

State of California

FLOOD HAZARD MITIGATION PLAN

FOR THE SACRAMENTO-SAN JOAQUIN DELTA

Covering portions of Contra Costa, Sacramento,
San Joaquin, Solano, and Yolo Counties

Disaster Declarations

FEMA-633-DR, FEMA-651-DR, FEMA-669-DR,
FEMA-677-DR

Prepared by
Department of Water Resources
for
Office of Emergency Services

September 15, 1983

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State of California
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PART I. SUMMARY AND RECOMMENDATIONS

A summary of the State Hazard Mitigation Plan for the Sacramento-San Joaquin Delta is as follows:

A. Short-Term Mitigation Plan

1. By February 1, 1984, the State will give the U. S. Army Corps of Engineers a Letter of Intent to sponsor a federal-state flood control project.
2. The Department of Water Resources will request an increase in funding for the Delta Levee Maintenance Subventions Program from Tidelands Oil revenue beginning in 1984-85 and continuing until a major federal levee rehabilitation project can be implemented.
3. The Department of Water Resources, in cooperation with local districts, will use appropriate construction and maintenance standards for nonproject levees to upgrade these levees to the standards described in the "Short-Term Rehabilitation Plan".
4. The local districts will implement a levee inspection program and file a report by June 1 of each year with the Director of the Department of Water Resources for 1983-84 and 1984-85. The Department of Water Resources will develop a state levee inspection program and request funding for the program beginning in 1984-85.
5. The local districts should complete their annual levee maintenance by November 1.
6. The Department of Water Resources will develop a program to reevaluate land subsidence rates in the Delta and request funding to begin the study in the 1984-85 fiscal year.
7. The local districts should develop and file with the Office of Emergency Services (copy to the Department of Water Resources) an emergency response and evacuation plan by June 1, 1984.
8. The State of California should continue to request emergency declarations for federal assistance for serious levee failures and severe storm damage that occur prior to implementation of a federal-state-local flood control project.

B. Long-Term Mitigation Plan

The State intends to develop a comprehensive federal-state-local flood control project that would consider all islands in the Delta and to seek legislation to finance the nonfederal share.

PART II. INTRODUCTION

A. Background

On February 9, 1983, President Reagan determined that damage resulting from severe storms, flooding, high tides, and wave action in certain areas of California warranted a major disaster declaration under provisions of the Federal Disaster Relief Act of 1974 (Public Law 93-288). This declaration included damage resulting from storms and flooding that took place from November 27, 1982, through March 30, 1983. In a letter dated February 16, 1983, the Federal Emergency Management Agency (FEMA) outlined the terms of the FEMA-State Disaster Assistance Agreement for the major disaster designated FEMA-677-DR. This agreement was executed by the FEMA Regional Director and the Governor. By letter dated March 17, 1983, Amendment No. 1 was added to the agreement to include that portion of the Sacramento-San Joaquin Delta (see Figure 1) located within the counties of Contra Costa, Sacramento, and San Joaquin.

B. Requirement for a Plan

Section 406 of Public Law 93-288 requires, as a condition to receiving federal disaster aid, that repairs be done in accordance with applicable codes, specifications, and standards. It also requires the state or local government recipient of federal aid to evaluate the natural hazards of the area in which the aid is to be used and, if appropriate, take mitigating action.

C. Interagency Flood Hazard Mitigation Report

A Federal Interagency Flood Hazard Mitigation Report is prepared by the (federal) Region IX Interagency Flood Hazard Mitigation Team within 15 to 30 days following each presidentially declared major flood disaster. A report covering the recent major disaster, FEMA-677-DR, was dated March 11, 1983. Supplement No. 1 to this report, dated March 24, 1983, made specific recommendations and provided a framework for a State Flood Hazard Mitigation Plan for the Sacramento-San Joaquin Delta.

D. Objective of This Plan

The objectives of this plan are to:

1. Follow up, in detail, recommendations of the Interagency Flood Hazard Mitigation Report.

2. Recommend hazard mitigation alternatives for local, state, and federal agencies.
3. Establish immediate and long-term planning frameworks for implementation of hazard mitigation efforts.

