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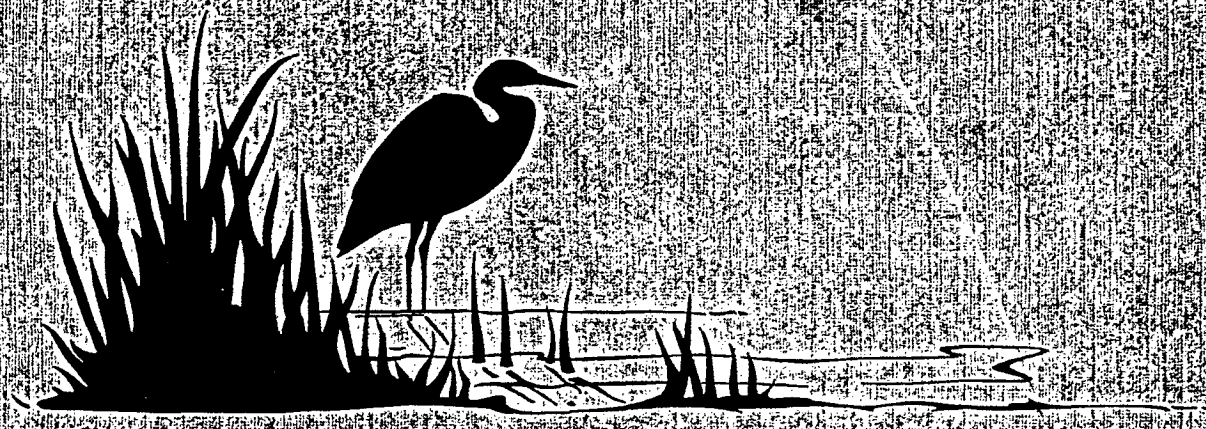
US Army Corps
of Engineers
Sacramento District
South Pacific Division

May 1995

Sacramento-San Joaquin Delta
Western Delta Islands, California
Reconnaissance Report



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SACRAMENTO-SAN JOAQUIN DELTA
WESTERN DELTA ISLANDS, CALIFORNIA

RECONNAISSANCE REPORT

MAY 1995

C-098621

SUMMARY

The purpose of this study was to evaluate the potential for fish and wildlife restoration and flood damage reduction on Twitchell Island, Jersey Island, and Webb Tract. The three islands are located at the western end of the Delta estuary near the confluence of the Sacramento and San Joaquin Rivers. The islands comprise about 12,500 acres, and each is adjacent to the Stockton Deep Water Ship Channel.

Fish and wildlife resources in the Delta have diminished drastically since the turn of the century. Corps water resources development on Delta tributary streams, navigation channels, and Corps project levees along the islands have affected the Delta environment. The three islands are also at risk of flooding due to levee instability. The most recent flooding occurred on Webb Tract in 1980. Failure of any of these islands could allow saltwater to intrude far into the Delta, causing the water to be unsuitable for agricultural and domestic uses and adverse to fishery habitat.

A detailed environmental restoration plan was developed for Twitchell Island. Under this plan, current agricultural lands would be converted to a mosaic of permanent and seasonal wetlands, riparian woodland, and grassland. Features would include low-lying ring levees to create small islands and ponds, water control structures, pumps, and service roads. This plan also includes levee improvements to protect the restored habitats. The new habitats would support a larger variety and number of wildlife species in the area. The average annual cost for this alternative is about $3,205,000.

A variety of flood control measures were also considered for each island. Based on engineering and economic studies, only levee improvements were found to be feasible to increase flood protection for the three islands. These improvements included raising and widening levees and constructing berms. A range in levee heights was considered. Average annual costs ranged from about $769,000 to $1,074,000 for Twitchell Island, $723,000 to $1,053,000 for Jersey Island, and $1,588,000 to $2,076,000 for Webb Tract.

The results of this reconnaissance study indicated a Federal interest in pursuing feasibility-phase studies for environmental restoration with levee improvement on Twitchell Island. Potentially feasible levee improvements plans have been identified for Jersey Island and Webb Tract. However, feasibility-level studies for Jersey Island and Webb Tract are not recommended at this time at the request of the non-Federal sponsor. The California State Department of Water Resources has indicated their support for pursuing feasibility-level studies on Twitchell Island.

RECONNAISSANCE REPORT
SACRAMENTO-SAN JOAQUIN DELTA
WESTERN DELTA ISLANDS, CALIFORNIA

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CHAPTER 3 - PROBLEMS AND OPPORTUNITIES

FLOODING

Problem

Twitchell and Jersey Islands and Webb Tract are subjected to flood threats caused by high water stages, erosion, and seepage. Flooding of the islands would cause damage to agriculture, residences, and public facilities and can adversely affect water quality in the Delta. Flooding of the islands causes loss of plants, mammals, and wildlife habitat, including habitat for threatened and endangered species.

High water stages in the Delta are caused by a combination of high flows and high tides. Water stages are usually highest from December through February. Prior to development of upstream storage reservoirs, vast expanses of the Delta were frequently flooded.

With existing upstream storage, flood events now occur on individual islands or tracts. Flooding caused by levee failure due to levee instability continues to be a serious problem. Contributors to levee instability include subsidence of the island interior, substandard levee construction, and seepage through the levees. The resulting levee instability can lead to flooding of the islands even with low water stages in the channels surrounding the levees.

A major problem in the study area is subsidence. Subsidence of the islands is primarily caused by microbial decomposition, topsoil erosion, and oxidation of peat soils. Levees which were originally built 2 to 3 feet above ground are now as much as 20 feet above the island interiors. Figure 3-1 illustrates the change in land surface over time due to subsidence.

Delta islands have experienced over 140 levee failures since 1900. Flooding during the early years of levee construction was common with eight levee failures on Jersey and Twitchell Islands between 1900 and 1910. Levee failures caused major flooding on Webb Tract in 1950, 1955, and 1980. Since 1967, there have been seven major levee failures in and around the study area. These levee failures and estimates of total flood damages are presented in table 3-1.

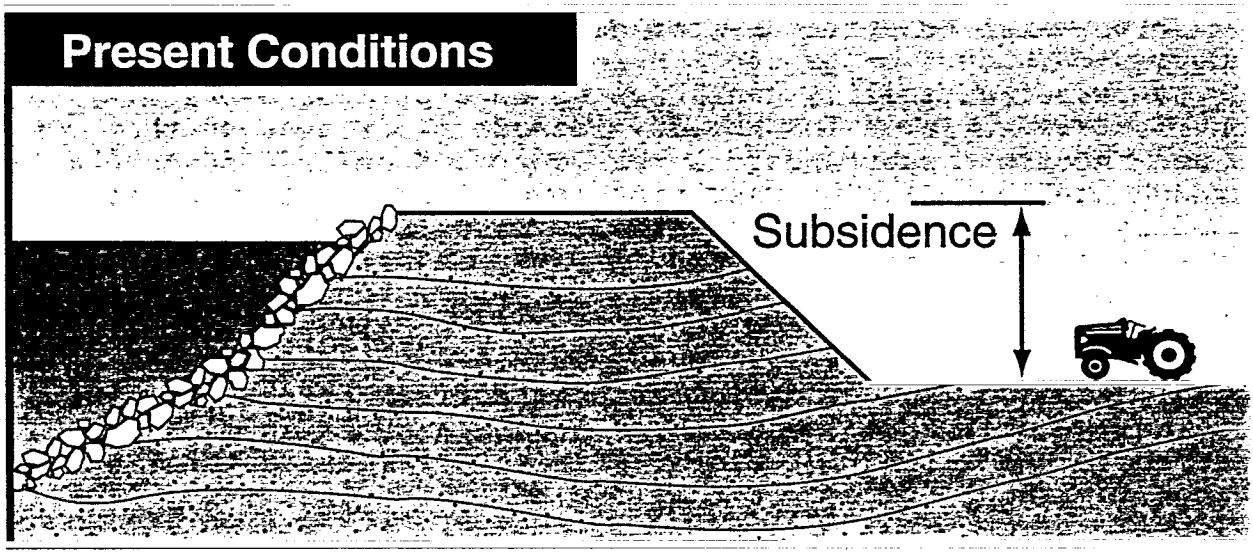

Figure 3-1. Land subsidence on western Delta islands. (Figure provided by DWR.)

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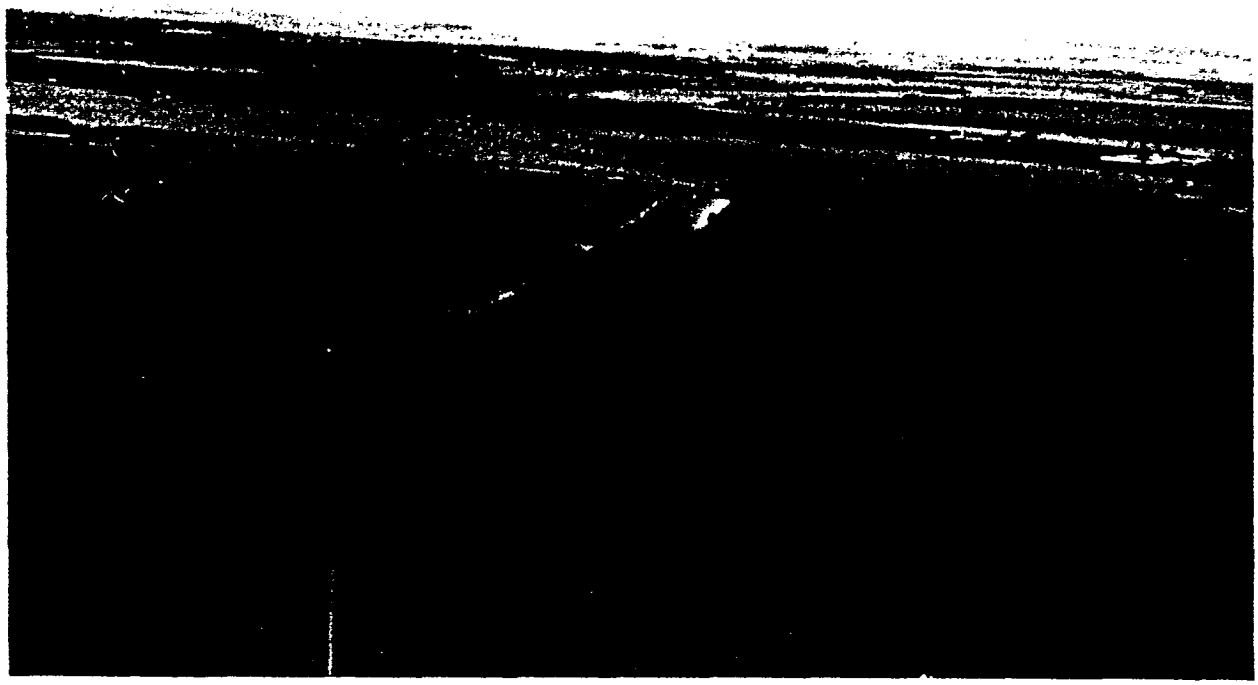

Figure 3-2. Flooding on Webb Tract (left) from the San Joaquin River in January 1980.

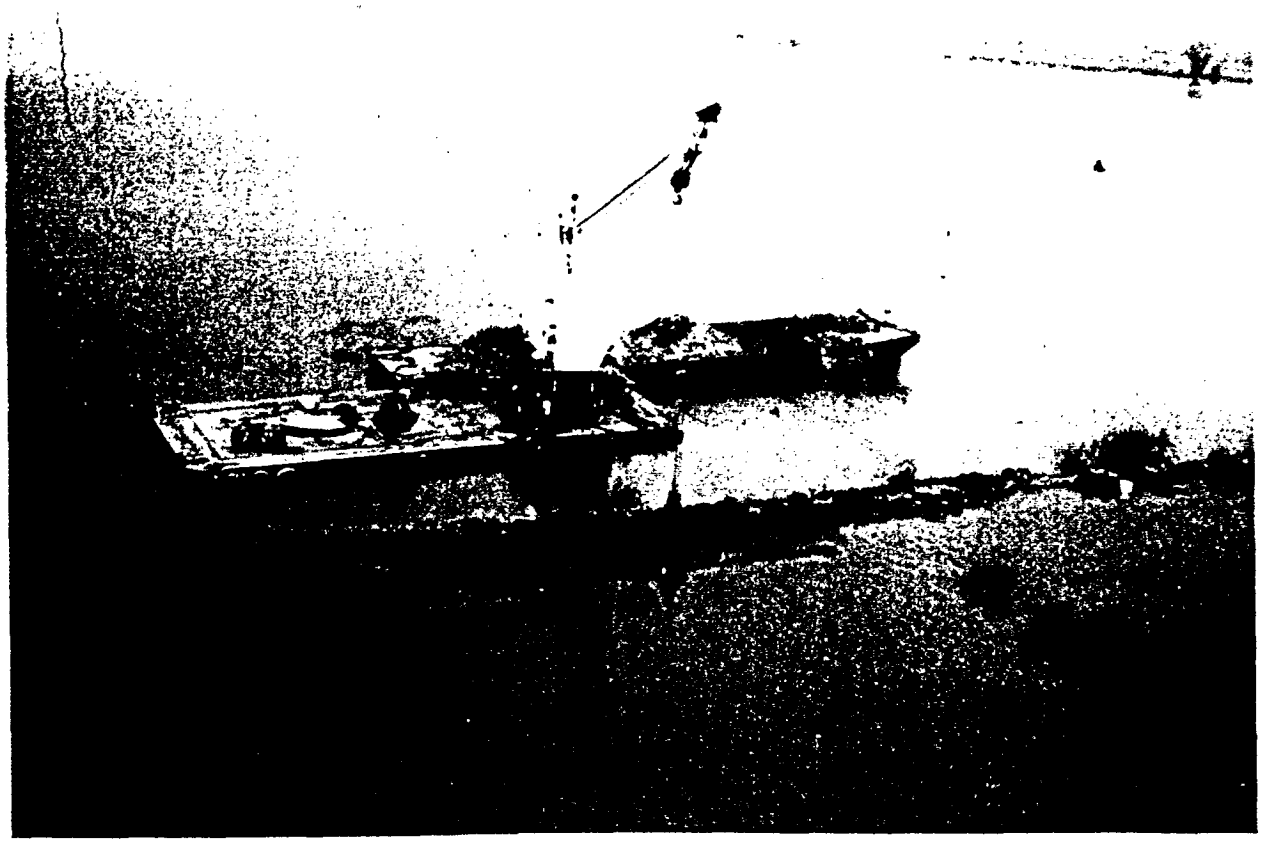

Figure 3-3. Repair work on north levee of Webb Tract in 1980.

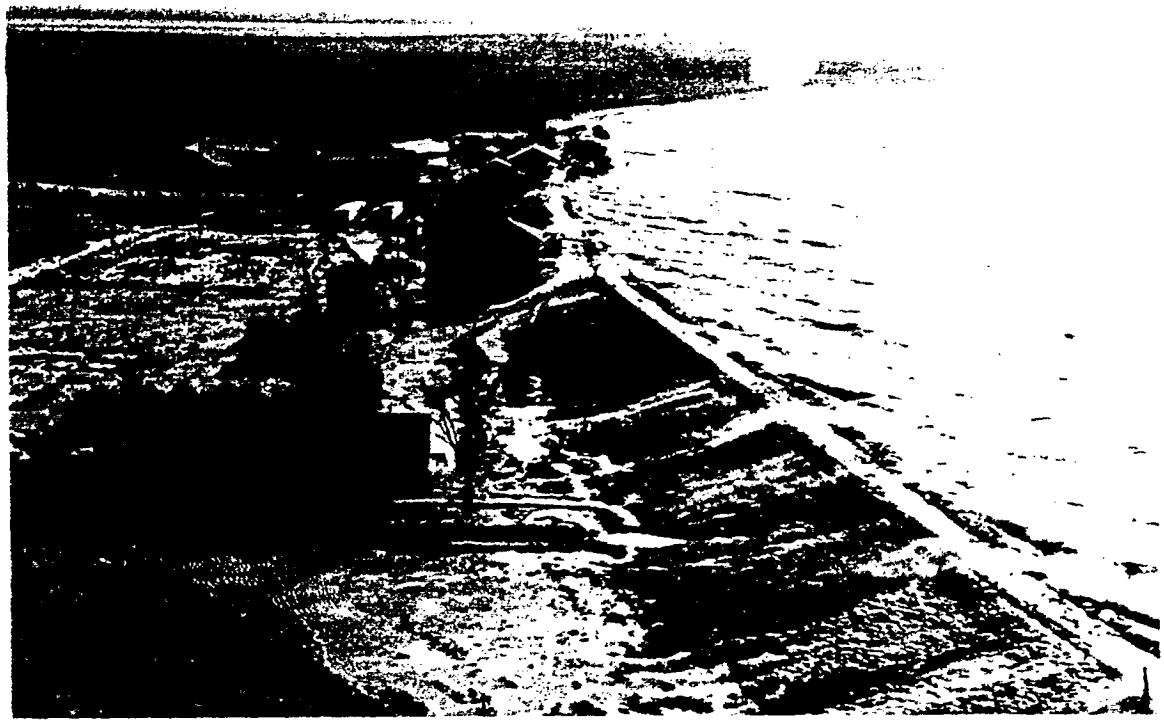

Figure 3-4 High water and strong winds threaten the north levee on Jersey Island in December 1983. (Photo by Kjeldsen-Sinnock, Inc.)

Figure 3-5 High water and strong winds on Twitchell Island along the San Joaquin River in March 1995. (Photo provided by DWR.)

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Table 3-1
Recent Historic Delta Floods and Damages
at the Time of Event

ISLAND/TRACT	DATE OF EVENT	DAMAGES
Sherman Island	20 Jan 1969	$ 7 million
Brannan-Andrus Isl.	22 Jun 1972	$27 million
Webb Tract	18 Jan 1980	$12 million
Holland Tract	18 Jan 1980	$ 7 million
Venice Island	30 Nov 1982	--[a]
Bradford Island	3 Dec 1983	--[a]
Tyler Island	19 Feb 1986	$10 million

[a] No data available.

