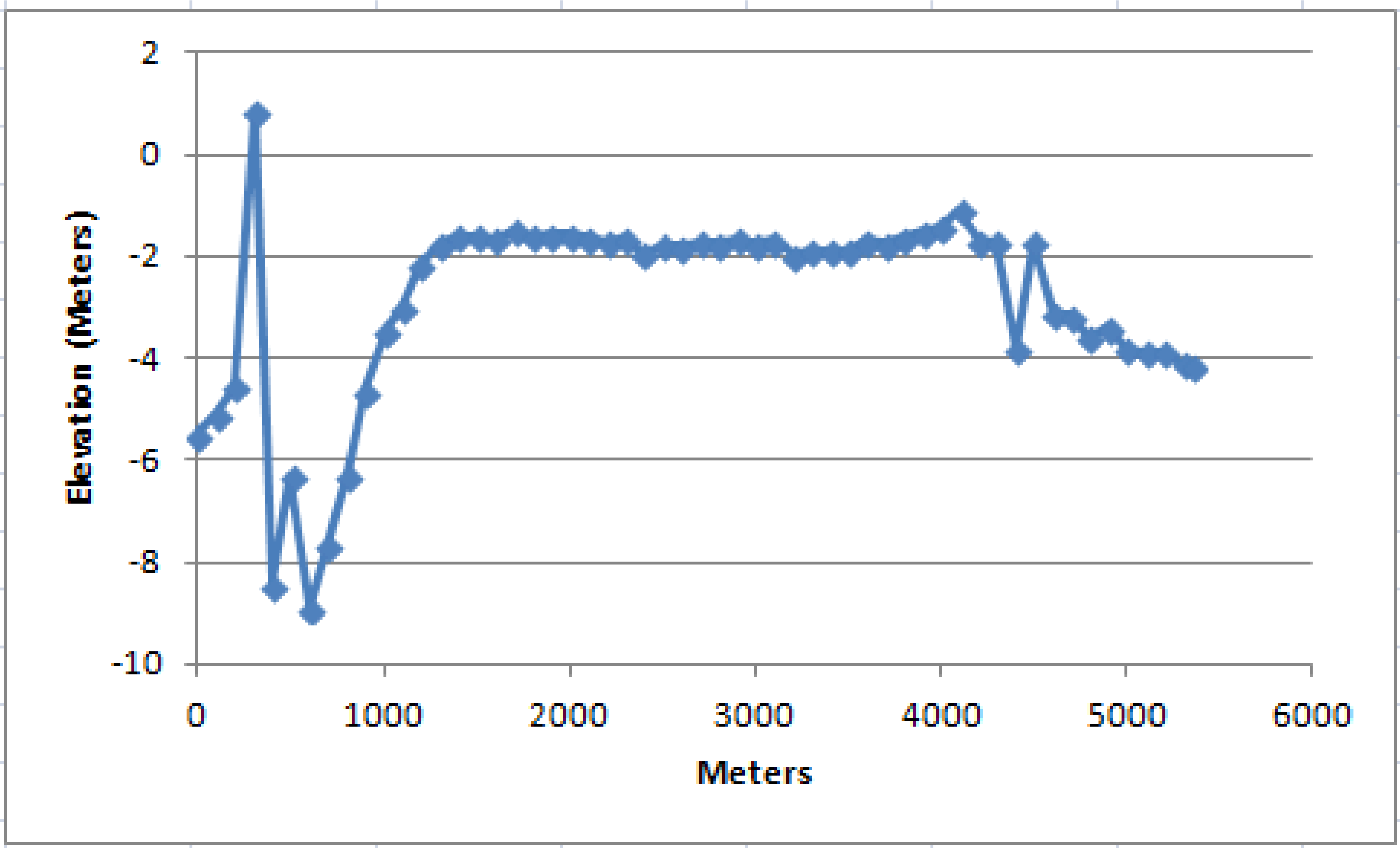
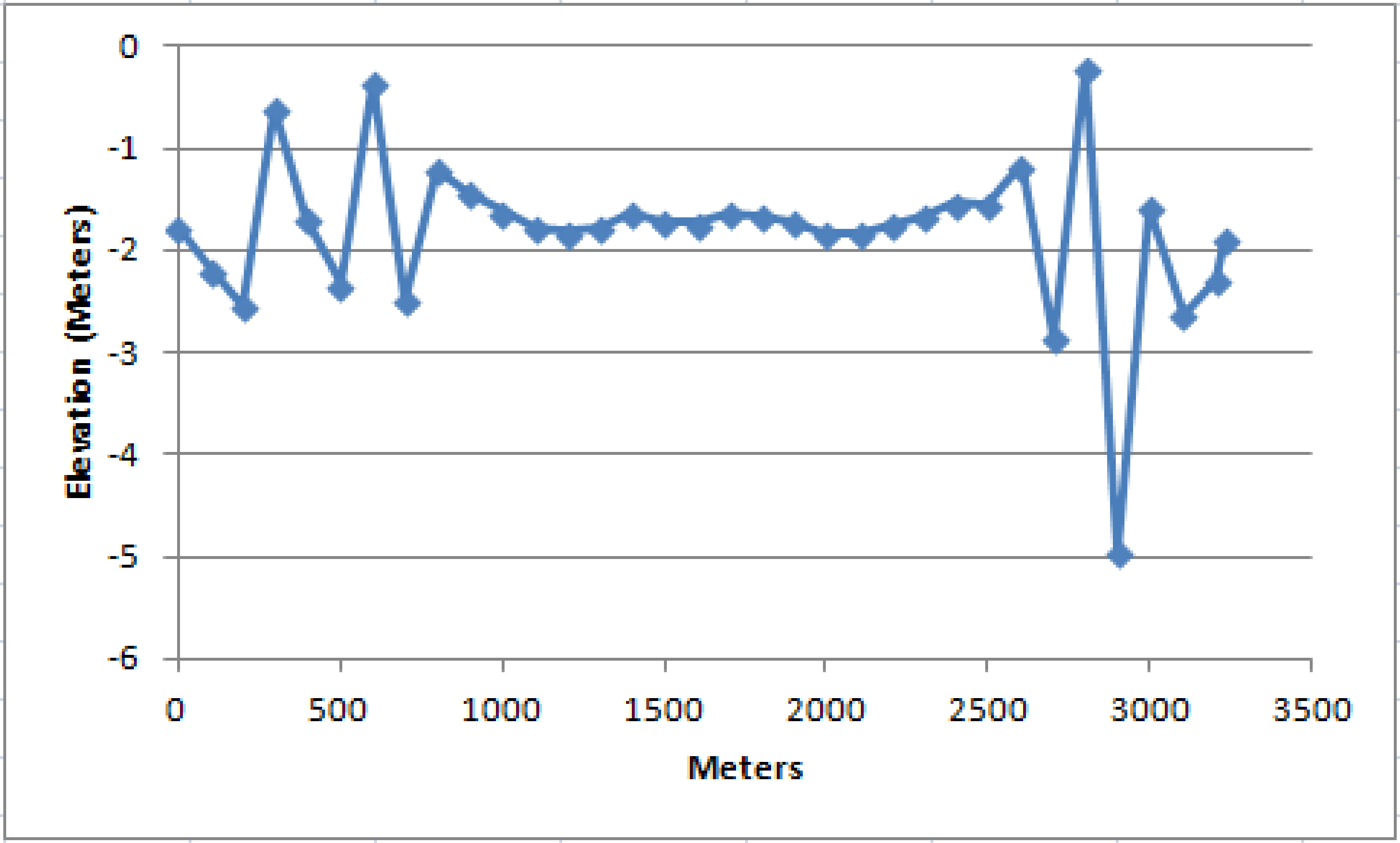
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