E. Purpose of This Plan

The purpose of this plan is to implement the requirements of Section 406 and the requirements of Amendment No. 1 to the FEMA-State Agreement. Amendment No. 1, Paragraph 10(b), states in part:

"The State ... will prepare and submit, not later than August 1, 1983, to the Regional Director for concurrence, a comprehensive hazard mitigation plan for the entire Sacramento-San Joaquin Delta area. This plan shall address state, local, private and federal activities and interests as they currently exist, are currently being developed, or are planned. This plan shall also identify major hazard mitigation measures to be taken for each district (applicant), by whom, sources of funding, and schedules for accomplishment. Such measures shall include: (1) establishment of applicable codes, specifications and standards for new construction, repair, and maintenance; (2) upgrading of levees and other related facilities to applicable codes, specifications, and standards; (3) periodic inspections, reports, and follow-up of all levee and related facilities; and (4) correction of maintenance deficiencies."

Amendment No. 1, Paragraph 10(b), further states:

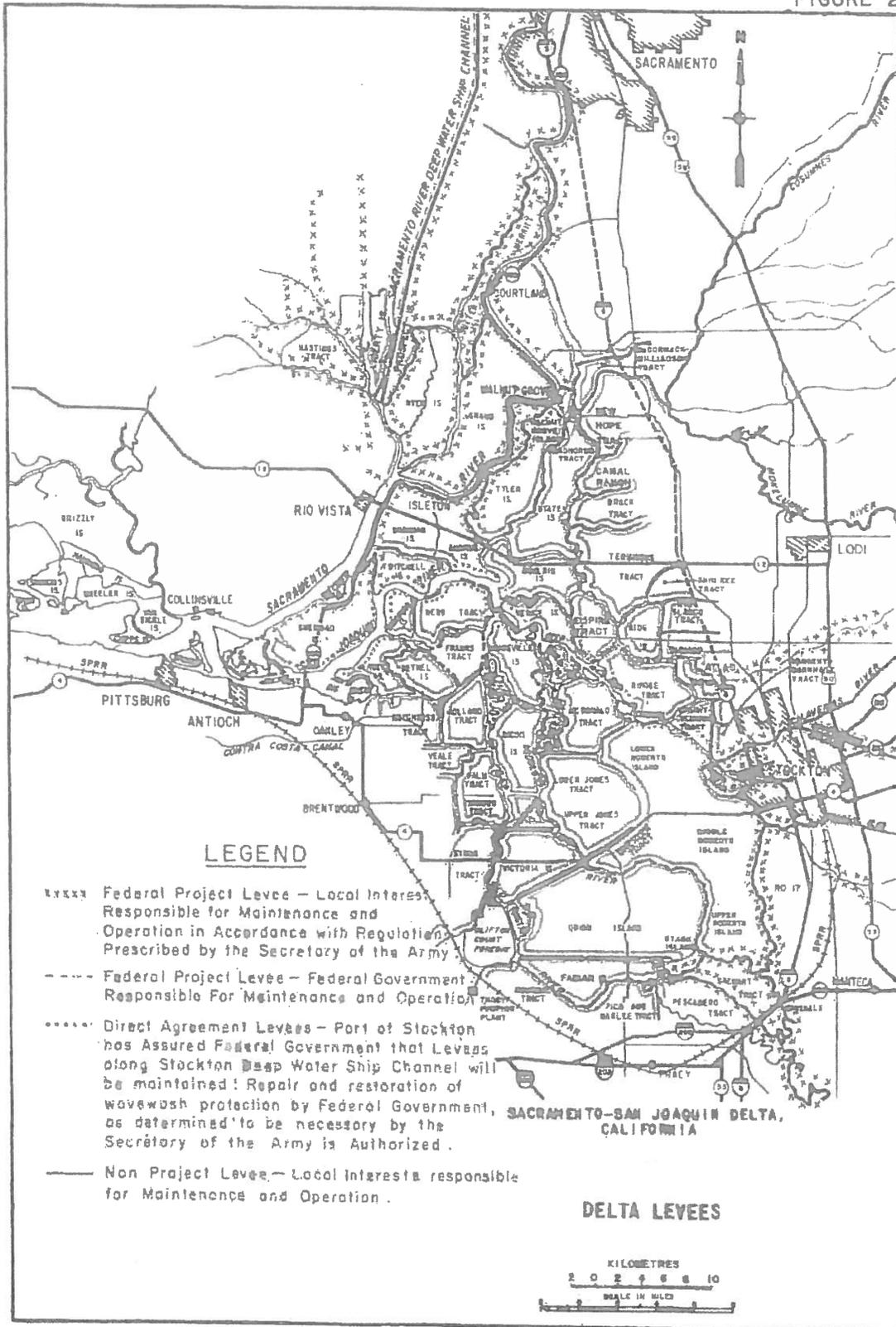
"It is understood that one plan will be submitted which will incorporate the requirements of Section 406 of the Act and which will also satisfy the requirements for major disaster declarations FEMA-633-DR, FEMA-651-DR, FEMA-669-DR, and FEMA-677-DR."