The most recent levee failure in the study area was the 1980 flood on Webb Tract. In mid-January 1980, a series of storms caused the major streams in the Sacramento and San Joaquin basins to reach flood warning stage. High Delta outflows coinciding with the highest tides of the winter resulted in the failure of the Webb Tract levee. A 12-foot rupture quickly enlarged to a width of 850 feet with deep scouring. Floodwater from the San Joaquin River poured through the breach until the entire tract was inundated. About $10.5 million (1980 dollars) were expended to close the levee break and dewater the tract.

During high water stages, the levees are patrolled for early signs of potential stability or piping failures. Although there has been only one major levee failure in the study area since 1950, there have been numerous times when failure was imminent and intense flood fights were waged to prevent flooding of the islands. Over $23 million were expended on flood emergency work on the three study islands between 1980 and 1986.

Opportunities

Many flood protection proposals have been made over the years to reduce the flood threat and potential damages to the Delta, including Twitchell and Jersey Islands and Webb Tract.

The proposals included downstream hydraulic barriers in the San Francisco Bay, additional upstream storage, channel

improvements, and levee strengthening. All of these measures were considered in this study.

ENVIRONMENTAL RESOURCES

Problem

Historically, the Delta was composed of numerous islands separated by interconnecting sloughs and river channels. These wetlands provided diverse habitats ranging from tidal marshes near mean sea level to riparian forests at higher elevations. Tule marshes occurred behind the naturally formed low alluvial levees. The Delta flooded periodically, providing foraging habitats for migrating and wintering waterfowl.

Between 1852 and 1930, essentially all of the Delta was converted to agricultural use with the construction of levees and dikes along the channels to form islands. These levees drastically altered the Delta and caused major changes in plant species composition and wildlife use. Of the original 738,000 acres of wetland habitat in the Delta, only 18,000 acres remain today. During the winter, an additional 20,000 acres of croplands are flooded to enhance waterfowl hunting, to leach out buildups of soil salts, and to provide some seasonal wetland habitat.

In recent decades, the populations of many fish species, including Delta smelt, American shad, salmon, and striped bass, have declined substantially in the Sacramento and San Joaquin River systems that feed the Delta.

The FWS estimates that the Delta smelt population now numbers only a few hundred thousand fish, down from millions only about a decade ago. The Delta smelt lives mainly in brackish water and nourishes in the entrapment zone in Suisun Bay, where saline and fresh water mix. The location of the entrapment zone needs to be maintained in Suisun Bay to ensure nourishment of the Delta smelt. The location of the entrapment zone is stabilized by the hydraulic barrier provided by levee systems in the western Delta.

Other factors contributing to the decline in Delta fisheries have been reported to be entrainment losses of both juvenile fish and eggs at water diversions, increased predation at water diversions and manmade structures along the rivers flowing into the Delta, changes in water quality, drought, decreased food supply, and loss of spawning grounds.

Wildlife habitat in the study area has also been modified and reduced. Reclamation of the wetland islands created valuable agricultural areas, but destroyed the extensive marshlands habitat so valuable to waterfowl. Migratory waterfowl populations have decreased about 75 percent since 1900. Shallow flooded agricultural fields provide some of the habitat values of the marshes and seasonally flooded areas. However, the deep waters of fully flooded islands provide few wildlife habitat values.

Several flood control and navigation projects are adjacent to the study islands and have contributed to the degradation of the Delta environment. Construction of the Stockton Deep Water Ship Channel and the Old River Channel Project resulted in the loss or degradation of hundreds of acres of wetlands. Dredged material from channels was spoiled on nearby islands, adversely affecting wetlands and other valuable habitats. Portions of the ship channels were routed or "cut" through islands, adversely affecting large areas of wetlands. Examples include Mandeville and Venice Islands along the Stockton Deep Water Ship Channel. Erosive wave action due to increased ship traffic made possible by the construction of navigation channels has degraded and destroyed small tidal marsh islands.

Past activities associated with the Sacramento River Flood Control Project and Sacramento Bank Protection Project have also contributed to the decline of fish and wildlife habitat. Levees constructed as part of the Sacramento River Flood Control System have significantly altered the hydrology of the river and Delta ecosystems. Prior to the construction of the levees, bottom lands adjacent to the river were frequently flooded, producing vast expanses of seasonal and permanent wetlands which supported countless numbers of waterfowl and other wildlife.

In addition, there has been significant environmental degradation in the Sacramento River and San Joaquin River basins attributable to the numerous dam and reservoir projects the Corps has constructed. These projects all serve as a basis for Corps involvement in environmental restoration in the study area.

Opportunities

Existing agricultural lands could be converted to wildlife habitat as part of an environmental restoration project. This restoration would help replace habitat lost in the study area and would offset significant environmental impacts caused by past Corps projects in the Sacramento and San Joaquin River basins.

Improvements to the levees in the study islands would help to protect them from flooding. The work would maintain the brackish water ecosystem (the entrapment zone) in Suisun Bay, which is critical habitat for the Delta smelt. Protecting the islands from flooding would protect existing wildlife habitat on the islands and also protect newly established wildlife habitat.

WATER QUALITY

Problem

Maintaining water quality standards in the Delta is important to many Federal, State, and local interests. Water use within the Delta benefits agriculture, industry, municipal areas, recreation, and fish and wildlife resources.

The primary water quality issue in the Delta is salinity levels in the water. The Delta together with Suisun Bay, San Pablo Bay, and a portion of San Francisco Bay form the Bay-Delta estuary where the tidal and freshwater currents meet and mix. The salinity level of the water in the estuary is between those of ocean water and fresh water. The area where tidal flows and river flows interact most intensely is known as the "entrapment zone." The entrapment zone is of ecological significance to many plants and fishes. The location of the entrapment zone between the Delta and San Pablo Bay depends on the forces of the tidal action and freshwater flows from the Delta. The FWS reports that the Delta smelt, a listed species, nourishes in the entrapment zone of Suisun Bay. The salinity levels of the Delta water are also important to water users in the Delta and users of exported water. Delta water uses include agricultural, municipal, and industrial users. Exported water pumped out of the Delta include urban area around the Bay, agricultural and municipal users in the San Joaquin Valley, and municipal water users in southern California.

The current physical configuration of the Delta is important in maintaining the stability of the estuary and salinity levels in the Delta waters suitable for municipal, industrial, and agricultural uses.

Levee failure and flooding of Twitchell Island, Jersey Island, or Webb Tract and resultant increase of tidal flows can affect the salinity levels of Delta waters and the location of the entrapment zone.

Opportunities

There is a need to protect the existing water quality to provide for fish and wildlife resources and to meet municipal and agricultural water needs. Levee improvements that protect against levee failure would maintain the stability of the water quality and the estuary.

RECREATION

Problems

The Delta is a popular recreation destination. Recreational activities include water sports, fishing, camping, hunting, and sightseeing. The Delta as a whole supports between 1 and 3 million user-days of recreation annually. Over 75 percent of these users reside in the five Delta counties of Contra Costa, San Joaquin, Sacramento, Alameda, and Solano.

Opportunities

Recreation facilities in the study area could be developed. The Delta Protection Commission has identified lands acquired by Federal, State, and local agencies for the protection and management of wildlife and wildlife habitat as potential recreation sites. Recreation use could include improved public access and enhanced recreational opportunities such as hunting, wildlife observation, nature study, bank fishing, and picnicking in conjunction with environmental restoration and levee improvement.

CHAPTER 4 - PLAN FORMULATION

OVERVIEW

Plan formulation is the process of developing and evaluating alternative plans to meet the needs of society as expressed in specific planning objectives and selecting the plan that best satisfies these objectives. This planning process is in accordance with the Federal Water Resources Council's Principles and Guidelines.

OBJECTIVES AND CRITERIA

The following planning objectives have been established to evaluate the problems identified in the study area. These objectives serve as guidelines for the formulation and evaluation of alternative plans for Jersey Island, Webb Tract, and Twitchell Island:

- Reduce flood damages to protect environmental resources and economic development.
- Protect and restore fish and wildlife habitat.
- Protect the estuary.
- Protect water quality.
- Enhance recreational opportunities in the study area incidental to the other objectives.
- Remain consistent with the State's policy of retaining the Delta in its present configuration.

In addition, each alternative is formulated to meet the established planning criteria for completeness, effectiveness, efficiency, and acceptability. These criteria are defined as follows:

- Completeness is the extend to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effect.
- Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified objectives.

- Efficiency is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the environment.

- Acceptability is the workability and viability of the alternative plan with respect to acceptance by state and local entities and the public, and compatibility with existing laws, regulations, and public policies.

PLANNING ASSUMPTIONS

Period of Analysis

The period of economic analysis for this study is the 50-year period from 2005 to 2055. In addition, the period of analysis included the time required for project construction. Construction of a project could potentially begin in 2002 and be completed by 2005, the base year. The actual base year would depend on congressional authorization, funding, and other factors.

Without-Project Condition

Under the without-project condition, no new major projects would be undertaken to improve flood control or environmental values in the study area. Current maintenance and emergency practices would continue. The without-project assumptions related to future land use in the study area are listed below.

- Sacramento and Contra Costa Counties will continue to participate in the National Flood Insurance Program.

- Land use on Twitchell Island will remain agricultural. The State, which owns much of Twitchell Island, will continue leasing the land for agriculture use.

- Jersey Island will remain primarily agricultural. The ISD will be using wastewater from their treatment plant to irrigate pasture lands on the island. The ISD plans also include possible creation of seasonal wetland habitat with treatment plant effluent.

- Land use on Webb Tract is currently agricultural. The island is owned by Delta Wetlands Corporation which plans to use the island as a water supply reservoir as part of the proposed "Delta Wetlands Project." The

Delta Wetlands Project is a planned development of water supply and wetlands habitat on four Delta islands. As part of the Delta Wetlands Project, Webb Tract would act as a reservoir from late winter through mid-summer and would provide managed seasonal wetlands from late summer through fall and early winter. The implementation date for the Delta Wetlands Project is unknown pending ongoing permit actions. Land use on Webb Tract will remain agricultural until the Delta Wetlands Project is developed.

- Due to the size of the drainage area, upstream land use changes are not expected to have any appreciable effect on flood stages in the study area. Flood stages will likely be minimally affected by sea level rise. The historical rate of sea level rise for the San Francisco Bay is 0.25 foot per 50 years.

- The State's levee subventions program will continue to assist the reclamation districts in working toward the goal of the HMP levee standard. Current State funding for the subventions program is not expected to be sufficient to reach the HMP goal without additional assistance. The assumption for without-project conditions is that the existing levee systems will be maintained at nearly the existing condition.

- The levees protecting each of the study islands will continue to provide direct flood control protection to structures, marinas, and agricultural land; to benefit fish and wildlife; and to help maintain water quality. In the event of a levee failure, the levee would be repaired, the island would be dewatered, and the island would be returned to its pre-failure condition.

With-Project Conditions

The with-project condition involves the implementation of one or more alternative plans. Alternative plans were formulated for each island separately. Plan formulation for each island included both environmental restoration and flood protection.

TECHNICAL STUDIES

Hydrology

The hydrology used for this study is compiled in the Corps office report "Sacramento-San Joaquin Delta, California, Special Study, Hydrology," February 1992. The report presents stage-frequency curves for 24 tide gage locations and wave-runup data for 12 locations. The stage-frequency curves include stage data recorded through water year 1988. The stage-frequency curves in the report are updates to the curves presented in the December 1976 report titled "Sacramento-San Joaquin Delta, California, Stage-Frequency Study, Hydrology."

Selection of the 24 tide gage locations was based primarily on availability of records. Eight of the 24 tide gages are located near the study islands. Stage data for the eight locations were generally available for the past 40 to 50 years. From the historic record for these eight gages, stage-frequency data with computed error were tabulated for use in the economic analysis. The estimated maximum 100-year water surface elevations (NGVD) are 7.5 feet for Twitchell Island, 7.0 feet for Jersey Island, and 7.1 feet for Webb Tract.

Wind data from the Stockton Metropolitan Airport were used to compute the design wind speed. Although Stockton is about 10 miles from the study area, it was the closest location for reliable wind data. The analysis found that winds can occur from most directions, particularly the north, northwest, and southeast. Wave height information, calculated from design wind speed and fetch, was used in determining levee design height. Five of the 12 locations used for wind-runup analysis were located on the three study islands.

Geotechnical

The geotechnical studies included a field inspection of island levees and a review of previous work completed by the Corps, DWR, and local reclamation districts. The study included evaluation of potential borrow sites, identification of probable non-failure Points (PNP's) and probable failure points (PFP's), and a design recommendation for stability remediation of the study island levees.

There are three potential material borrow sources for Twitchell Island, Jersey Island, and Webb Tract levee improvements. These sources are on-site locations, dredged materials, and borrow from areas in the nearby Montezuma Hills.

The Montezuma Hills are about 5 miles west of the study islands. The quantities of material available from on-site locations are about 1 million cubic yards on Twitchell Island and 2 million cubic yards each on Jersey Island and Webb Tract. Dredged material is available in sufficient quantities to complete any levee rehabilitation. The quantity of material available from Montezuma Hills exceeds 20 million cubic yards. Conventional excavation equipment can be used for all borrow sources.

PNP and PFP for levees on the study islands were determined by the template method and by engineering judgment. Values were determined at 16 locations on Twitchell Island, 22 locations on Jersey Island, and 11 locations on Webb Tract. PNP values were determined with consideration of historical flood levels and evaluation of the existing levee cross section. PFP were typically estimated to be no higher than 6 inches below the top of the levee. Available explorations were investigated as part of the evaluation of the existing levee stability. Most of the available explorations were quite old, taken in the late 1950's. Moreover, most of the explorations were drilled at the levee toe and consequently provide only a general characterization of the foundation conditions. The values for the PNP and PFP are approximate and considered to be reconnaissance level.

Based on field inspections and surveys of the top of levees and levee cross sections, levee shaping and a landside berm are required in many areas to fully stabilize the levee systems. The recommended levee template would include a minimum 12-foot crown width and slopes of 1V on 3H landside and 1V on 2H waterside. Berm placement is recommended whenever the existing levee height exceeds 15 feet. The height of the berm would be approximately one-third to one-half of the height of the existing or enlarged levee section. The berm would have a slope of 1V on 15H. The geotechnical studies are compiled as an office report and included in appendix A.

Hazardous, Toxic, and Radiological Waste

A CESA was performed for the study area. The CESA included site visits, a review of the previous preliminary assessment of the three islands, and coordination with the Contra Costa County Department of Health, California Department of Substance Control, California Regional Water Quality Control Board, and Sacramento County Environmental Management Department. The site visits were conducted in November 1994. Two potential sites on Jersey Island and three potential sites on Webb Tract were observed during the site visits. In addition, there are 11 or 12 existing above-

ground steel tanks (300 to 10,000 gallons each) on Twitchell Island.

To ensure the safety of proposed projects, additional investigations and screening during further studies should be performed to make sure that contaminants do not exist at dangerous levels. The CESA found that potential soil and ground-water contamination sources may exist within the study limits. A water quality concern is the possibility of pesticide residues in the island soils and their potential effect on drainage. Surface and subsurface sampling should be conducted to determine if pesticide residues are present. The complete discussion of the site visits, outside agency contacts, findings, and recommendations is included in appendix A.

Impacts of Levee Failure on Water Quality and Supply

Twitchell Island, Jersey Island, and Webb Tract are located near the estuary where fresh river water and brackish bay water mix. The levees on these islands are critical to controlling salinity intrusion into the Delta and maintaining the stability of the estuary. A review and evaluation of past studies on the impacts of levee failure on Delta water quality and water supply was compiled in the report titled "A Reconnaissance Level Study--Water Quality, Water Supply, and Environmental Issues Pertaining to the Levee Failures at Three Sacramento-San Joaquin Delta Islands (Twitchell Island, Jersey Island, and Webb Tract)," completed in December 1994. This report is included as appendix B. Both short-term and long-term inundation of the three study islands were found to have significant effects on the water quality in and water supply from the western Delta.

Short-term water quality impacts result from breached levees and subsequent flooding during low-flow conditions. The immediate impacts of a levee break on a study island would be a greater tendency for salinity intrusion into the central Delta, jeopardizing the freshwater supply for the SWP and CVP, and a corresponding increase in releases from upstream reservoirs to control that salinity. The volume of fresh water needed to restore water quality after a low-flow levee failure was estimated for each of the study islands based on data from the June 1972 Brannan-Andrus levee failure. The required freshwater volumes for Jersey Island, Webb Tract, and Twitchell Island are 45,000, 97,000, and 65,000 acre-feet, respectively. The estimated average annual costs for this water are shown in table 4-1. Representatives from both DWR and the Bureau of Reclamation were consulted regarding the cost of water. Both agencies agreed that a cost of $100 per acre-foot was reasonable.

Long-term water quality impacts would result if a flooded island remains permanently inundated. If a western Delta island is flooded and not reclaimed, the long-term adverse impacts would include: (1) upstream migration of the mixing zone which would degrade Delta water quality and adversely affect the Federally threatened Delta smelt; (2) increased potential for formation of potential carcinogens; (3) increased salinity at the SWP and CVP pumping stations; (4) increased evaporation losses; and (5) increased costs for bank protection on surrounding islands. The estimated cost of long-term inundation of any of the study islands would range from $50 to $100 million. However, the magnitude of these potential damages validate the without-project assumption that the study islands would be reclaimed in the event of levee failure.

Table 4-1
Average Annual Water Costs
Short-Term Inundation
($1000)

Island/Tract	Average Annual Costs
Twitchell Island	$117
Jersey Island	$ 77
Webb Tract	$254

Risk-Based Analysis

A risk-based framework was developed for each of the study islands. This framework was used as the basis for computing with- and without-project damages. The analysis applied a Monte Carlo simulation to evaluate levee reliability, depth-damage information, and the probability distribution for the stage-frequency data.