REPRESENTATIVE CROSS SECTIONS #6
FOR FRANK'S TRACT

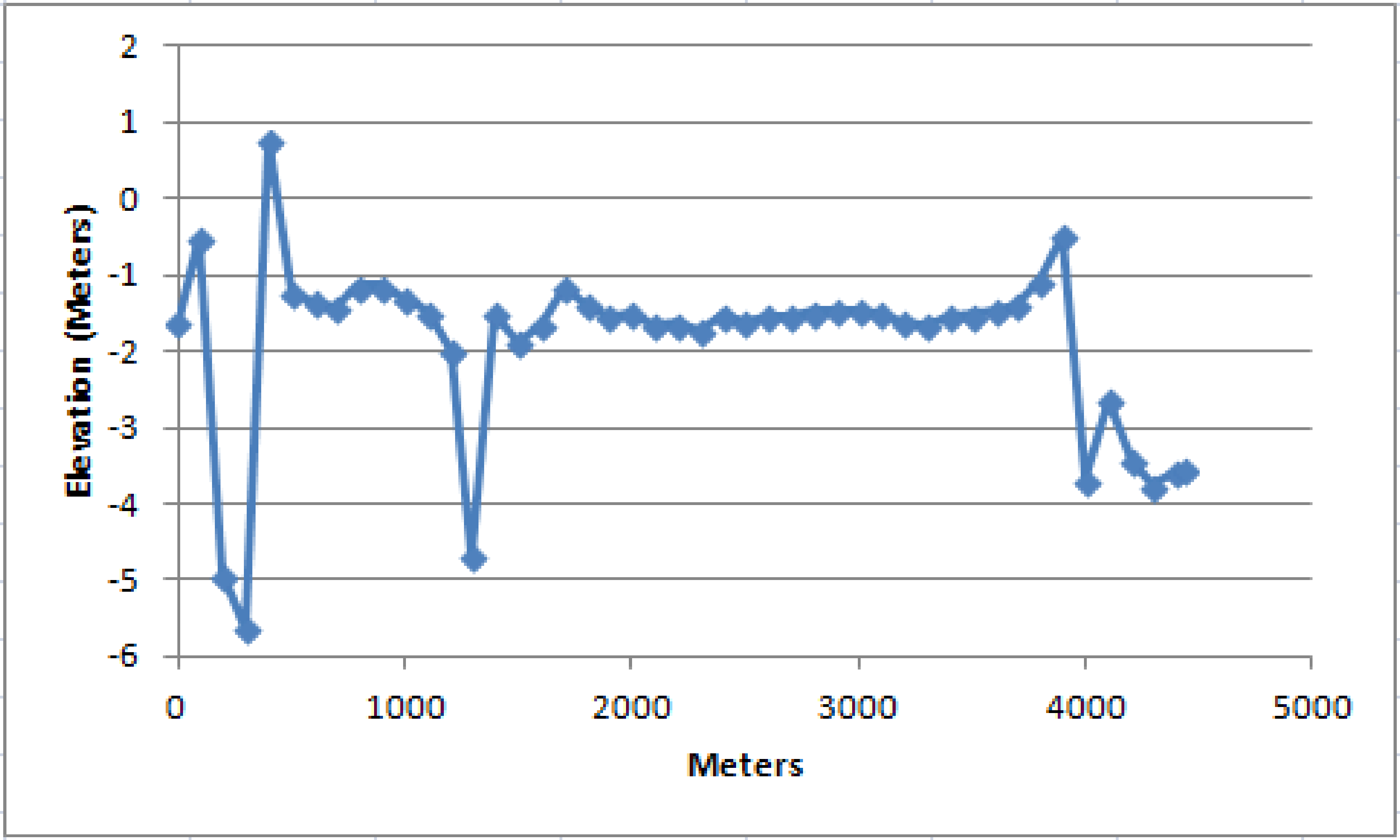
U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