This mitigation plan fulfills these requirements for both nonproject and direct agreement levees in the Delta (see Figure 2).

F. Flood Hazard Mitigation

Flood hazard mitigation is a management strategy in which current actions and expenditures to reduce the occurrence or severity of potential flood disasters are balanced with potential losses from future floods. Flood hazard mitigation can reduce the severity of the effects of flood emergencies on people and property by reducing the cause or occurrence of the hazard, reducing exposure to the hazard, or reducing the effects through preparedness, response, and recovery measures.

FIGURE 2



Flood hazard mitigation includes such actions as:

- ° Minimizing probability of flood occurrence (e.g., restoration of damaged dams and levees, dam safety measures).
- ° Improving structures and facilities at risk (e.g., flood-proofing, restoring damaged public facilities to meet applicable codes and specifications).
- ° Identifying hazard-prone areas and standards for prohibited or restricted use (e.g., flood plain regulations, structural and nonstructural floodproofing, hazard mitigation plans).
- ° Providing loss recovery and relief (e.g., insurance, disaster grants and housing, low interest loans).
- ° Providing hazard warning and population protection (e.g., procedures for warning, emergency public information, direction and control, protective measures, shelter, relocation, training).
- ° Considering opportunities for sharing the cost of levee improvements in connection with water transfer plans (see Appendix A).

G. Hazards

Since 1980, levee failures have occurred on 12 of about 60 Delta islands (see Figure 3). Factors that contribute to levee failures include: instability of the levee section and foundation materials; subsidence; rodent burrows; erosion from wind waves and boat wakes; inadequate height (freeboard); seismic activity; and seepage.

Specific locations of levee instability and foundation weakness are difficult to identify because weak areas are not readily apparent from visual inspections. Beaver dens often are not apparent until a portion of the levee collapses. Erosion is more readily apparent and can be corrected if identified. Increased moisture from seepage through and under levees, which reduces the shear strength of the soils and thereby contributes to instability of the levees, may or may not be apparent. It is suspected that, in some areas, dredging soil from the channels as a source of material for bolstering levees has contributed to increased instability, subsidence, and seepage.

Flooding of islands can have several adverse impacts, including temporary detriments to water quality due to ocean water intrusion, increased loss of water by evaporation, increased seepage on islands adjacent to the flooded areas, loss of agricultural land, damage to urban and recreational developments, and fish and wildlife losses.

PART III. GOVERNMENTAL AND REGULATORY STRUCTURES

A. General

The existing governmental structure could provide necessary assurances to implement a Delta levees mitigation plan, both on a short-term and long-term basis. However, development of a Delta-wide reclamation district with authority to collect revenues, set maintenance standards, provide assurances, set priorities, and carry out maintenance would facilitate completion of a comprehensive Delta levees rehabilitation plan.

B. Local Districts

Essentially all of the islands and tracts in the Delta have an organized district to administer levee maintenance and restoration. Reclamation and levee districts currently have authority to raise funds from three major sources:

1. The districts are empowered under specific Water Code sections to create and update assessment rolls of the lands within their boundaries on which the governing boards can periodically levy assessments.
2. Water Code sections also allow the governing boards of reclamation districts to establish a schedule of charges and fees for services and benefits provided by the districts.
3. Those districts that use county assessment rolls to levy special taxes for levee maintenance continue to receive an allocation under the post-Proposition 13 tax collection by the county, which includes not only property revenues but also state subventions.