The statistical variation for stage-frequency data was based on the historic length of record and the estimated error for rare events. For the reconnaissance study, the statistical variation for the economic data was not included. To evaluate levee reliability, the PNP and PFP for critical levee locations were incorporated into the analysis as outlined in Planning Guidance Letter No. 26.

Economics

An economic analysis to measure the beneficial contributions of flood damage reduction projects was completed for Twitchell Island, Jersey Island, and Webb Tract. This analysis is discussed in appendix C. Economic benefits are expressed as average annual damages using a Federal discount rate of 7.75 percent and a project life of 50 years. All damages are expressed in October 1994 price levels.

An inventory of damageable property on each island was created from U.S. Geological Survey quadrangle maps, on-site visits, and a 1991 land use inventory compiled by DWR. The assessed values of the structures were obtained from the Sacramento County and Contra Costa County assessors' rolls and adjusted to October 1994 values using the Marshall & Swift Valuation Service. Damage/benefit categories used in the analysis were single family residences and mobile homes, agricultural structures, commercial structures, public structures, agricultural production, roads, vehicles, emergency costs, and levee repair and dewatering costs. An in-depth analysis of future growth was not completed, but the amount of future growth is not considered to be significant given current development and zoning.

Flood damages were computed by determining relationships between damageable property, flood depths, and frequencies of flooding. Observed historic events and depth-damage information compiled by other agencies were used in the damage calculations. The average annual equivalent damages for each island were calculated using a Monte Carlo simulation. Inputs to the simulation included stage-damage relationships, stage-frequency hydrology, and PNP and PFP stages of the without- and with-project alternatives. The without-project damages on each island for a 100-year flood event are shown in table 4-2.

Table 4-2
Without-Project Damages 100-Year Flood Event
October 1994 Prices ($1000)

Island/Tract	Damages
Twitchell Island	$13,353
Jersey Island	$15,344
Webb Tract	$16,484

POTENTIAL MEASURES

Environmental Restoration

The purpose of this measure is to restore environmental resources on the three study islands. This would include the creation of a mosaic of permanent and seasonal wetlands, upland grasslands, and riparian habitat on each of the islands. Upland and riparian habitat would be recommended in areas where the existing topography would not easily permit development of wetlands. Environmental restoration is possible on Webb Tract, Jersey Island and Twitchell Island.

Downstream Flood Control Barriers

In the past there have been proposals to construct a barrier across a narrow point in the San Francisco Bay estuary downstream of the Delta to provide flood control and stop salinity intrusion. Studies have shown that such a barrier would not reduce upstream flood stages, navigation traffic would be hampered, and fish and wildlife would be adversely affected. As a result, such a barrier was not evaluated further.

Channel Improvements or Upstream Storage

Channel improvements or upstream flood control reservoirs constructed on tributaries to the Delta could somewhat alleviate the flood threat in some areas of the Delta by reducing flood stages. However, the threat of flooding due to extremely high tidal stages would not be reduced, particularly in the western Delta where the combination of high tides and large floodflows is the major influence on water surface elevations. Channel improvements or upstream dams would not significantly reduce the risk of levee failure in the study area. As a result, the use of upstream storage or channel improvements was not evaluated further.

Levee Improvement

The purpose of this measure is to improve the structural integrity of the existing levees protecting each of the study area islands. The work involves improving structural stability and raising levees. This measure would reduce flooding and seepage on the study islands. Improvement of the existing levees is a practical approach to increasing flood protection for the islands. As a result, levee improvement was evaluated further.

Nonstructural Measures

The purpose of nonstructural measures is to reduce flood damages rather that controlling floodwaters. Nonstructural measures may include such physical activities as relocating, elevating, floodproofing, or constructing floodwalls or levees to protect individual or small groups of structures. These measures can also include regulations and policies such as flood plain zoning and flood warning and preparedness planning. Nonstructural measures were evaluated further.

DESCRIPTION OF MEASURES

The measures carried forward for further study are described below.

Nonstructural Measures

The following nonstructural measures were evaluated as possible ways to reduce flood damage in the study area.

National Flood Insurance Program. FEMA has delineated the boundaries of the 100-year flood plain on flood insurance rate maps for the study area. FEMA through the Federal Insurance Administration provides Federally subsidized flood insurance for those residences and businesses projected to be affected by flooding under authority of the Flood Insurance Act of 1968, as amended, and emergency assistance under the Flood Disaster Protection Act of 1973. Both counties in the study area currently participate in the program.

Flood plain management consists of land regulations to ensure that flood-prone areas are used in a manner compatible with the risk of flooding. Land-use regulation is usually accomplished through zoning ordinances, subdivision regulations, and building codes enacted and enforced by local governments. To participate in the National Flood Insurance Program, a community must adopt flood plain management regulations to reduce or avoid future flood damages. These regulations have been implemented in the study area. Thus, this study assumes that all new structures within the study area will be protected from flooding up to the 100-year event, in accordance with the regulations.

Flood Forecasting and Warning System. The NWS provides forecasts and warnings of severe weather events which can endanger human life and property. To warn of tidal flooding, the NWS uses wind, wave, tide, and storm data obtained from a variety of

sources including weather stations, wave and tide gages, buoys, ship reports, and satellites. Various forecasting techniques base predictions on past weather conditions. The NWS, through its River Forecast Center, provides flood forecasts and warnings. This information is disseminated through the California Data Exchange Center computer system. DWR's flood operation center sends flood warnings to the local reclamation districts once predetermined stages are forecast.

The California Data Exchange Center provides flood forecasts for all major tributaries influencing the study area including the Sacramento, San Joaquin, and Mokelumne Rivers. Also, projections of high tides are forecasted. The river systems are very well monitored. Lead times for forecasts for the Sacramento and San Joaquin Rivers are 3 days or more; lead time for the Mokelumne River is over 1 day. When conditions are conducive to tidal flooding, the NWS issues special weather statements forecasting the threat to various Federal, State, county, and local agencies. The State Office of Emergency Services is generally responsible for disseminating this information to the threatened reclamation districts.

Reduction in flood damages is limited to property which can be moved or rearranged. Flood forecasting reduces the risk of loss of life and aids in flood fighting, but does not eliminate the inconvenience and emotional trauma caused by floods. Also, damages to structures and property which cannot be moved quickly are not reduced.

The existing warning system has worked well in the past for the three reclamation districts in the study area. The State and NWS continue to improve the dissemination of flood warning information. The Corps will continue to participate and provide input to the collection of data for the River Forecast Center.

Flood Proofing and Relocations. The flood proofing methods which are feasible for a particular building depend on the type of structure and its function. Flood proofing techniques are generally not practical when flood depths exceed 3 feet. Because much of the study area would be subject to deep flooding, flood proofing is not considered appropriate for the study area.

Although raising structures could significantly reduce flood damages to the structures and their contents, it would not eliminate the inconvenience caused by flooding. Also, individual buildings would be partially inaccessible during the flood since roads and walkways would be flooded. Raising the structures in

the study area is not considered economically feasible given their current condition and the height required to raise them.

Relocations of existing structures would be expensive and impractical. Many of the structures are farm related and must remain located on the islands. Other structures would need to be moved a minimum of 5 to 10 miles to find areas outside the existing flood plain. Options to floodproof, raise, and relocate structures in the study area are not considered practical or economically feasible. Therefore, these nonstructural measures were not evaluated further.

Levee Improvement Measure

This measure consists of improving the levees on each of the study islands. Levees on each island were evaluated independently. For each island, levee improvement alternatives were evaluated for a range of top-of-levee heights and various sources of construction materials. Levee design heights were based on various static water levels plus an increment for potential wave height.

The potential construction materials evaluated included on-island borrow material, off-island borrow material, and dredged material from the San Francisco Bay. Levee improvements were limited to the land side only to preserve waterside environmental resources. The waterside banks were generally considered stable, but will be evaluated more closely during later studies. The levee improvement designs consider levee settlement, levee stability, seepage, and erosion.

The improved levee section would consist of the following criteria.

Waterside slope	2H on 1V
Landside slope	3H on 1V
Minimum crown width	12 feet

In addition, in areas where the existing levee height exceeds 15 feet, a landside berm would be constructed. The following criteria were used in the berm design.

Height of berm	1/3 to 1/2 levee height
Berm slope	15H on 1V
Foundation	6-inch layer of drain rock with a geotextile filter

A typical improved levee section with landside berm is depicted in figure 4-1. Tables 4-3, 4-4, and 4-5 show the target levee heights, required length of stability berm, and required length of raised levee for each island. Plates 5 through 16 depict the locations of stability berms and levee raising for each of the study islands.

The reconnaissance study limited its study to improvements placed only on the land side of the levees. During the feasibility phase, close examination needs to be made of reinforcing levees on the water side where environmentally and economically feasible.

Table 4-3
Levee Improvement Plans
Jersey Island

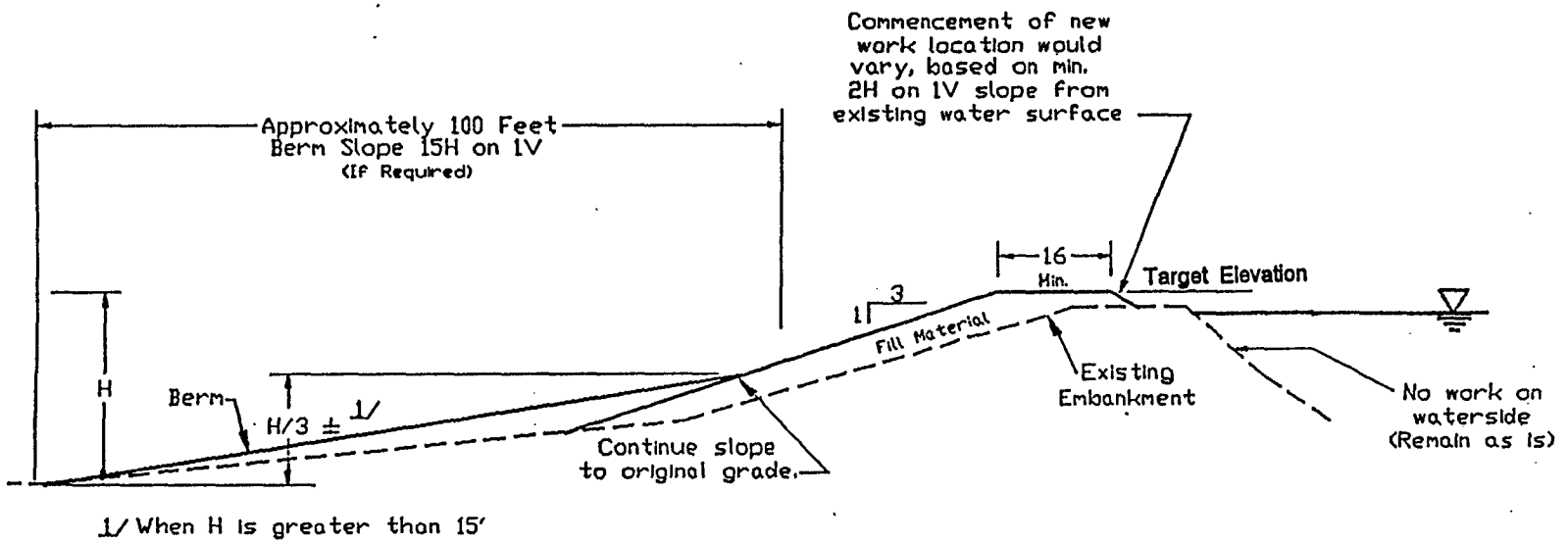
Target Levee Height[1] (feet NGVD)	Length of Stability Berm (feet)	Length of Levee Raising (feet)
7.5	47,500	28,000
7.0	47,500	18,000
6.5	47,500	17,000
6.0	47,500	10,000

[1] Target levee height at Station 200+00.

Table 4-4
Levee Improvement Plans
Webb Tract

Target Levee Height[1] (feet NGVD)	Length of Stability Berm (feet)	Length of Levee Raising (feet)
7.65	68,000	37,000
7.15	68,000	18,500
6.65	68,000	13,500
6.15	68,000	13,500

[1] Target levee height at Station 230+00.



1/ When H is greater than 15'

SACRAMENTO-SAN JOAQUIN DELTA, CA

LEVEE ENLARGEMENT

TYPICAL SECTION

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

FIGURE 4-1

Table 4-5
Levee Improvement Plans
Twitchell Island

Target Levee Height[1] (feet NGVD)	Length of Stability Berm (feet)	Length of Levee Raising (feet)
7.75	63,000	21,500
7.25	63,000	12,000
6.75	63,000	8,000
6.25	63,000	2,000

[1] Target levee height at Station 259+87.

Environmental Restoration Measure

Under this measure, agricultural lands would be converted to a mosaic of wetlands, grasslands, and riparian woodland. Potential project features include low lying ring levees, canals, small islands, ponds, water control structures, pumps, siphons, and service roads.

Full island environmental restoration conceptual plans were developed for Jersey Island, Twitchell Island and Webb Tract. Full-island restoration plans, although developed, were found not to be compatible with the future land-use plans for Jersey Island and Webb Tract.

ISD, the owner of most of Jersey Island, wishes to maintain the fullest flexibility to manage their treated wastewater on the island. The potential exists to develop upland grasslands or woodland habitat on some small portions of Jersey Island once ISD has fully established their long-range needs on the island.

The future plan for Webb Tract is development of the island primarily for water storage. Conversion of Twitchell Island for environmental restoration is supported by the non-Federal sponsor. A detailed discussion of the formulation of environmental restoration is included in appendix D.

Four different wildlife habitat types could be developed for Twitchell Island: permanent wetlands, seasonal wetlands, riparian woodland, and grassland. Table 4-6 shows the breakdown of habitat

types and the percentage composition of habitats on Twitchell Island. Plate 17 shows the restoration plans for the island.

Table 4-6
Environmental Restoration
Habitat Breakdown
Twitchell Island

	Area (acres)	Percent
Permanent Wetlands	504	14%
Seasonal Wetlands	970	27%
Riparian Woodland	216	6%
Upland Grassland	1,880	53%
TOTAL	3,570	100%

About 14 percent of the island would be converted to units permanent wetlands. Each wetland unit would range in area from to 203 acres and have an average depth of 4 feet. This depth would retard the growth of emergent vegetation (tules and hardst bulrush) and thus minimize maintenance. Several small mounds would be constructed within the permanent wetlands to increase habitat diversity and minimize wind-generated waves.

About 25 percent of the island would be converted to units seasonal wetlands. These units would vary in size from 44 to 2 acres. Seasonal wetlands would be managed primarily to provide food for wintering and migrant waterfowl. Water depths would range from 6 inches to 1 foot. A staggered flooding regime beginning in August or September would provide food resources throughout the winter. Drawdowns in the spring would also be staggered to maximize diversity of available cover and food resources.

About 5 percent of the island would be converted to a riparian corridor which would line the perimeter of each islan This corridor would be approximately 150 feet wide and would b placed adjacent to the landside toe of the levee or on the

stabilization berm. The riparian corridor would (1) provide cover and travel lanes between upland wildlife areas, (2) help reduce the rate of subsidence near the levees, (3) benefit many wildlife species, (4) provide wind protection to levee structures, and (5) provide sanctuary value to wildlife by limiting access and disturbance by humans.

Approximately one half of the island would be converted to grassland units. These units would range in size from 2 to 492 acres. They would provide food, cover, and nesting habitat for a wide variety of species. Several different strategies could be used to manage these units to benefit different wildlife species. For example, some units with moist soil could be planted in wheat to benefit geese such as Aleutian Canada geese, cackling Canada geese, and white-fronted geese. On other units, a mixture of vetch, ryegrass, foxtail, and wheatgrass could be seeded. This mix would provide a variety of cover types and food for waterfowl, upland game birds, song birds, and small mammals.

ALTERNATIVES

The structural alternatives are evaluated separately for Twitchell Island, Jersey Island, and Webb Tract. Although each island has similar kinds of benefits, each island is evaluated separately because each island is physically independent and generates separable benefits. Levee improvement generates tangible monetary benefits which include protecting agricultural resources, structures, and wildlife habitat, and savings in emergency costs, repair costs, and stored water. The environmental restoration alternatives would restore various habitat types that have diminished in the Delta. Corps navigation project and/or flood control projects are contiguous to each of the study area islands, and the study area islands have been affected by the Corps projects on the Sacramento and San Joaquin Rivers and tributaries. These river systems are the primary sources of fresh water into the Delta.

No-Action Plan

In the absence of a major project, the levee systems on the three study islands would continue to be at risk from levee failure. Levee failures threaten the land-based resources on each of the islands, affect water quality, can disrupt water supplies, and lead to costly levee repairs.

Under the no-action plan for each island, there would be no new projects to address flood damage reduction and/or

environmental restoration of historic natural resources. Normal maintenance and emergency activities are expected to continue, including repair of any erosion, slumping, or levee failures. The no-action alternative was assumed to be analogous to the without-project condition.

Levee failures on any of the study islands could adversely affect water quality in the Delta by elevating salt concentrations in the Delta water used for municipal, industrial, and agricultural purposes. Levee failures would affect the export of water, reduce agricultural yields, make water unpalatable, and increase consumer costs for replacement of plumbing fixtures and appliances. Such failures can also affect the location of the entrapment zone and adversely affect the Delta smelt. Flooded islands cause the temporary loss of wildlife habitat, displacing numerous species.

Jersey Island Plans

Levee Improvements.

For Jersey Island, levee improvement alternatives were evaluated for a range of top-of-levee heights and various sources of construction materials. Levee design heights were based on various static flood profiles plus an increment for potential wave height.

Levee improvements would be limited to the landside only to preserve waterside environmental resources. The levee improvement designs would consider levee settlement, levee stability, seepage, and erosion. In addition, in areas where the existing levee height exceeds 15 feet, a landside berm would be constructed. The target levee heights range from 7.5 feet to 6.0 feet at cross section 200+00.