REPRESENTATIVE CROSS SECTIONS #7 FOR FRANK'S TRACT

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

REPRESENTATIVE CROSS SECTIONS #8
FOR FRANK'S TRACT

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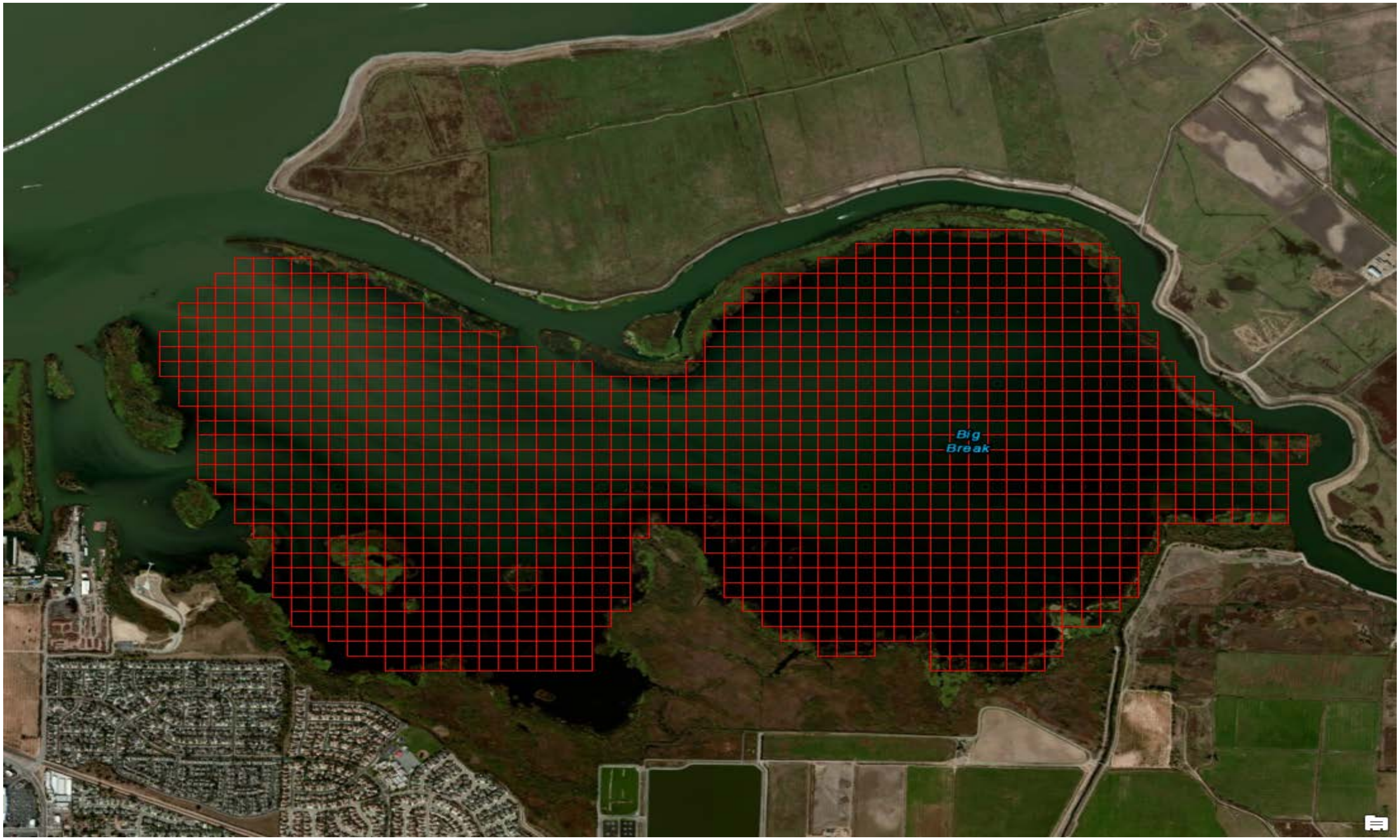
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