Until 1980, funds made available for levee maintenance and restoration from these sources had been relatively small -- less than \$1 million per year. Because of the many levee failures since 1980, the local districts have been assessed up to their capability to pay. In fact, because many districts are in debt for money borrowed to repair and restore their levees, their funding capabilities may not be sufficient to accomplish the flood hazard mitigation obligations requested by FEMA.

C. Counties and Cities

The Delta area includes land in five counties: Contra Costa, Sacramento, San Joaquin, Solano and Yolo. These counties are members of a Delta Advisory Planning Council (DAPC); the

objective is to provide a unified county position with regard to Delta matters. All five counties are participating in the National Flood Insurance Program.

Counties have the necessary authority to control land use. This authority has been exercised to control urban development in the Delta. Under this plan, counties would continue to exercise land use control as part of their general plan.

A number of cities are located on the periphery of the Delta, including Sacramento, Tracy, Rio Vista, Pittsburg, and Antioch. Their involvement with the nonproject levees in the Delta is minimal. Isleton and the western portion of Stockton are within the Delta and are protected by nonproject levees. The cities, like the counties, have authority to control land use, and all are participating in the National Flood Insurance Program.

D. State of California

Many state agencies have regulatory powers covering the Delta area. The two principal agencies involved in flood control activities are The Reclamation Board and the Department of Water Resources. Other state agencies with vested interests in the Delta include, but are not limited to: Department of Boating and Waterways; Department of Fish and Game; Department of Parks and Recreation; State Lands Commission; and the State Water Resources Control Board, including the Central Valley and San Francisco Bay Regional Water Quality Control Boards.

The Office of Emergency Services administers funds made available under the Natural Disaster Assistance Act, which have been used for flood damage repair in the Delta.

E. Federal Government

Many federal agencies are involved and have some regulatory powers concerning the 700 miles of navigable waterways in the Delta. The principal federal interests in the Delta are with the following agencies: U. S. Army Corps of Engineers; U. S. Bureau of Reclamation; U. S. Department of Commerce, including the National Marine Fisheries Service, U. S. Fish and Wildlife Service, and the U. S. Coast Guard.

The Federal Emergency Management Agency (FEMA) administers disaster relief funds, made available under Public Law 93-288, which have been used for repair of flood damage in the Delta.

PART IV. SHORT-TERM MITIGATION PLAN

A. Policy

Water Code Section 12981 declares State policy to preserve the Delta in essentially its current configuration. Many bills (summarized in Appendix B) have been introduced during the current legislative session to reaffirm or modify this policy. Action on these bills will give legislative direction concerning activities in the Delta.

Rehabilitation of levees around individual islands is still the approach desired by most Delta interests. When practical, this course of action should be pursued.

A two-prong program is needed to reduce levee failures: rehabilitation of levees by adding materials; and improved maintenance of existing levees.

B. Maintenance

1. Responsibilities

The local districts are responsible for the expense and the work involved in correcting maintenance deficiencies. Each district should:

- a. Prepare a plan of annual levee maintenance by June 1 of each year describing planned maintenance work and a schedule for its accomplishment.
- b. Make a profile of the levee crown not less than every fifth year, or more often if determined necessary by the Board of Trustees of the district (i.e. following severe storms).
- c. Adopt an emergency response and evacuation plan to be put into effect when flooding is imminent.
- d. Complete annual levee maintenance by November 1 of each year.

2. Mitigation Actions

In general, district maintenance includes, but is not limited to:

- a. Controlling encroachments on the levee that might endanger the levee or hinder levee construction and maintenance.

- b. Exterminating burrowing rodents and filling their burrows with compacted material.
- c. Shaping the levee crown for proper drainage.
- d. Repairing minor slipouts, erosion, and subsidence of the levee section.
- e. Cleaning drain and toe ditches adjacent to the landside levee toe that intercept seepage.
- f. Minor repairing of revetment work or riprap that has been displaced, washed out, or removed.
- g. Repairing and shaping patrol and access roads.
- h. Controlling the weight and speed of vehicles using roads on levee crowns so as to not exceed the strength of the structural section.
- i. Cutting, removing or trimming vegetation such as weeds, brush, and trees to the extent necessary to maintain a safe levee.
- j. Removing debris and litter from the levee and berm where it interferes with levee maintenance.
- k. Inventorying and inspecting pipes and conduits through the levee (and gates on such facilities) to ensure that they are in working condition.
- l. Repairing and maintaining gates necessary to control vehicular traffic on the levees.