Environmental Impacts. Under the levee improvement alternatives, vegetation and wildlife losses result from the levee construction on the landside of the levee. No work on the water side would occur except for the possible use of a barge and crane to import borrow material from off site. The majority of environmental impacts are associated with the placement of the stability berm. Because the berm is basically the same for all of the levee improvement alternatives, the worst case mitigation cost was used to estimate the costs of all four alternatives. Additional discussion of potential environmental impacts is included in appendix E.

The increased flood protection would protect and reduce short-term and permanent impacts to vegetation and wildlife caused by levee failure. However, the project would result in the long-term loss of some riparian forest, emergent marsh, and other cover types. As shown in table 4-7, the agricultural, developed, and ruderal habitat types would sustain most of the impacts from levee and berm construction. Native vegetation is largely confined to areas outside the impact zone on the interior of the islands and to the waterside of the levees.

Table 4-7
Affected Habitat Types
Jersey Island Levee Improvements

Habitat Type	Area Affected (acres)
Agricultural	35
Ruderal grassland	141
Developed	35
Emergent marsh	1
Upland scrub-shrub	4
Barren	5
TOTAL	221

Environmental Mitigation. For this reconnaissance study, a range of mitigation ratios were provided by FWS for each affected cover type. Depending on the cover type, mitigation could consist of establishing a wetland/upland complex, reseeding levee slopes, or modifying agricultural practices. The actual required mitigation would be developed during the feasibility phase and would be based on a Habitat Evaluation Procedure (HEP) analysis.

Some impacts could be mitigated through avoidance. Examples include using existing paved areas or uplands for construction or storage, and scheduling construction activities to avoid disturbing nesting raptors. However, impacts to vegetation that could not be avoided would be compensated.

To mitigate for the loss of "ruderal grassland" cover type, the reconstructed levees would be seeded with native grasses.

Seeding would also control erosion. The value of these areas to wildlife should be regained within a few years. A wetland/upland complex would be established as mitigation for the emergent marsh and upland scrub-shrub. Mitigation for affected agricultural areas would also be provided. No mitigation would be necessary for the "developed" and "barren" cover types.

Total costs include the cost of initial planting, maintenance for 3 years, and land costs. To minimize mitigation costs, maximum use of the berm was made for revegetation of upland scrub-shrub and grassland. For the emergent marsh, it was assumed that a portion of the island would be used for mitigation plantings.

The total first cost for mitigation of the levee improvement alternative on Jersey Island is $787,500.

Benefits and Costs. Table 4-8 shows the estimated average annual benefits and costs for four levels of levee improvement for Jersey Island. The flood damage reduction categories include structure damages, crop damages, levee repairs, island dewatering, and the cost of loss reservoir water. The costs include all required construction costs including environmental mitigation and all lands, easements, rights-of-way, relocations, and disposal areas (LERRD's).

Table 4-8
Costs and Benefits
Levee Improvement Plans
Jersey Island

Target Levee Height[1] (feet)	Stage Exceedence Interval	Average Annual Costs ($1,000)	Average Annual Benefits ($1,000)	Benefit-Cost Ratio
7.5	1000 years	1,053	2,316	2.20
7.0	100 years	908	2,126	2.34
6.5	12 years	798	1,135	1.42
6.0	6 years	723	426	0.59

[1] Target levee height at Section 200+00.

Webb Tract Plans

Levee Improvements.

For Webb Tract, levee improvement alternatives were evaluated for a range of top-of-levee heights and various sources of construction materials. Levee design heights were based on various static flood profiles plus an increment for potential wave height.

Levee improvements would be limited to the landside only to preserve waterside environmental resources. The levee improvement designs would consider levee settlement, levee stability, seepage, and erosion. In addition, in areas where the existing levee height exceeds 15 feet, a landside berm would be constructed. The target levee heights range from 7.65 feet to 6.15 feet at cross section 230+00.

Environmental Impacts. Under the levee improvement alternatives, vegetation and wildlife losses result from the levee construction on the landside of the levee. No work on the waterside would occur except for the possible use of a barge and crane to import borrow material from off site. The majority of environmental impacts are associated with the placement of the stability berm. Because the berm is basically the same for all of the levee improvement alternatives evaluated, the worst case mitigation cost was used to estimate the costs of all four alternatives.

The increased flood protection would protect and reduce short-term and permanent impacts to vegetation and wildlife caused by levee failure. However, the project would result in the long-term loss of some riparian forest, emergent marsh, and other cover types. As shown in table 4-9, the agricultural, developed, and ruderal habitat types would sustain most of the impacts from levee and berm construction. Native vegetation is largely confined to areas outside the impact zone on the interior of the islands and to the waterside of the levees.

Environmental Mitigation. For this reconnaissance study, a range of mitigation ratios were provided by FWS for each affected cover type. Depending on the cover type, mitigation could consist of establishing a wetland/upland complex, reseeding levee slopes, or modifying agricultural practices. The actual required mitigation would be developed during the feasibility phase and would be based on a HEP analysis.

Table 4-9
Affected Habitat Types
Webb Tract Levee Improvements

Habitat Type	Area Affected (acres)
Agricultural	51
Ruderal grassland	168
Developed	31
Riparian scrub-shrub	16
Emergent marsh	1
Upland scrub-shrub	14
Barren	15
TOTAL	296

Some impacts could be mitigated through avoidance. Examples include using existing paved areas or uplands for construction or storage, and scheduling construction activities to avoid disturbing nesting raptors. However, impacts to vegetation that could not be avoided would be compensated.

To mitigate for the loss of "ruderal grassland" cover type, the reconstructed levees would be seeded with native grasses. Seeding would also control erosion. The value of these areas to wildlife should be regained within a few years. A wetland/upland complex would be established as mitigation for the emergent marsh, upland scrub-shrub, and riparian scrub-shrub. Mitigation for affected agricultural areas would also be provided. No mitigation would be necessary for the "developed" and "barren" cover types.

Total costs include the cost of initial planting, maintenance for 3 years, and land costs. To minimize mitigation costs, maximum use of the berm was made for revegetation of upland scrub-shrub and grassland. For the emergent marsh and riparian cover types, it was assumed that a portion of the island would be used for mitigation plantings.

The total first cost for mitigation of the levee improvement alternative on Webb Tract is $1,080,000.

Benefits and Costs. Table 4-10 shows the estimated average annual benefits and costs for four levels of levee improvement for Webb Tract. The flood damage reduction categories include structure damages, crop damages, levee repairs, island dewatering, and the cost of loss reservoir water. The costs include all required construction costs including environmental mitigation and all lands, easements, rights-of-way, relocations, and disposal areas (LERRD's).

Table 4-10
Costs and Benefits
Levee Improvement Plans
Webb Tract
($1,000)

Target Levee Height[1] (feet)	Stage Exceedence Interval	Average Annual Costs ($1,000)	Average Annual Benefits ($1,000)	Benefit-Cost Ratio
7.65	700 years	2,076	1,969	0.95
7.15	100 years	1,796	1,903	1.06
6.65	20 years	1,626	1,723	1.06
6.15	8 years	1,588	1,298	0.82

[1] Target levee height at Section 230+00.

Twitchell Island Plans

Levee Improvements

For Twitchell Island, levee improvement alternatives were evaluated for a range of top-of-levee heights and various sources of construction materials. Levee design heights were based on various static flood profiles plus an increment for potential wave height.

Levee improvements would be limited to the landside only to preserve waterside environmental resources. The levee improvement designs would consider levee settlement, levee stability, seepage, and erosion. In addition, in areas where the existing levee height exceeds 15 feet, a landside berm would be constructed. The target levee heights range from 7.75 feet to 6.25 feet at cross section 259+87.

Environmental Impacts. Under the levee improvement alternatives, vegetation and wildlife losses result from the lev construction on the landside of the levee. No work on the waterside would occur except for the possible use of a barge and crane to import borrow material from off site. The majority of environmental impacts are associated with the placement of the stability berm. Because the berm is basically the same for all the levee improvement alternatives, the worst case mitigation co was used to estimate the costs of all four alternatives.

The increased flood protection would protect and reduce short-term and permanent impacts to vegetation and wildlife caus by levee failure. However, the project would result in the long term loss of some riparian forest, emergent marsh, and other cov types. As shown in table 4-11, the agricultural, developed, and ruderal habitat types would sustain most of the impacts from lev and berm construction. Native vegetation is largely confined to areas outside the impact zone on the interior of the islands and to the waterside of the levees.

TABLE 4-11
Affected Habitat Types
Twitchell Island Levee Improvements

Habitat Type	Area Affected (acres)
Agricultural	168
Ruderal grassland	112
Developed	71
Emergent marsh	10
Upland scrub-shrub	8
Upland forest	1
TOTAL	340

Environmental Mitigation. For this reconnaissance study, a range of mitigation ratios were provided by FWS for each affecte cover type. Depending on the cover type, mitigation could consi of establishing a wetland/upland complex, reseeding levee slopes or modifying agricultural practices. The actual required

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mitigation would be developed during the feasibility phase and would be based on a HEP analysis.

Some impacts could be mitigated through avoidance. Examples include using existing paved areas or uplands for construction or storage, and scheduling construction activities to avoid disturbing nesting raptors. However, impacts to vegetation that could not be avoided would be compensated. No mitigation would be necessary for the "developed" cover type.

To mitigate for the loss of "ruderal grassland" cover type, the reconstructed levees would be seeded with native grasses. Seeding would also control erosion. The value of these areas to wildlife should be regained within a few years. A wetland/upland complex would be established as mitigation for the emergent marsh, and upland forest and scrub-shrub. Mitigation for affected agricultural areas would also be provided.

Total costs include the cost of initial planting, maintenance for 3 years, and land costs. To minimize mitigation costs, maximum use of the berm was made for revegetation of upland scrub/shrub, forest, and grassland. For the emergent marsh, it was assumed that a portion of the island would be used for mitigation plantings.

The total first cost for mitigation of levee improvement alternatives on Twitchell Island is $237,000.

Table 4-12
Costs and Benefits
Levee Improvement Plans
Twitchell Island

Target Levee Height[1] (feet)	Stage Exceedence Interval	Average Annual Costs ($1,000)	Average Annual Benefits ($1,000)	Benefit-Cost Ratio
7.75	1000 years	1,074	1,358	1.26
7.25	100 years	899	1,238	1.38
6.75	20 years	844	905	1.07
6.25	8 years	769	436	0.57

[1] Target levee height at Section 259+87.

Benefits and Costs. Table 4-12 shows the estimated average annual benefits and costs for four levels of levee improvement for Twitchell Island. The flood damage reduction categories include structure damages, crop damages, levee repairs, island dewatering, and the cost of loss reservoir water. The costs include all required construction costs including environmental mitigation and all lands, easements, rights-of-way, relocations, and disposal areas (LERRD's).

Environmental Restoration

Environmental Benefits and Impacts. There are many environmental benefits associated with this alternative. In general, 3,570 acres of agricultural areas would be replaced with wetlands, riparian woodlands, and grasslands and the levees would be reinforced to increase the level of flood protection to the island.

Restoration of Twitchell Island would significantly benefit vegetation and wildlife resources. The addition of over 1,400 acres of permanent and seasonal wetlands supports the goal of 20,000 acres of restored wetlands in the Delta as identified in the Central Valley Habitat Joint Venture Implementation Plan. The restoration work would increase the areal extent and distribution of community types that are valuable and scarce in the region. The work would increase nesting and foraging opportunities for wildlife including Pacific Flyway waterfowl. In addition, restoration would likely increase the diversity and abundance of both plant and animal species which inhabit the island.

Although some vegetation and wildlife resources would be adversely affected by the restoration work, no mitigation is required with this alternative. Initial losses to vegetation and wildlife would stem from construction of the canals and levees associated with the seasonal and permanent wetlands. Some existing drainage canals which provide palustrine emergent marsh habitat would be enlarged, and this habitat would be temporarily lost. However, the emergent marsh should return to the enlarged canals within 1 to 3 years.

Existing agricultural crops and pasture provide habitat for large number of waterfowl and other wildlife. About 1,690 acres of this agricultural land would be converted to seasonal and permanent wetlands and riparian habitat. Although wildlife which use these resources would be temporarily displaced, the restored areas would provide a much greater diversity of habitat for

wildlife in the long term. As a result, the diversity and abundance of wildlife using the area would increase substantially, and no mitigation is required.

Levees would be strengthened to provide flood protection to the restoration area. Improvements would consist of placement of a stability berm with a minimal amount of levee raising at several low spots. The proposed levee improvements would improve the probability of levee failure to one failure in 25 years or a probability of 0.04.

Costs. The first cost for environmental restoration features for this alternative is estimated to be $30,870,000. The first cost for the necessary levee improvements is $6,456,000. The total average annual cost of this alternative is $3,205,000.

SUMMARY OF ALTERNATIVE PLANS

Environmental restoration and levee improvement plans were evaluated for each of the study islands. Although environmental restoration was identified for each of the islands, the owners of Webb Tract and Jersey Island currently want to continue their planning efforts without environmental restoration work by the Corps.

The environmental restoration plan for Twitchell Island includes creation of various habitat and levee strengthening to protect the constructed project. During feasibility-phase studies, greater cost savings will be pursued. More detailed topography will help identify ways to minimize excavation and construction costs. Real estate costs may be reduced by avoiding expensive improvements. Systems to reduce the cost of plantings will also be investigated. In addition, some of the levee improvement costs may be offset by flood control benefits to other Delta resources.

Flood damage reduction benefits and costs were quantified for a range of levee improvements for each island. The optimum benefit-to-cost ratio ranged from 2.3 to 1.1 with at least one feasible plan identified for each island. The levee improvements consist primarily of construction of a stability berm around the perimeter of the island and the raising of low levee crowns.

CHAPTER 5 - FEASIBILITY PHASE STUDIES

REQUIRED STUDIES

A large number of studies will be required during the feasibility phase of the investigation. A scope of work, cost estimate, and schedule for the feasibility study will be prepared and referenced in a Feasibility Cost-Sharing Agreement (FCSA) to be prepared by the Corps. The FCSA will be between the Department of the Army (represented by the Sacramento District Engineer) and the non-Federal sponsor (DWR) and will identify the equal sharing of costs for the feasibility study. Accompanying submission of the final FCSA and Project Study Plan for approval will be a letter of intent from the non-Federal sponsor stating that the FCSA is acceptable and that the sponsor will sign the agreement upon certification of the reconnaissance report.

STUDY MANAGEMENT

The non-Federal sponsor will be involved in study management. In order to manage a cost-shared study, an Executive Committee and a Study Management Team will be formed. This management structure will be formalized in the FCSA.

The Study Management Team will include the Corps and the non-Federal sponsor. This team will develop the studies, guide in their accomplishment, and participate in selection of potential solutions. The team will be directly involved in establishing mutual roles and in focusing on the critical issues. Corps representatives will include the study manager and the Chief of the San Joaquin River Basin Branch. The team will recommend to the Executive Committee the tasks to be conducted and the extent of planning and evaluation to be carried out in the feasibility phase. The team will also report the results of studies to the Committee and recommend alternative courses of action for project implementation.

The Executive Committee will include the District Engineer, his chief planner or designee, and the Deputy District Engineer for Project Management. The non-Federal sponsor, along with primary technical advisors, will be equal partners with the Corps representatives on the Committee. The District Engineer and his counterpart with the non-Federal sponsor will co-chair the Committee.

The Executive Committee will participate in Issue Resolution Conferences (IRC) and ratify decisions made by the Study

Management Team. The Committee is also responsible for resolving any disputes that may arise during the study. The Committee will agree on the solutions and study direction, which may include termination. At least one IRC will be held prior to the public distribution of the draft feasibility report to ensure that all issues are resolved prior to submitting the final report to higher authority. Additional IRC's will be held, as required, throughout the study to resolve any problems that may arise.

A Life Cycle Project Manager (LCPM) will be assigned to the study prior to signing the FCSA. The LCPM's role is to manage construction and allocate funds for accomplishment of tasks. The LCPM will be the primary point of contact for the non-Federal sponsor for items regarding the FCSA, policy issues, budgetary requests, schedule, and overall project development.

The Corps study manager will be required to perform both the general supervision of personnel involved in the study and the management of the study itself. The study manager will ensure that funds are allocated to the proper organizational elements and that appropriate analyses are conducted to develop the information needed to evaluate the resource problems in the study area. The study manager will also direct the flow of technical information between the Corps and the non-Federal sponsor in order to accomplish the work in an efficient and timely manner.

FINANCIAL ANALYSIS

Feasibility Phase

The feasibility phase will be cost shared 50 percent Federal/50 percent non-Federal. Fifty percent of the non-Federal share or 25 percent of the total project cost can be in-kind services.

Construction Phase

The cost of constructing the project will be shared in accordance with the Water Resources Development Act of 1986. During construction of a project, the non-Federal sponsor must pay 5 percent of the costs assigned to flood control. In addition, the sponsor must provide all LERRD's. If the total of these two is less than 25 percent of the total project cost, the sponsor will pay the difference during construction. However, the total non-Federal cost will not exceed 50 percent of the total project cost. For environmental restoration, the cost sharing is 75 percent Federal and 25 percent non-Federal with credit given for LERRD's.

CHAPTER 6 - DISCUSSION AND CONCLUSIONS

DISCUSSION

The levees in the study area provide direct flood protection to land-based resources on each island and benefit fish and wildlife, water quality, and recreation. Levees in the western Delta act as hydraulic barriers that help reduce intrusion of brackish water into the interior Delta. This is important to maintain adequate water quality for the benefit of fishery resources, recreation, and agriculture, municipal, and industrial water users.

The plan for improving and stabilizing the existing levee systems appears to be the most feasible plan to protect the valuable resources in the study area. To preclude potential adverse environmental impacts of levee stabilization, levee improvements were confined to the landside of the levee.