BIG BREAK
GRID SYSTEM

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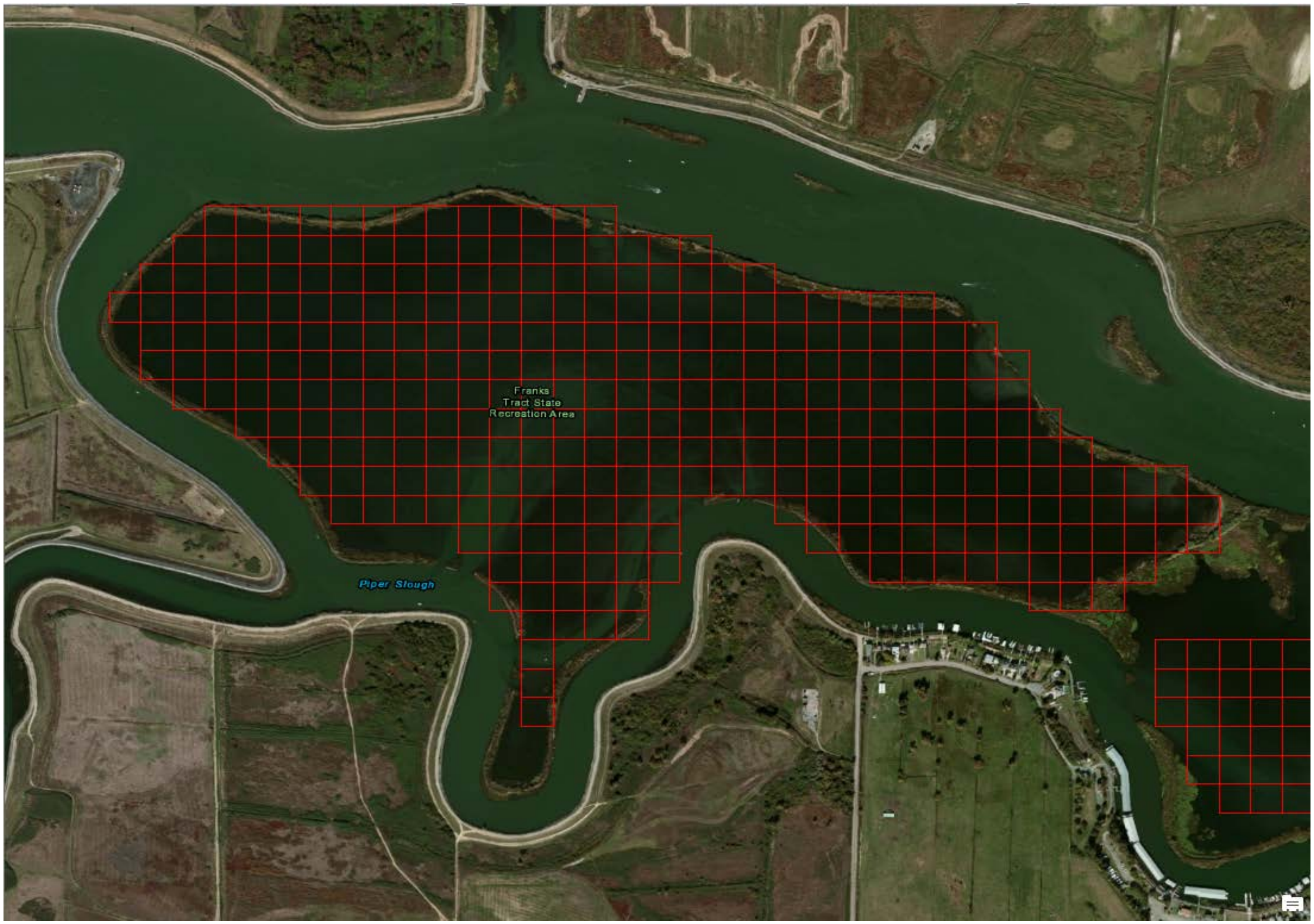
SACRAMENTO DISTRICT

PLATE 16

DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

FRANK'S TRACT
GRID SYSTEM

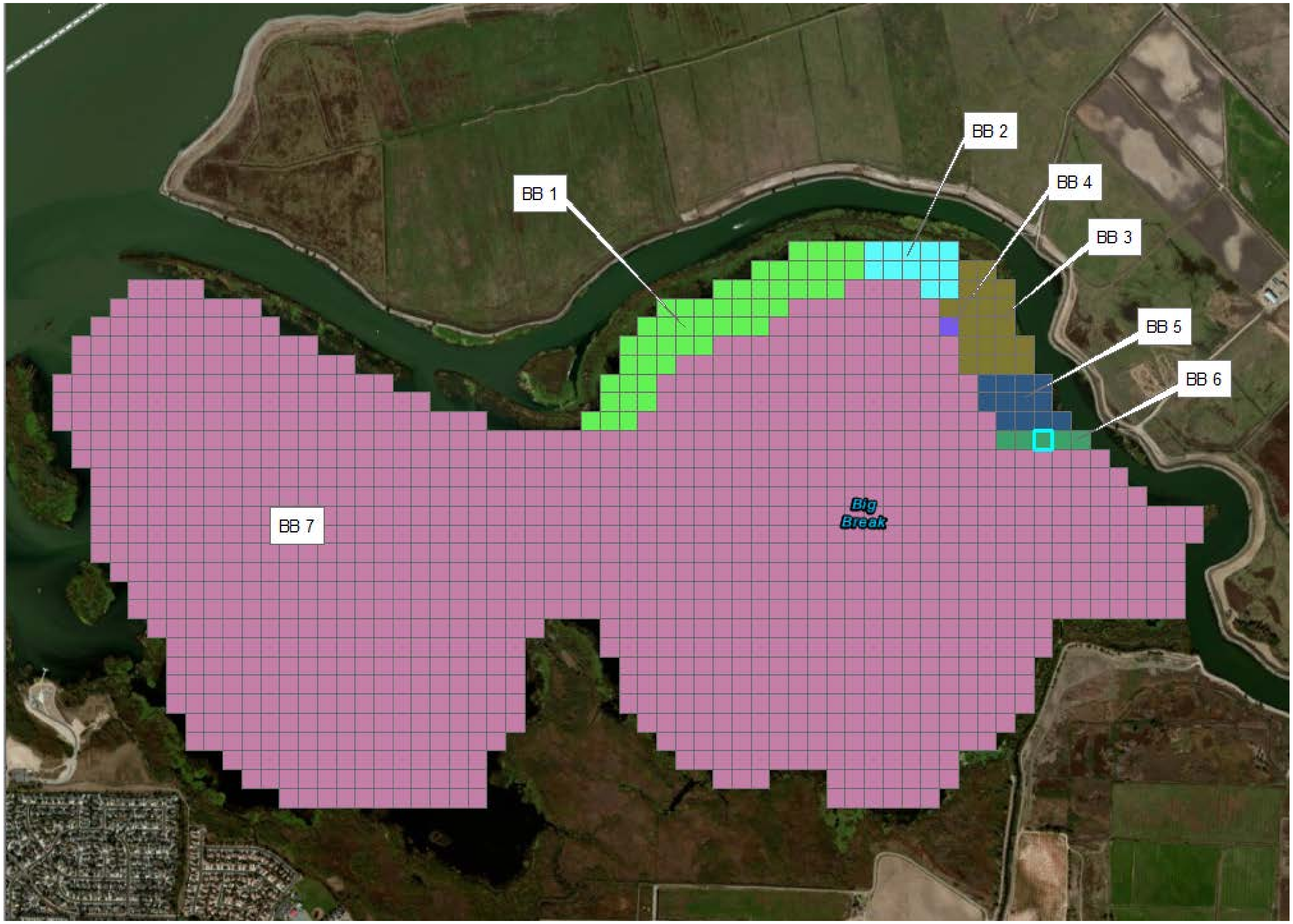
U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