The environmental resources of the study area and the overall Delta have greatly declined since the late 1800's. The San Francisco Bay-Delta ecosystem is considered one of the most altered estuaries on earth. Of the over 700,000 acres of original Delta wetlands, only 18,000 acres remain today. The Corps has constructed numerous upstream reservoirs on the rivers that provide fresh water to the Delta, and several Corps navigation and flood control projects are contiguous to the study islands.

Restoration of seasonal and permanent wetlands and riparian woodland in the western Delta represents a great opportunity to contribute to efforts to reverse the decline of wetlands habitat and wildlife resources.

The restoration alternatives have been designed so that components can be implemented either in whole or in smaller units depending on funding, availability of lands, and/or support of a non-Federal sponsor.

CONCLUSIONS

Based on the studies discussed in this report, it is concluded that:

- A continuing flood threat exists for each of the three study islands: Jersey Island, Webb Tract, and Twitchell Island.

- There is at least one feasible alternative for each of the study islands.

- Historic environmental resources in the study area have seriously declined, and this decline is partly due to past water resources development in the contributing watersheds and by the Corps projects located adjacent t the study islands. Consequently, a Federal interest exists for environmental restoration.

- There is the potential to use dredged material for leve improvement and/or for environmental restoration. Future studies should fully consider the use of dredged material and should include application of Section 204 of the Water Resources Development Act of 1992, as appropriate.

- Levee improvement is economically feasible for the thre islands. The three islands are also good candidates fo environmental restoration. Environmental restoration b the Corps is supported at this time for only Twitchell Island. The landowners of Jersey Island and Webb Tract are interested in habitat creation; however, at the present time, Corps restoration is not consistent with the owners' current plans for island development.

- A non-Federal entity has indicated a willingness and capability to share the costs of feasibility phase studies on Twitchell Island. These studies include environmental restoration on the islands with levee improvement to protect those and other Delta resources.

CHAPTER 7 - RECOMMENDATION

The results of this reconnaissance study indicate there is a Federal interest in at least one potential environmental restoration alternative with levee improvement in the western Delta study area. This alternative for Twitchell Island has local support, appears economically feasible, and has a non-Federal sponsor that is willing and able to cost share the feasibility phase. Therefore, I recommend that feasibility studies for Twitchell Island in the Western Delta be initiated.

FOR: John N. Reese LTC EN
Colonel, Corps of Engineers
District Engineer
Deputy

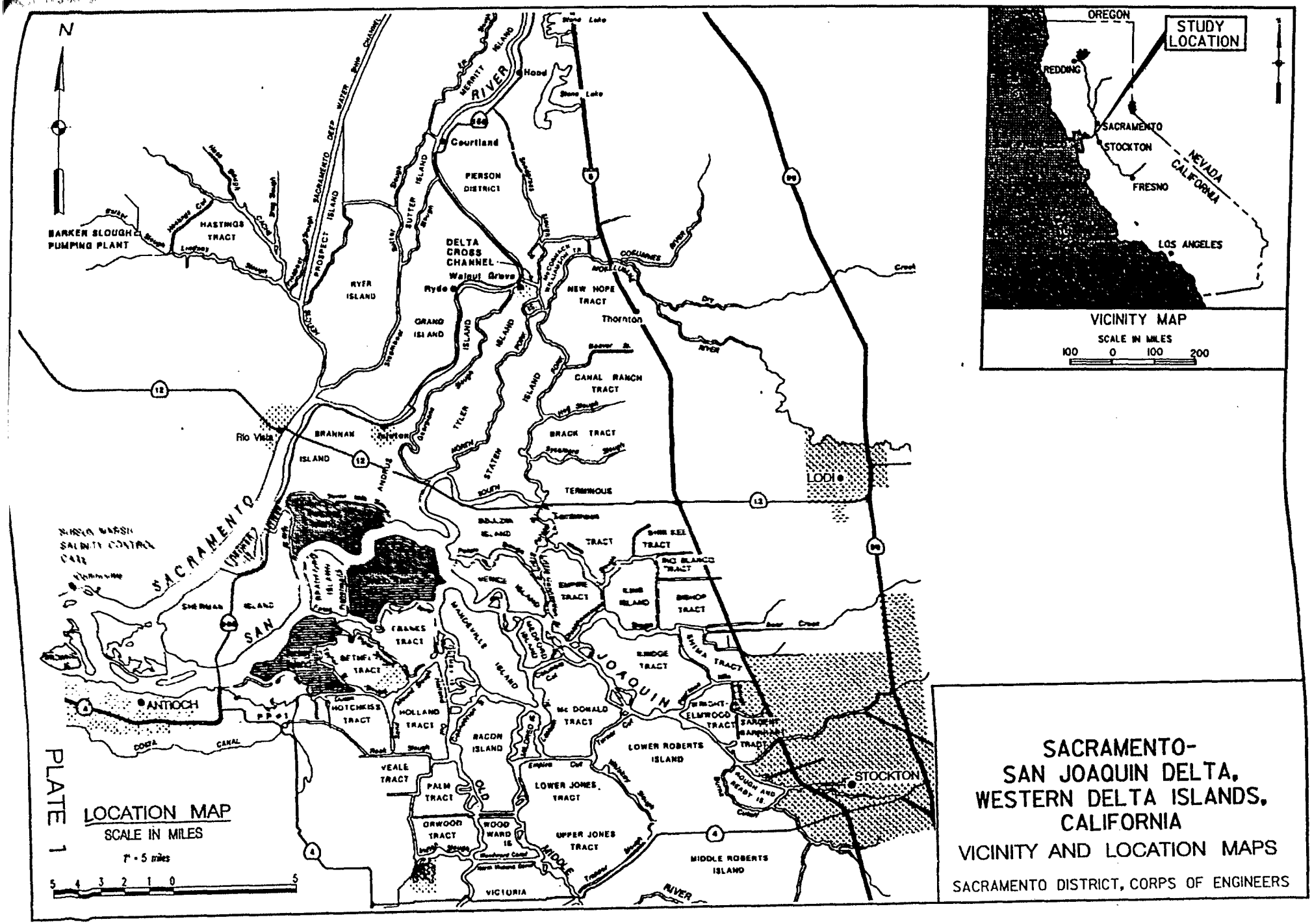


PLATE 1

SACRAMENTO-SAN JOAQUIN DELTA, WESTERN DELTA ISLANDS, CALIFORNIA

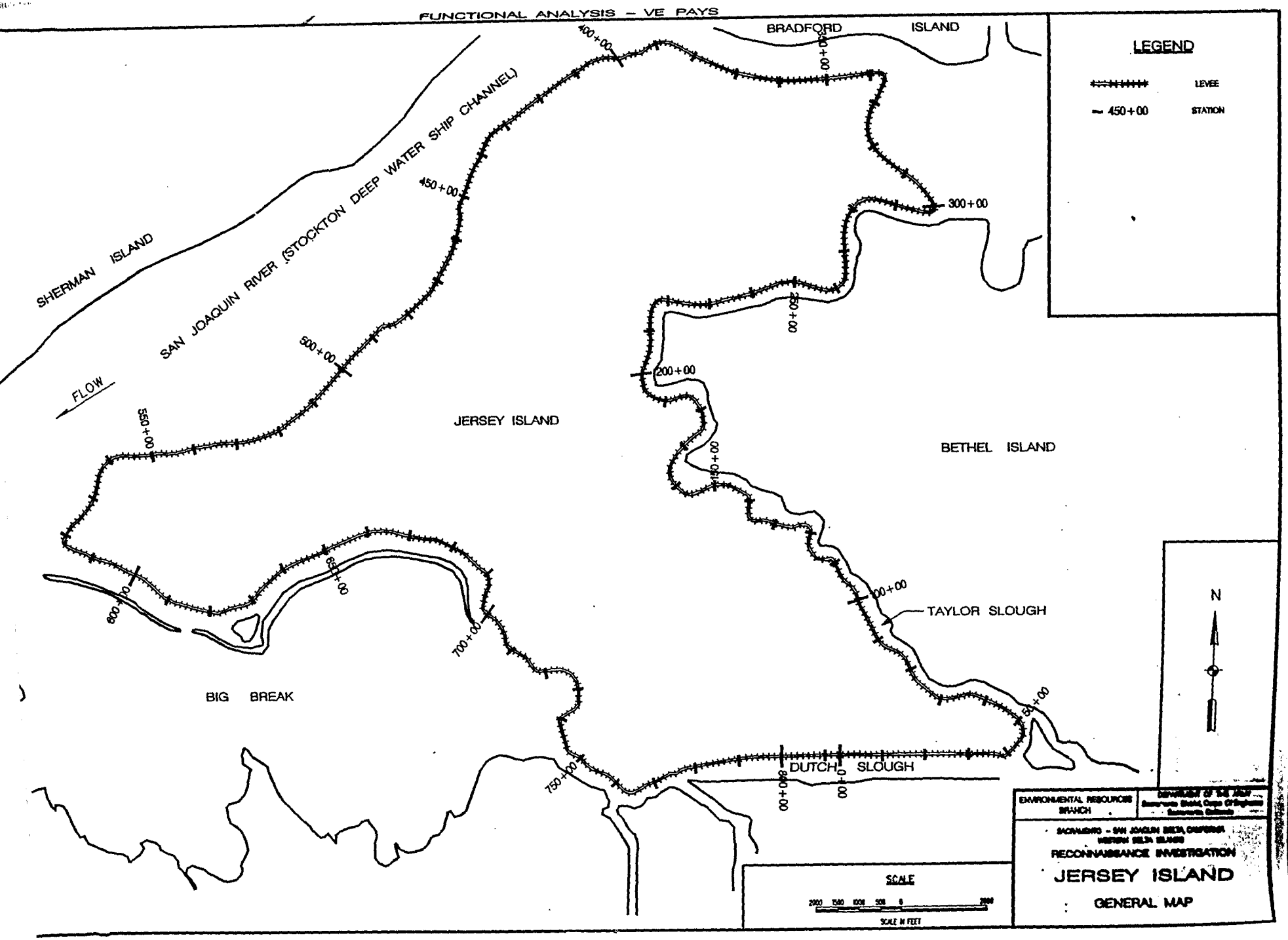
VICINITY AND LOCATION MAPS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

C-098671

C—098671

FUNCTIONAL ANALYSIS – VE PAYS



C-098672

C-098672

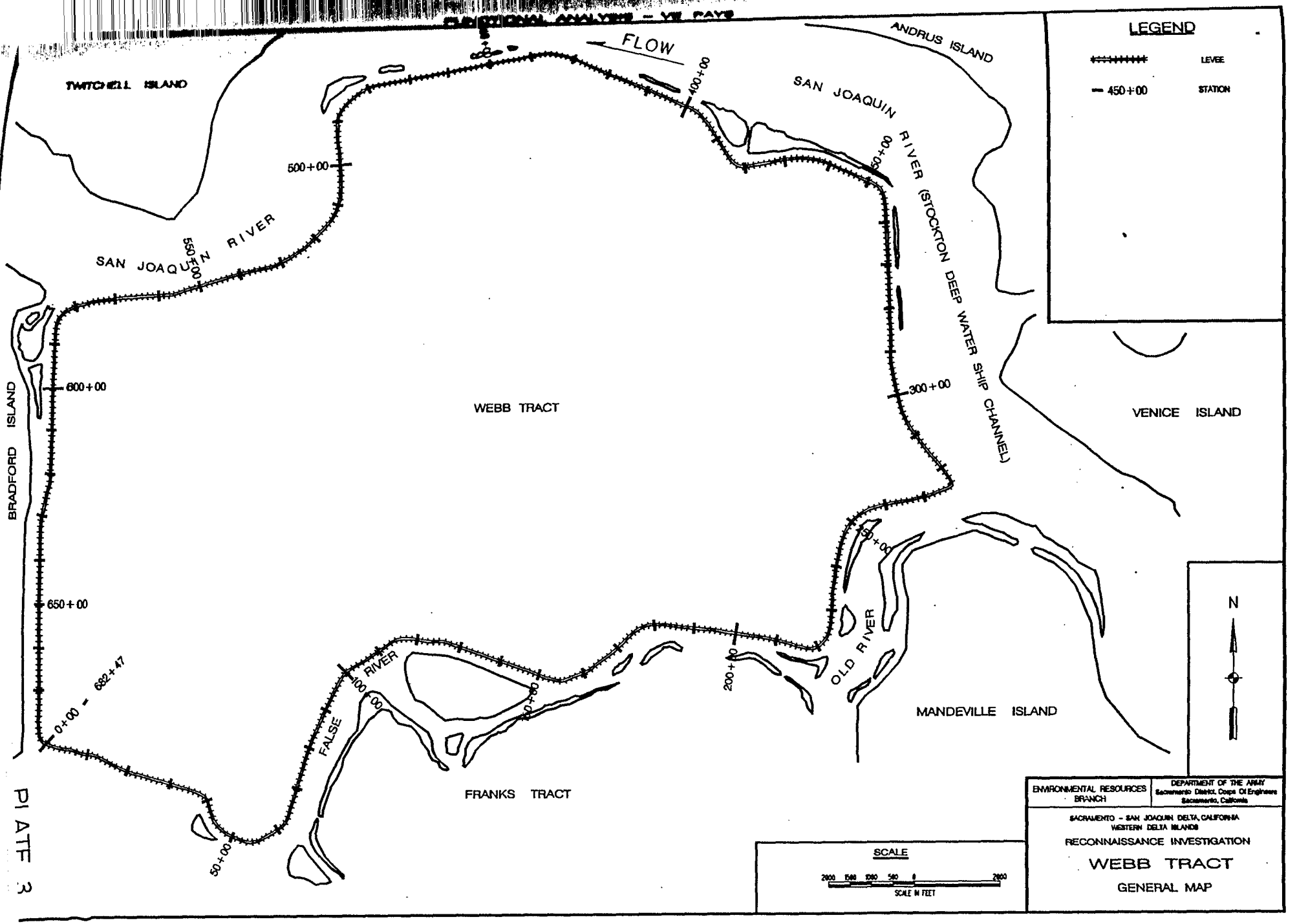
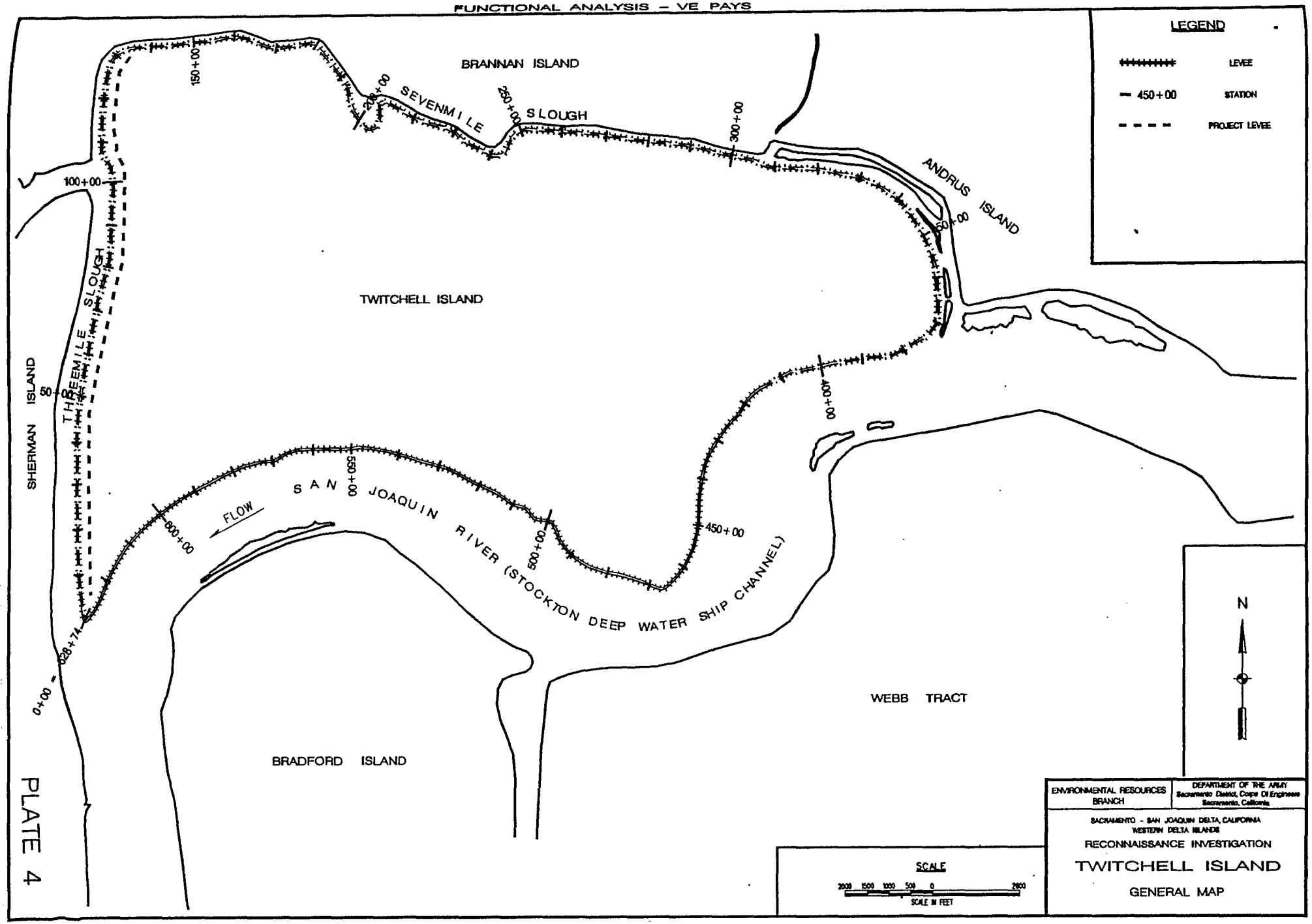


PLATE 3



ENVIRONMENTAL RESOURCES BRANCH

DEPARTMENT OF THE ARMY
Sacramento District, Corps Of Engineers
Sacramento, California