LITTLE FRANK'S TRACT
GRID SYSTEM

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



DELTA ISLAND FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

BIG BREAK PROJECT AREA INCREMENTS

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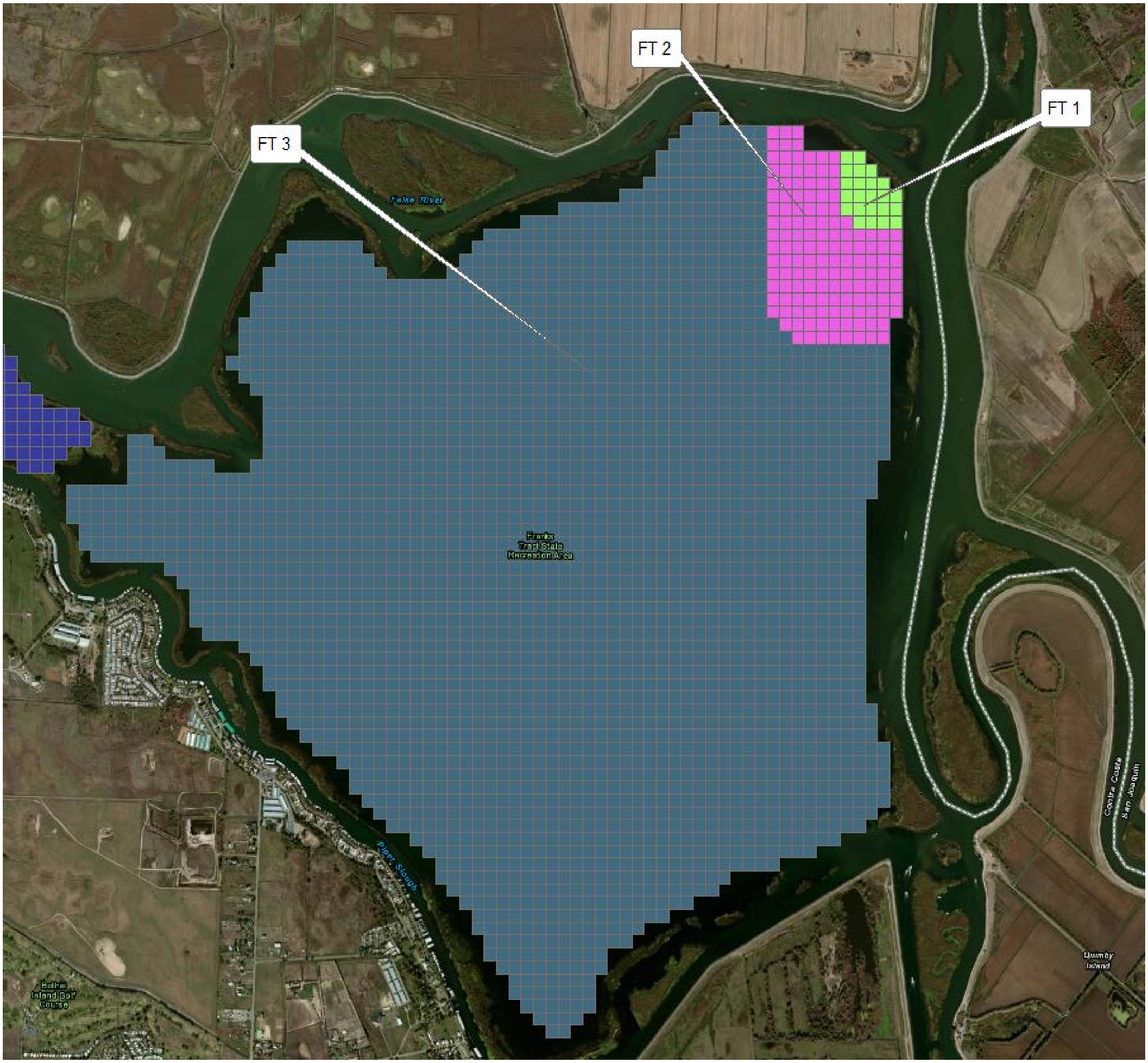
SACRAMENTO DISTRICT



DELTA ISLAND FESIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

FRANK'S TRACT
PROJECT AREA INCREAMENTS

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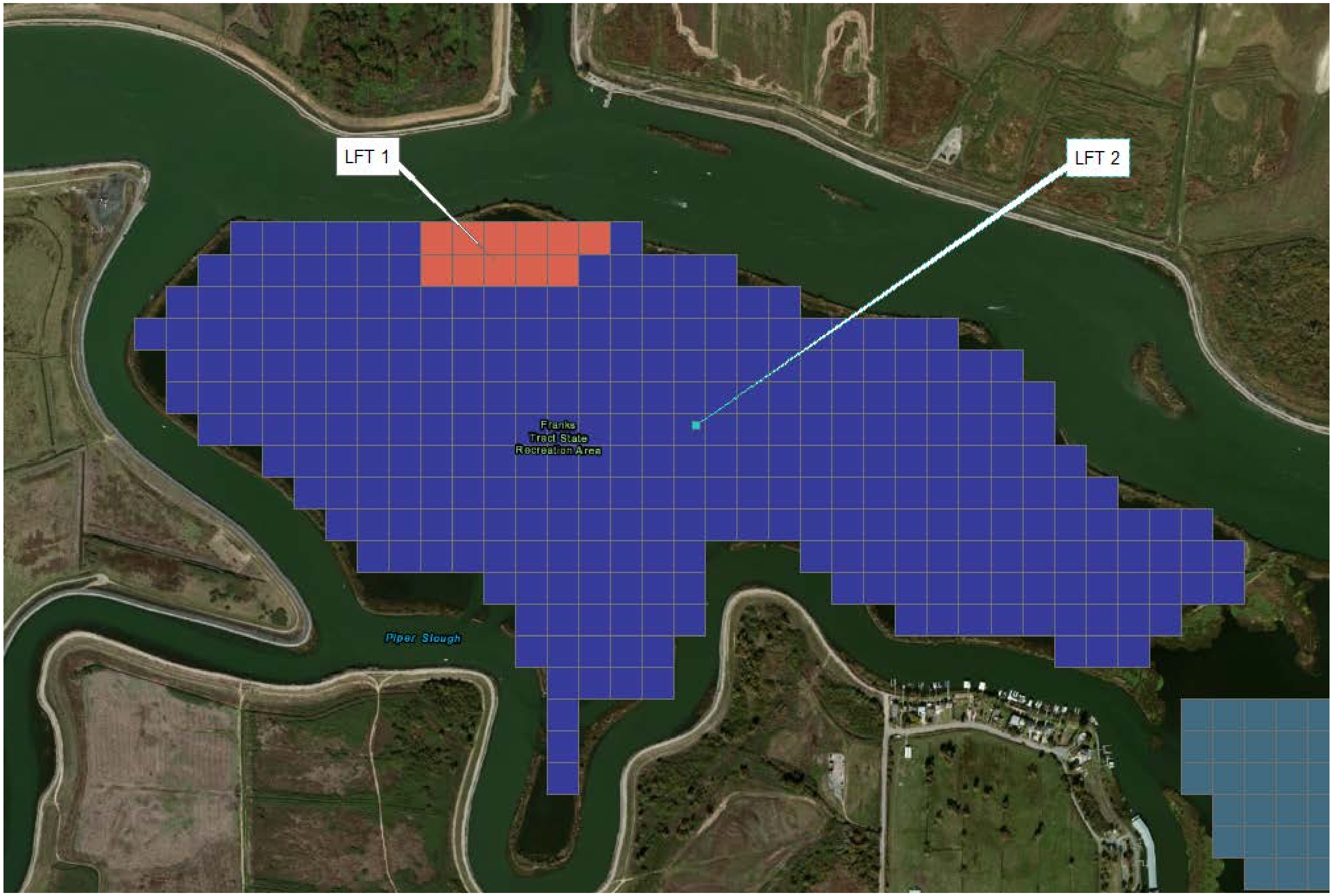

DELTA ISLAND FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

LITTLE FRANK'S TRACT PROJECT AREA INCREMENTS

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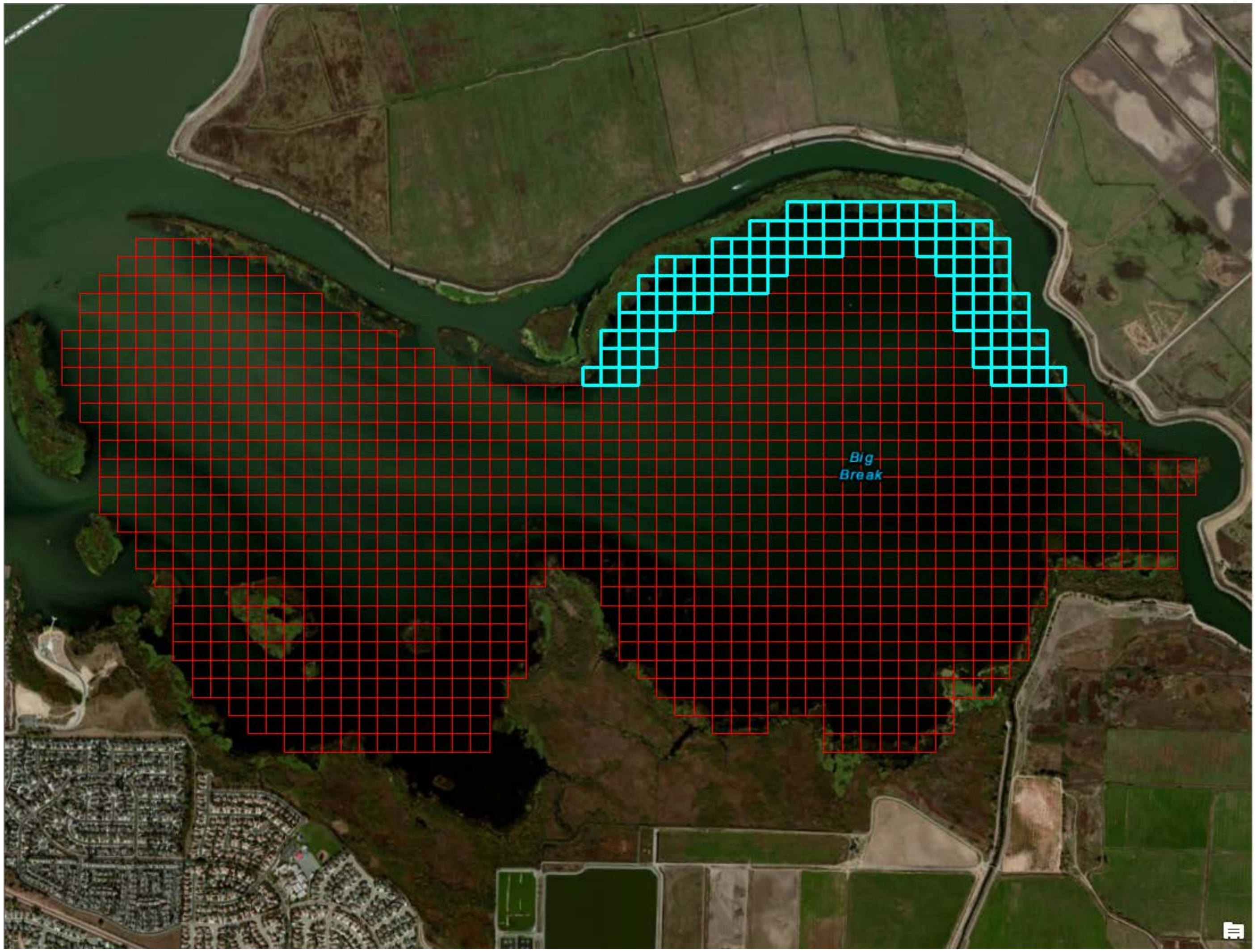
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