SACRAMENTO - SAN JOAQUIN DELTA, CALIFORNIA
WESTERN DELTA ISLANDS
RECONNAISSANCE INVESTIGATION

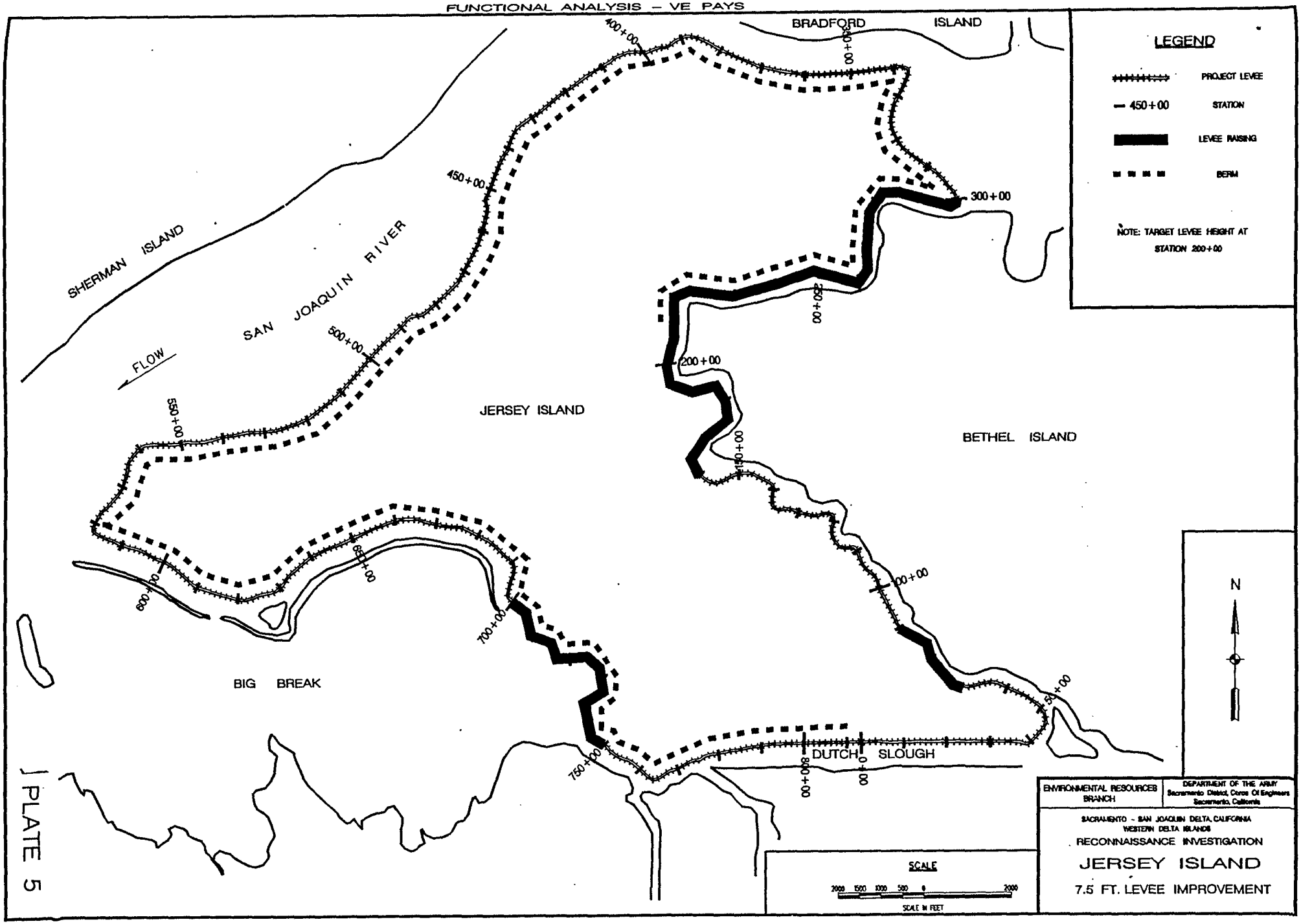
TWITCHELL ISLAND
GENERAL MAP

PLATE 4

C-098674

C—098674

FUNCTIONAL ANALYSIS – VE PAYS



ENVIRONMENTAL RESOURCES BRANCH

DEPARTMENT OF THE ARMY
Sacramento District, Corps Of Engineers
Sacramento, California

SACRAMENTO - SAN JOAQUIN DELTA CALIFORNIA
WESTERN DELTA ISLANDS
RECONNAISSANCE INVESTIGATION

JERSEY ISLAND
7.5 FT. LEVEE IMPROVEMENT

PLATE 5

C-098675

C—098675

FUNCTIONAL ANALYSIS – VE PAYS

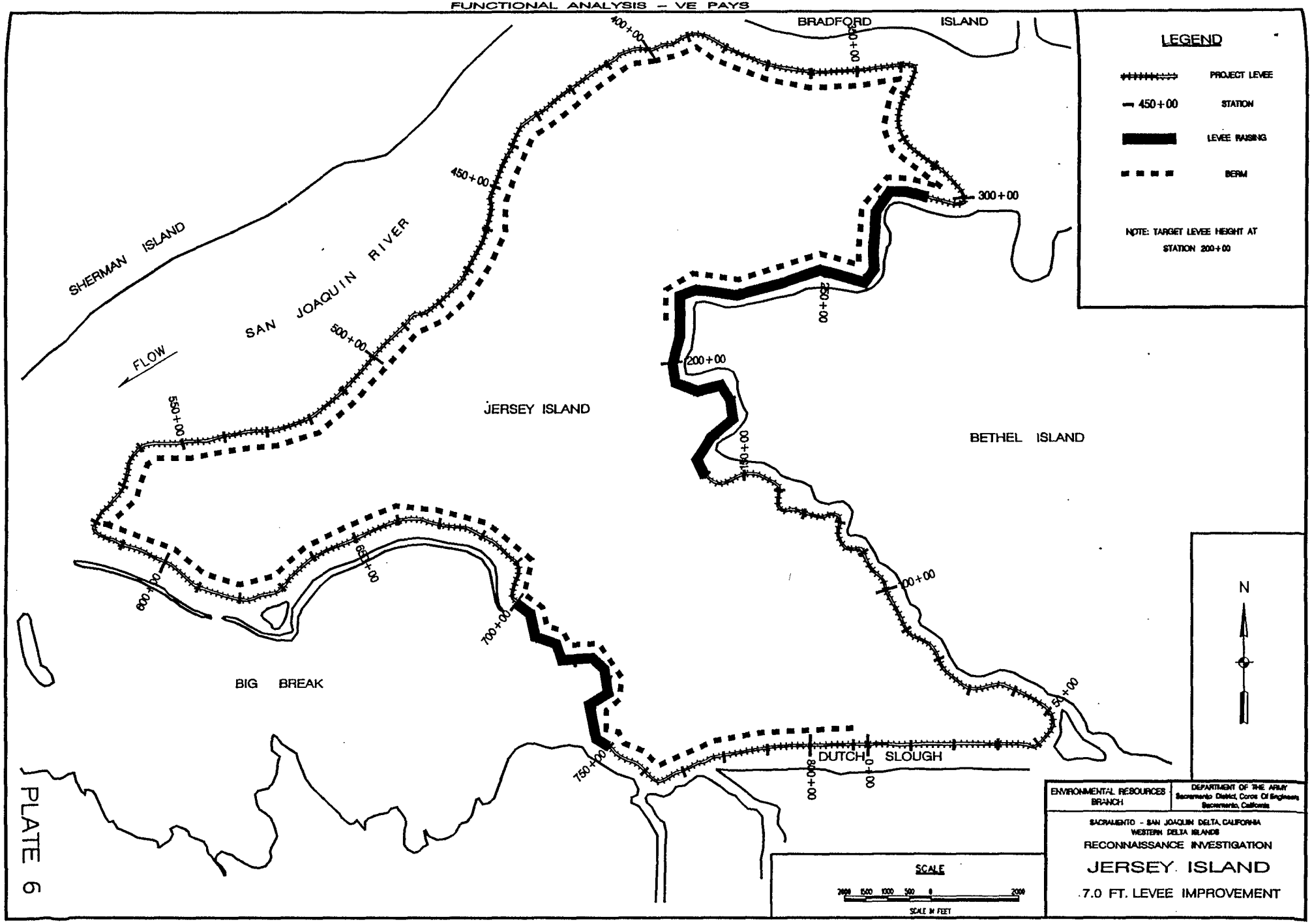


PLATE 6

C-098676

C-098676

FUNCTIONAL ANALYSIS – VE PAYS

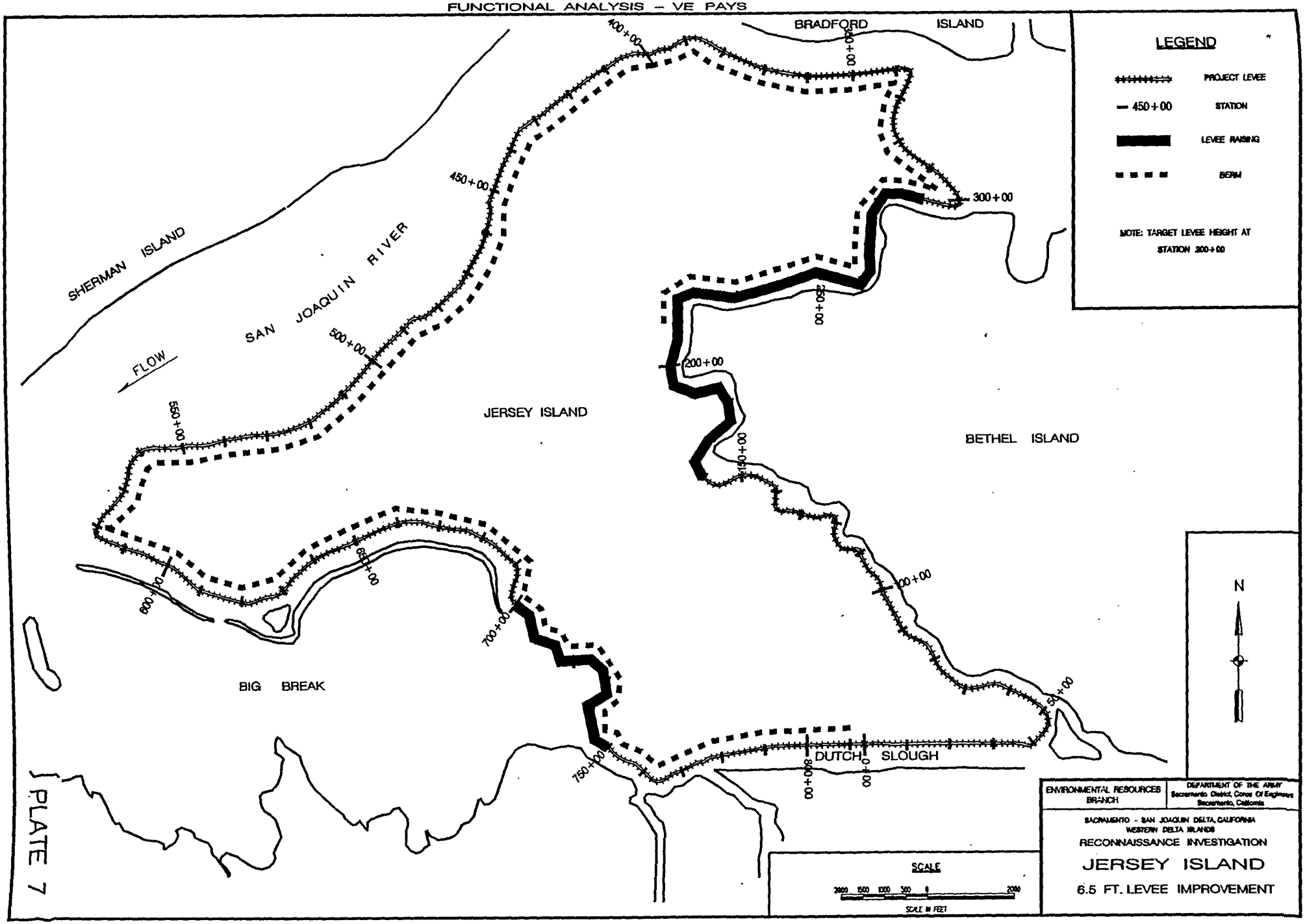
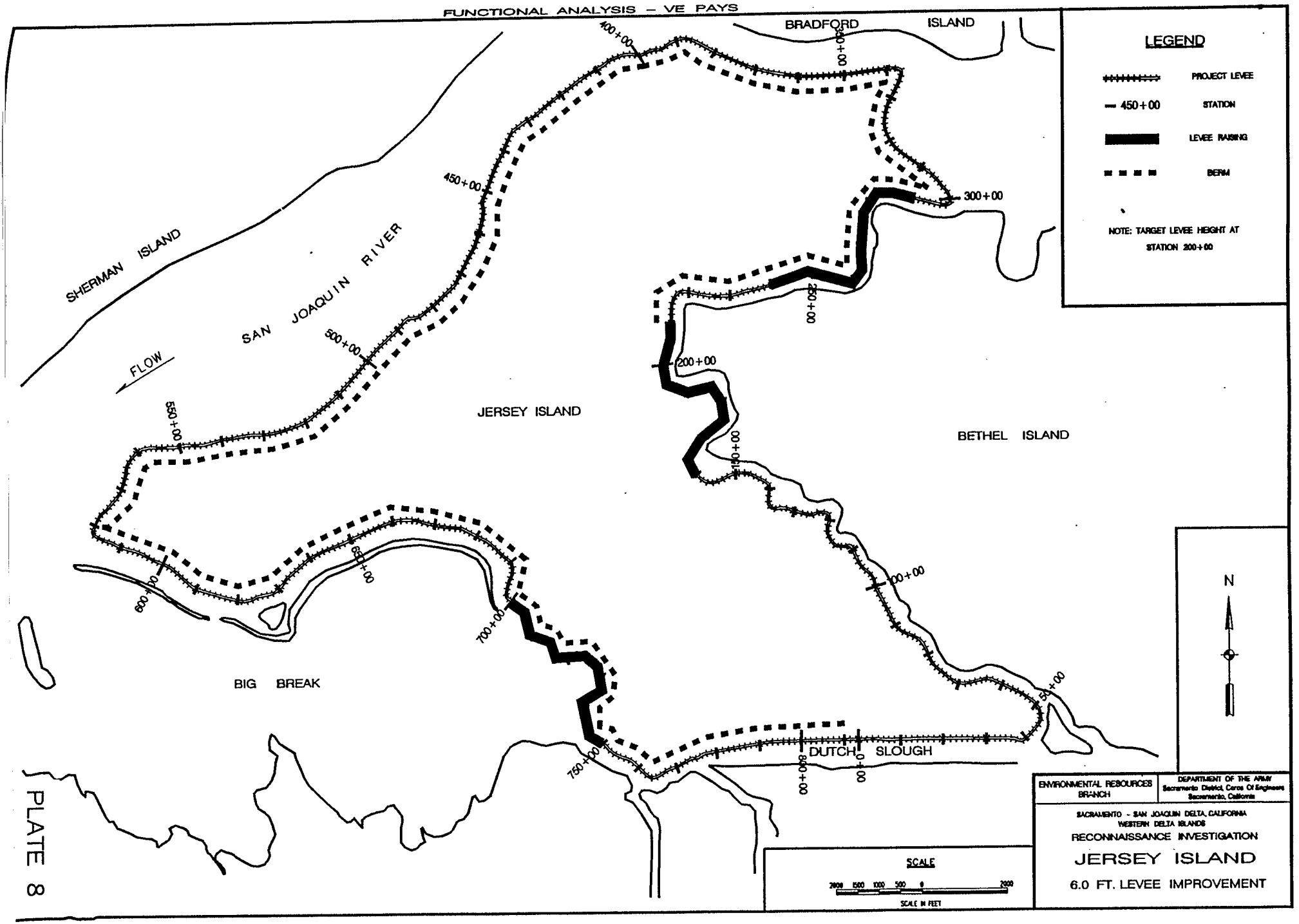


PLATE 7

C-098677

C-098677

FUNCTIONAL ANALYSIS – VE PAYS



ENVIRONMENTAL RESOURCES BRANCH

DEPARTMENT OF THE ARMY
Sacramento District, Corps Of Engineers
Sacramento, California

SACRAMENTO - SAN JOAQUIN DELTA, CALIFORNIA
WESTERN DELTA ISLANDS
RECONNAISSANCE INVESTIGATION

JERSEY ISLAND

6.0 FT. LEVEE IMPROVEMENT

PLATE 8

C-098678

C—098678

FUNCTIONAL ANALYSIS – VE PAYS

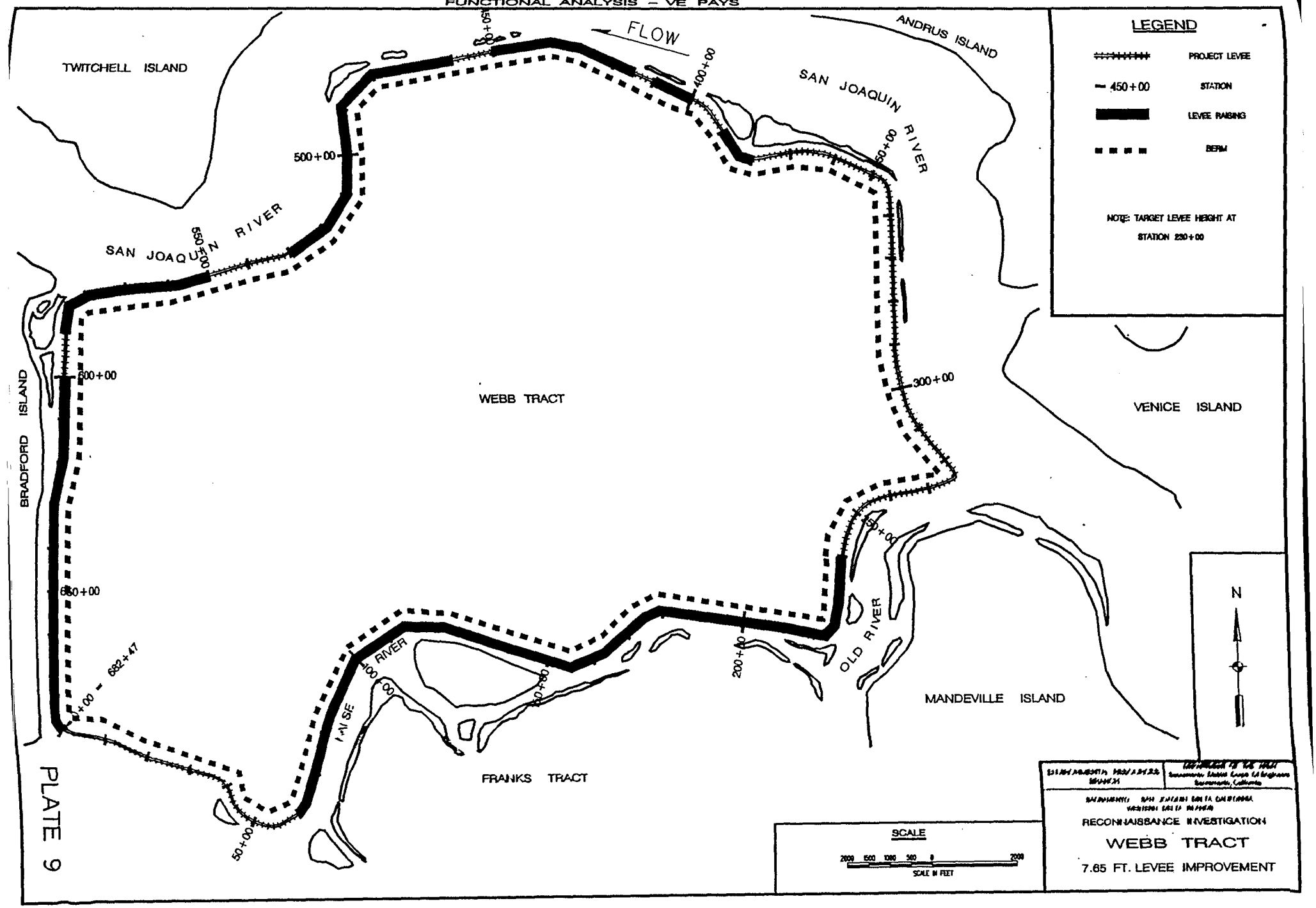
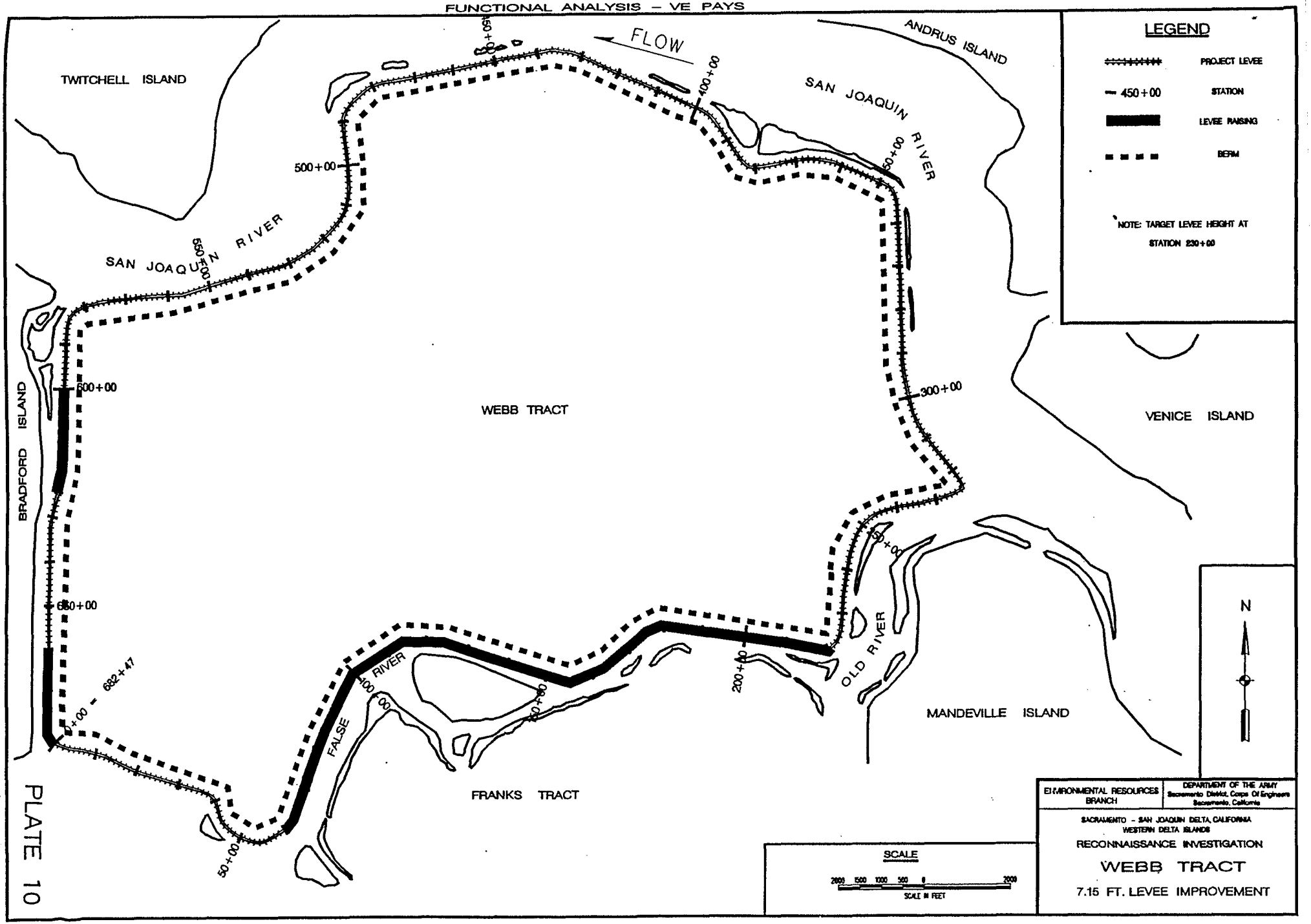


PLATE 9

C-098679

C-098679



ENVIRONMENTAL RESOURCES BRANCH

DEPARTMENT OF THE ARMY
Sacramento District, Corps Of Engineers
Sacramento, California

SACRAMENTO – SAN JOAQUIN DELTA, CALIFORNIA
WESTERN DELTA ISLANDS
RECONNAISSANCE INVESTIGATION

WEBB TRACT

7.15 FT. LEVEE IMPROVEMENT

PLATE 10

C-098680

C-098680

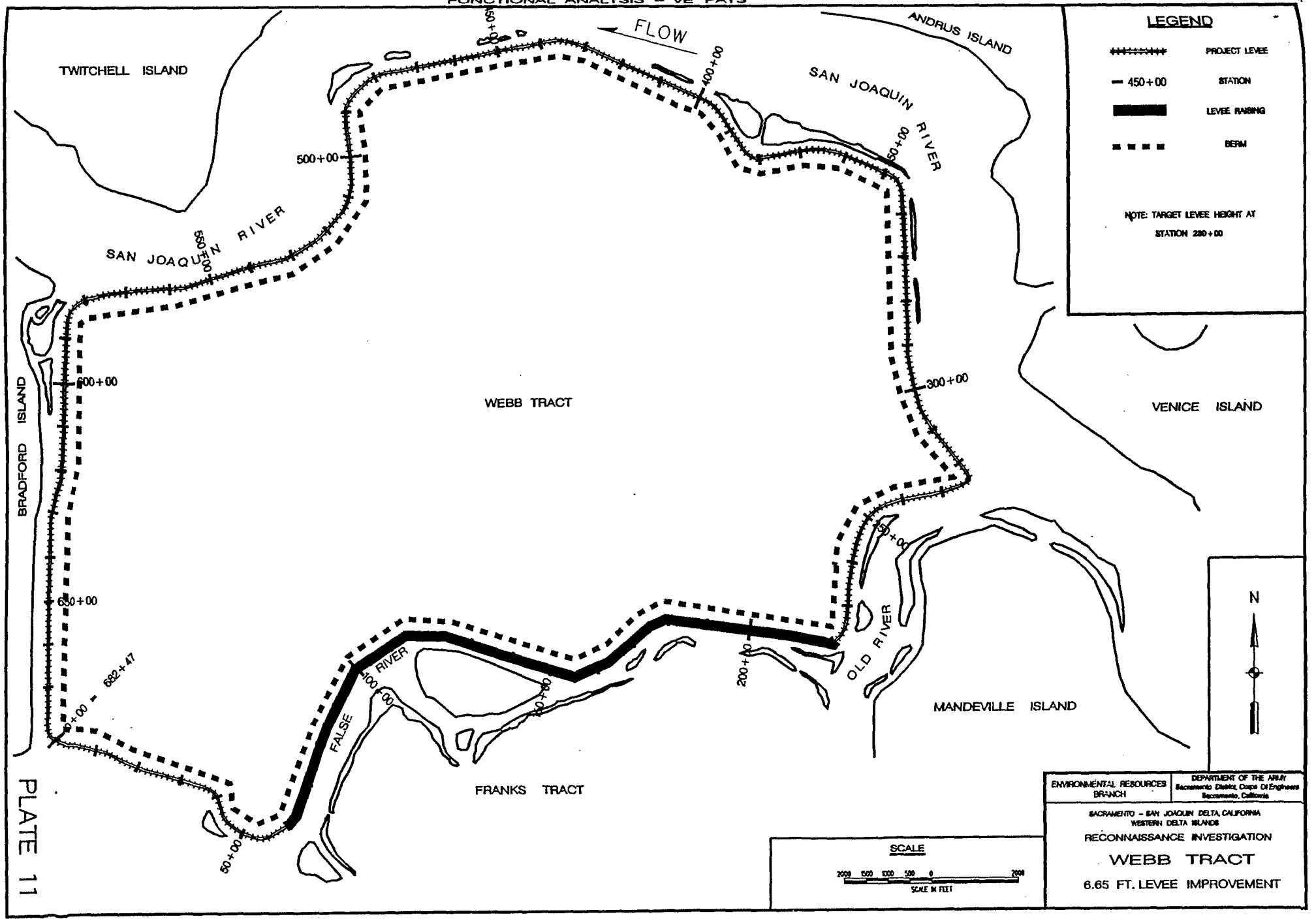
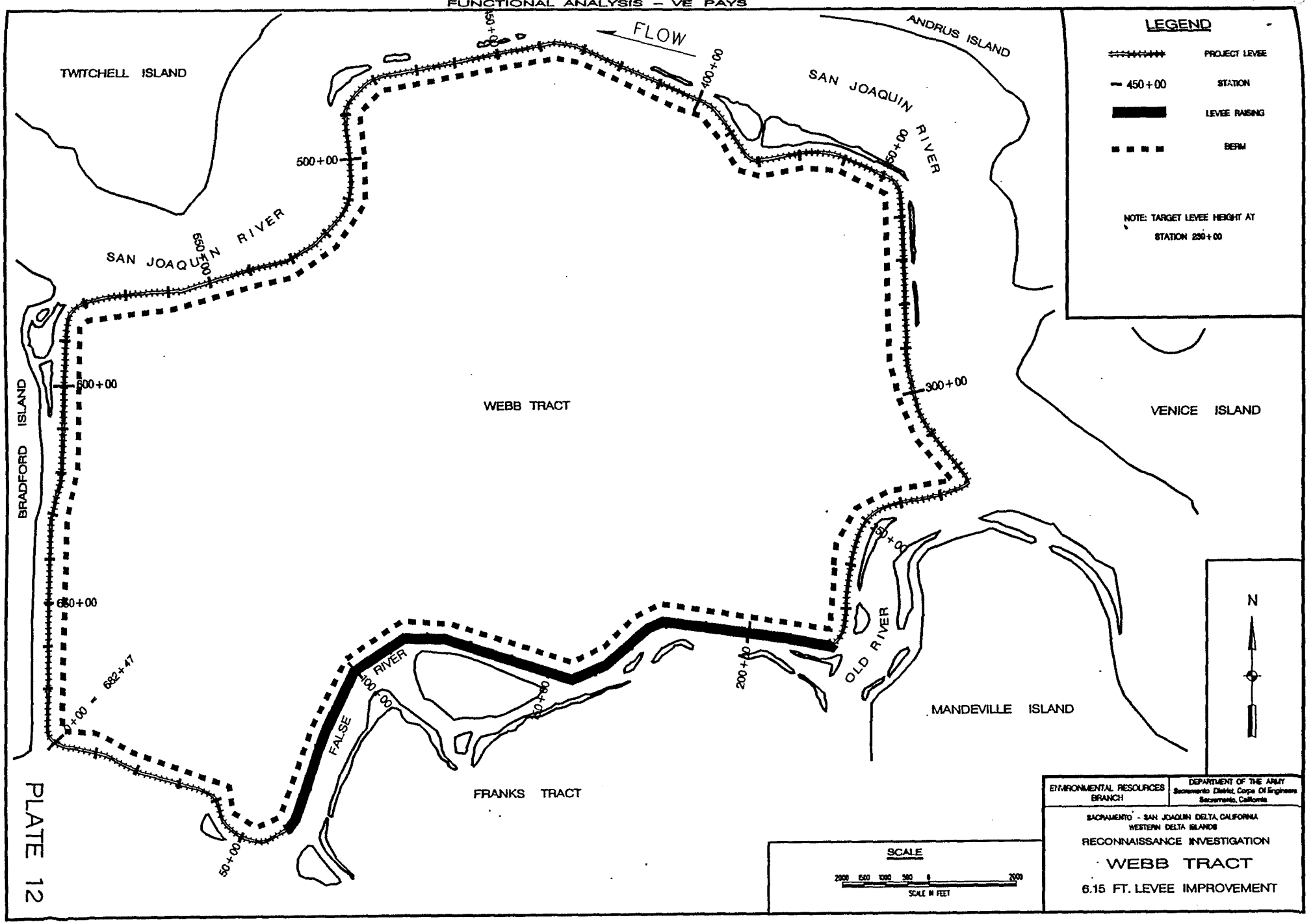


PLATE 11

C-098681

C—098681

FUNCTIONAL ANALYSIS – VE PAYS



ENVIRONMENTAL RESOURCES BRANCH

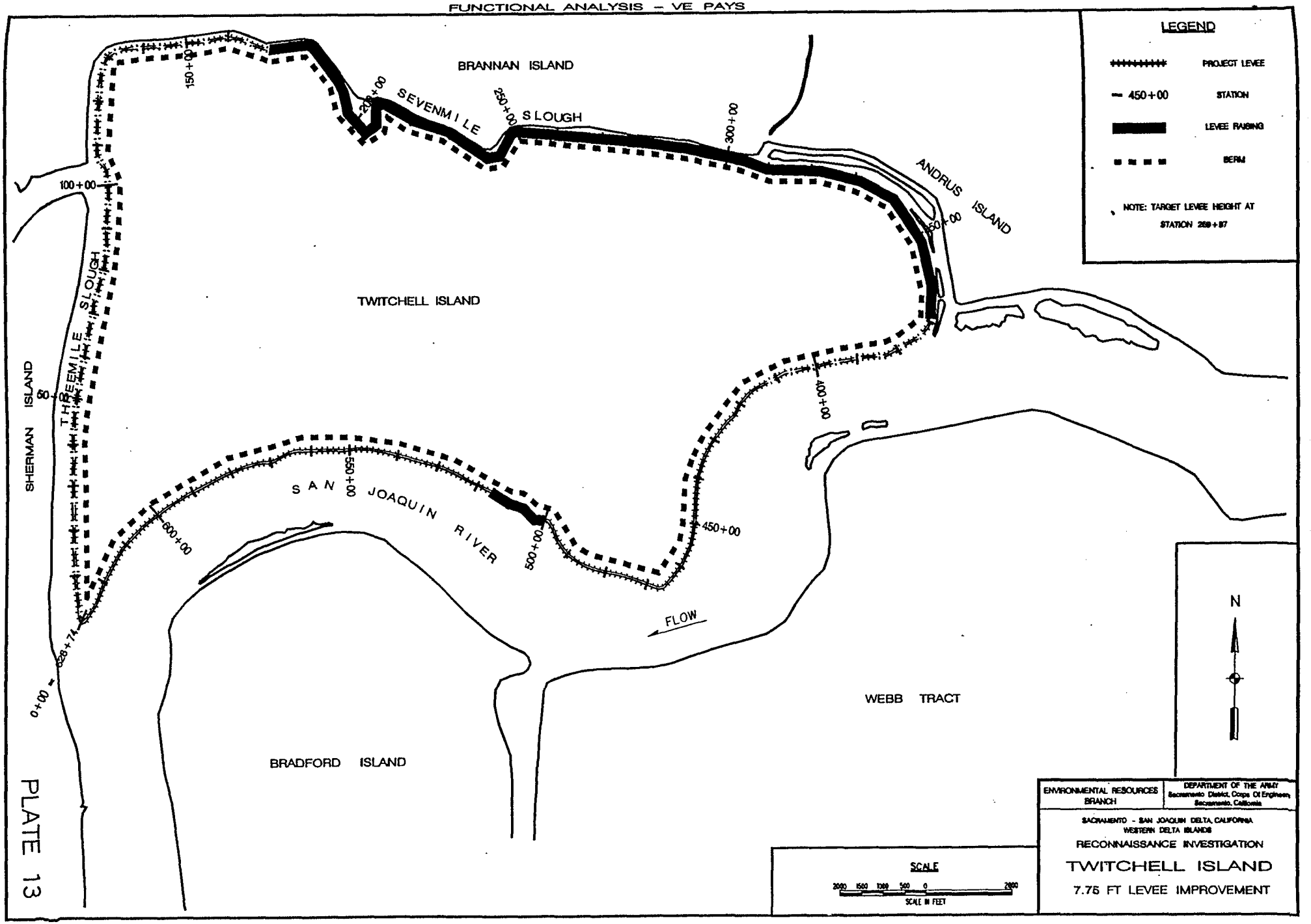
DEPARTMENT OF THE ARMY
Sacramento District, Corps Of Engineers
Sacramento, California