BIG BREAK
TSP TOTAL PROJECT AREA

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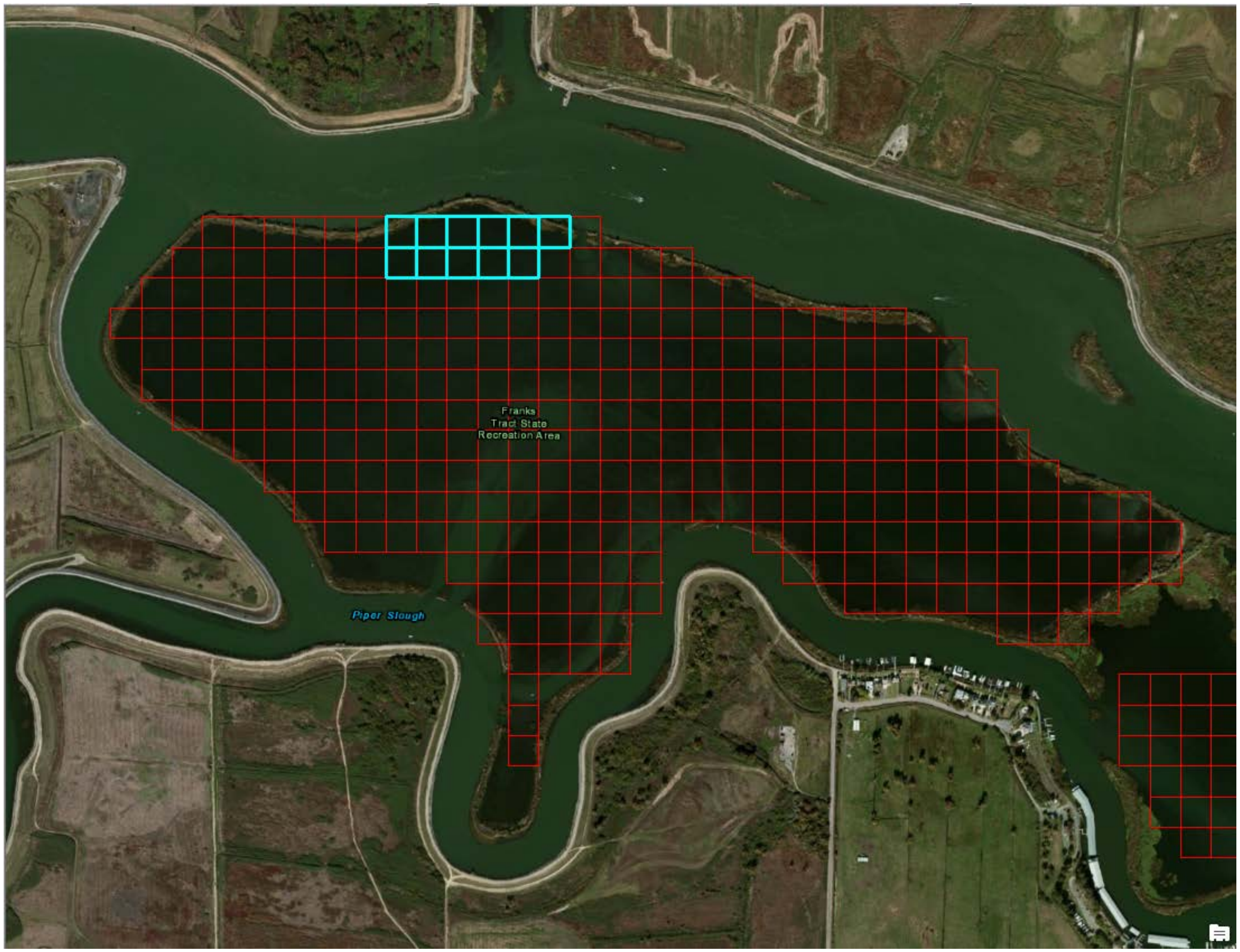
SACRAMENTO DISTRICT



DELTA ISLANDS FEASIBILITY STUDY
ENGINEERING HYDRAULIC APPENDIX

LITTLE FRANK'S TRACT
TSP TOTAL PROJECT AREA

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