SACRAMENTO - SAN JOAQUIN DELTA CALIFORNIA
WESTERN DELTA ISLANDS
RECONNAISSANCE INVESTIGATION
WEBB TRACT
6.15 FT. LEVEE IMPROVEMENT

PLATE 12

C-098682

C-098682



ENVIRONMENTAL RESOURCES BRANCH

DEPARTMENT OF THE ARMY
Sacramento District, Corps Of Engineers
Sacramento, California

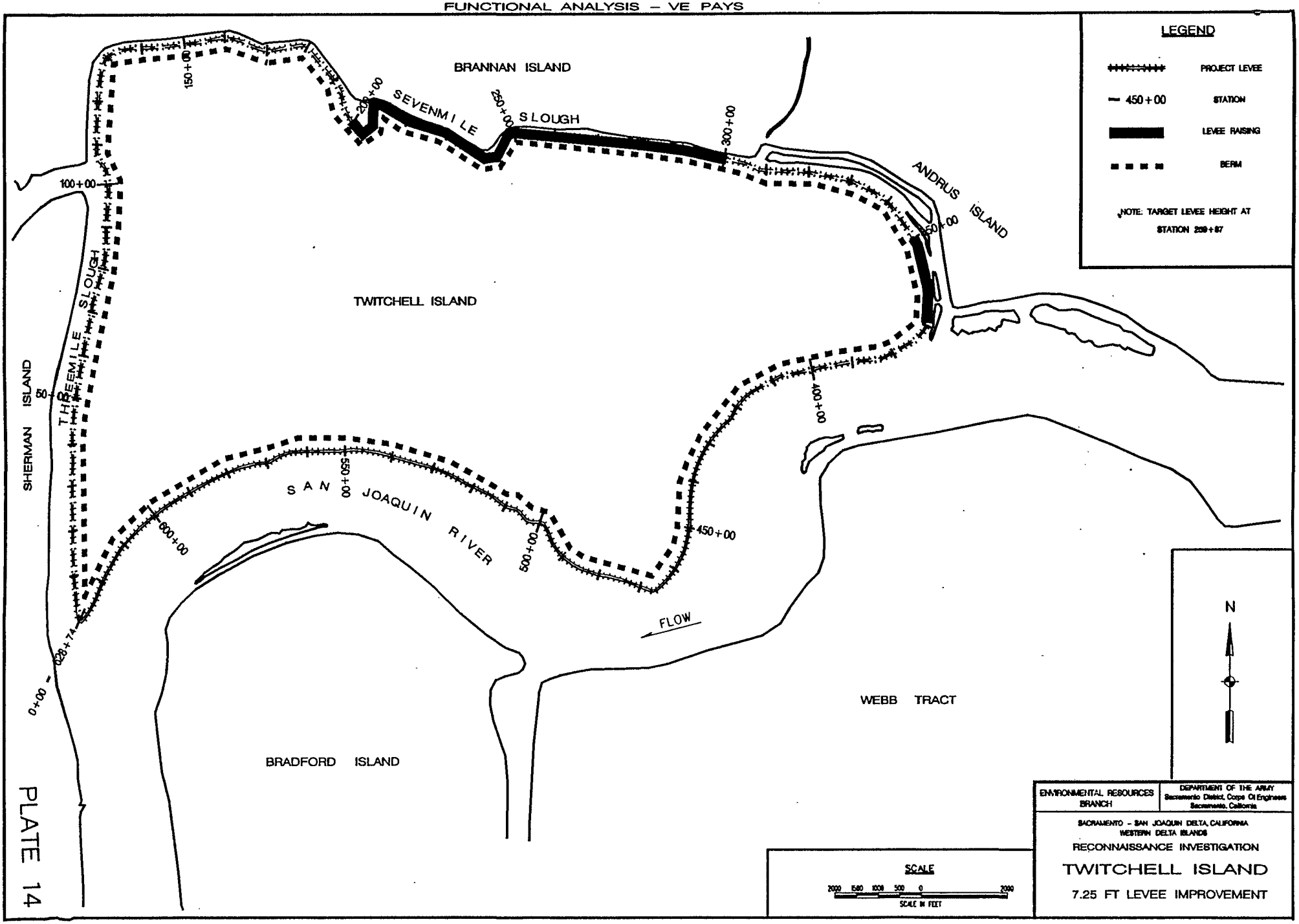
SACRAMENTO - SAN JOAQUIN DELTA, CALIFORNIA
WESTERN DELTA ISLANDS
RECONNAISSANCE INVESTIGATION

TWITCHELL ISLAND
7.75 FT LEVEE IMPROVEMENT

PLATE 13

C-098683

C—098683



ENVIRONMENTAL RESOURCES BRANCH

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Sacramento District, Corps Of Engineers
Sacramento, California

SACRAMENTO – SAN JOAQUIN DELTA, CALIFORNIA
WESTERN DELTA ISLANDS

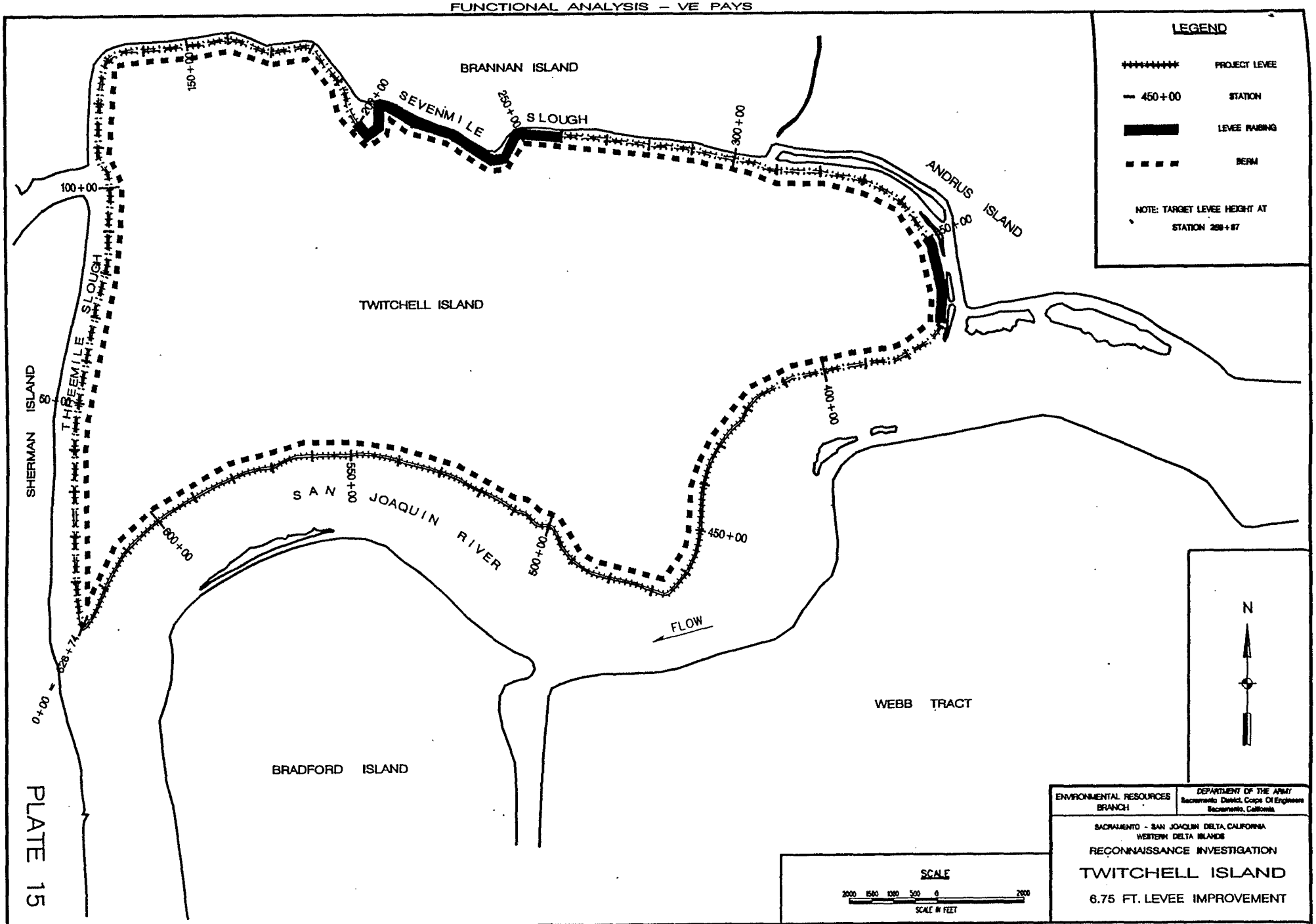
RECONNAISSANCE INVESTIGATION

TWITCHELL ISLAND

7.25 FT LEVEE IMPROVEMENT

PLATE 14

C—098684



ENVIRONMENTAL RESOURCES BRANCH

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Sacramento District, Corps Of Engineers
Sacramento, California

SACRAMENTO - SAN JOAQUIN DELTA, CALIFORNIA
WESTERN DELTA ISLANDS

RECONNAISSANCE INVESTIGATION

TWITCHELL ISLAND

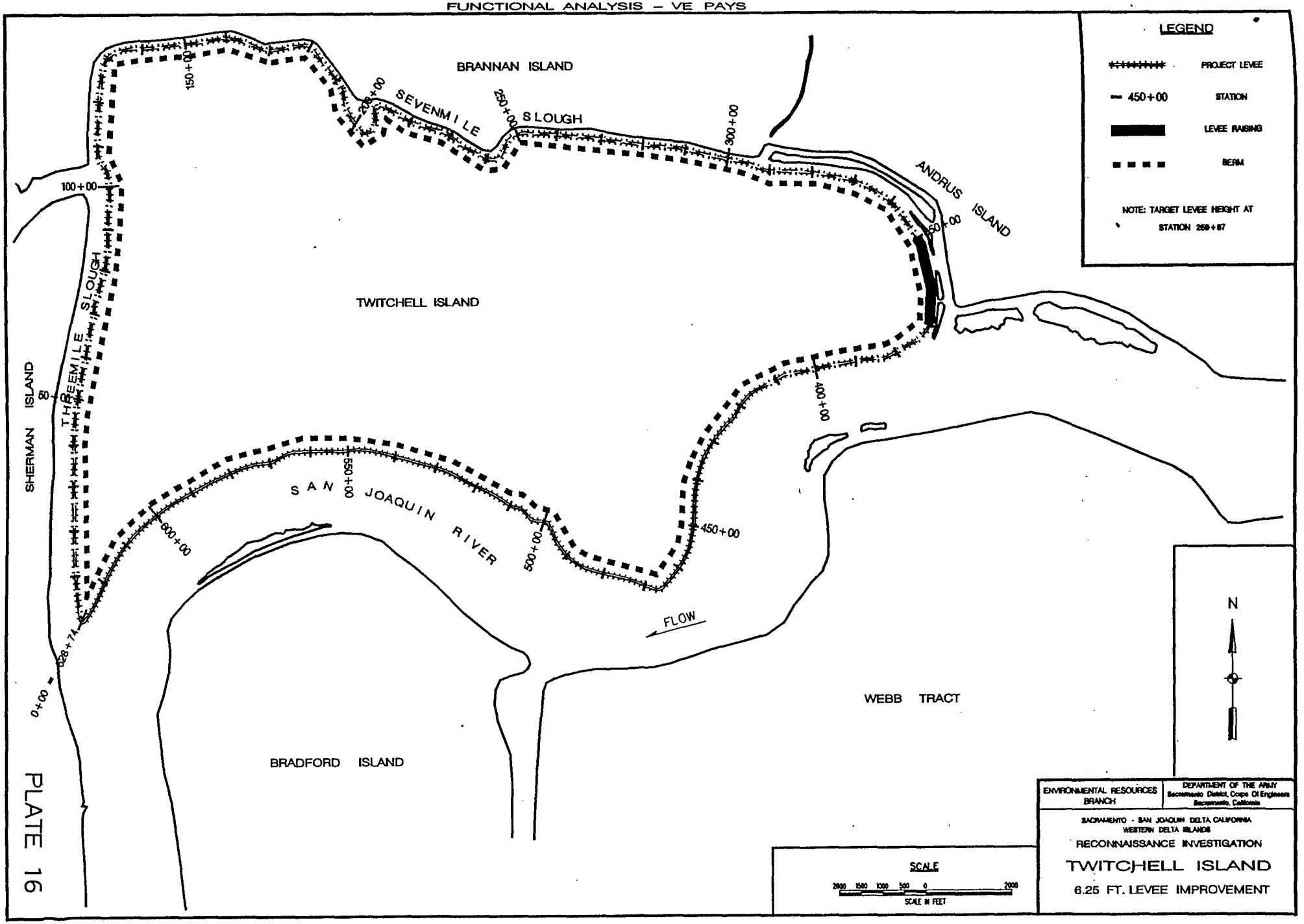
6.75 FT. LEVEE IMPROVEMENT

PLATE 15

C-098685

C-098685

FUNCTIONAL ANALYSIS – VE PAYS



ENVIRONMENTAL RESOURCES BRANCH

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Sacramento District, Corps Of Engineers
Sacramento, California

SACRAMENTO - SAN JOAQUIN DELTA CALIFORNIA
WESTERN DELTA ISLANDS
RECONNAISSANCE INVESTIGATION

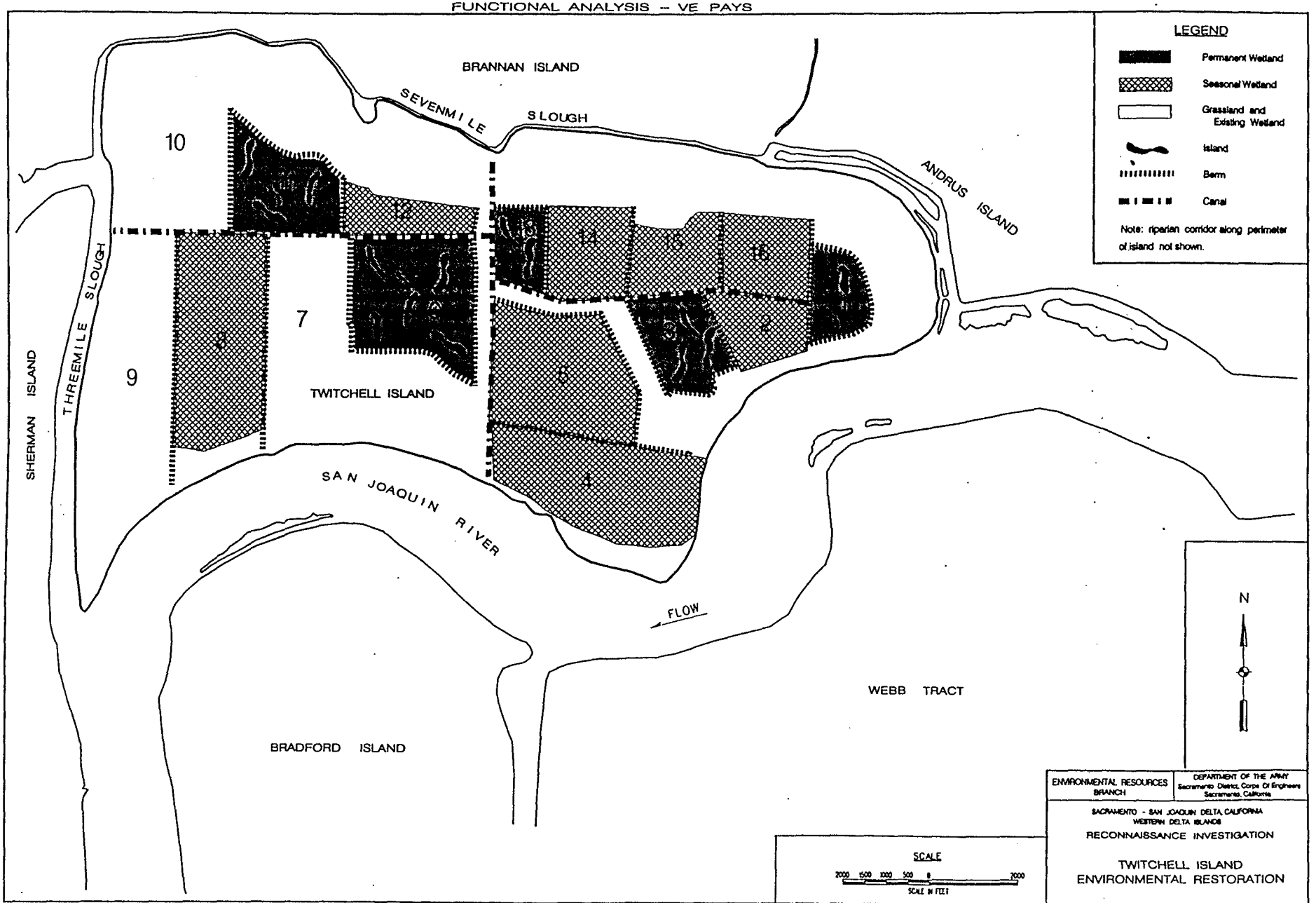
TWITCHELL ISLAND
6.25 FT. LEVEE IMPROVEMENT

PLATE 16

C-098686

C-098686

FUNCTIONAL ANALYSIS – VE PAYS



SAFETY PAYS

PLATE 17