C. Rehabilitation

1. Policy

Short-term responsibility for levee rehabilitation remains with the local districts. The cost, however, will be shared by the state and federal agencies and possibly by other beneficiaries of the Delta. Until increased funding is available, the local districts will continue to use funds from their own revenues, the Delta Levee Maintenance Subventions Program, and federal and state disaster assistance programs to rehabilitate the Delta levees.

Dredging material for levee repair or restoration will not be permitted within 135 feet of the centerline of any levee below a depth of minus 35 feet mean sea level. (Ship channels will be considered separately.)

Materials used to repair or restore the levees must allow enough consolidation to minimize erosion during wave and tidal action and rain runoff. Districts will take and record soundings before dredging to be sure depths are adequate for the materials required.

2. Short-Term Levee Rehabilitation Plan

a. Local Districts

Local districts should:

- (1) Rehabilitate levees as rapidly as possible, considering engineering, fiscal, and environmental restraints, to the following minimum standards:
 - (a) Levees shall have 1 foot of freeboard above the flood expected once in 100 years. (It is important to recognize that 1 foot of freeboard at a 100-year flood does not mean 100-year flood protection. Common levee design practice calls for 3 feet of freeboard at project design flood. Also, the uncertainties of Delta levee foundations and unpredictability of Delta tide levels suggest that even with 3 feet of freeboard, the degree of protection would be far less than the design flood frequency.)
 - (b) The minimum crown width shall be at least 16 feet.
 - (c) Waterside slopes shall be at least 1.5 horizontal to 1 vertical, with revetment in areas where erosion has been a problem. The size of the revetment material shall be appropriate for the slope.
 - (d) Landside slopes shall be at least 2 horizontal to 1 vertical, with flatter slopes in the lower portion of the levee in areas where soil stability and seepage have been problems.
 - (e) The levees shall have all-weather access roads.
- (2) Prepare a plan for annual rehabilitation work by June 1 of each year describing rehabilitation work and a schedule for its accomplishment.

b. State of California

- (1) By February 1, 1984, the State will give the U. S. Army Corps of Engineers a Letter of Intent to sponsor a federal-state flood control project.
- (2) The Department of Water Resources will recommend to the State Legislature increased funding of the Delta Levee Maintenance Subventions Program to \$10 million per year from Tidelands Oil revenues, to begin in the 1984-85 fiscal year and continue until a federal-state flood control project is implemented. The Department will also recommend to the State Legislature that the cost sharing formula be changed so that the State would pay 75 percent and the local districts 25 percent of the cost of levee rehabilitation work done under the program.
- (3) The Department of Water Resources will request funding for an annual Delta levee inspection program to begin in the 1984-85 fiscal year. Until funds are made available for a state inspection program, the local district's engineer should make a joint inspection with district representatives and submit a summary of work to be completed for the year, present condition of the levees, mitigation measures to be performed the following year, and a reevaluation of natural hazards affecting the district. This summary report should be submitted to the Director of the Department of Water Resources by June 1 of each year.
- (4) By April 1984, the Department of Water Resources, working with representatives of local districts, will develop criteria for using soils from the channels as a source of material for bolstering levees. These criteria will reduce the hazard to levees due to this practice.
- (5) The Department of Water Resources will request funds in the 1984-85 fiscal year to initiate a program to reevaluate the rate of subsidence in the Delta.

PART V. LONG-TERM MITIGATION PLAN

A. Policy

The long-term mitigation plan is to implement a major levee rehabilitation project within 20 years. The State supports the concept of a System Plan as described in the Corps' Draft Feasibility Report, dated October 1982, and in the Department's Bulletin 192-82, Delta Levees Investigation, dated December 1982, with the understanding that the local districts may complete construction necessary to comply with federal flood control standards on some islands before a federal flood control project is implemented. All islands should be included in the System Plan for stage construction, as recommended in the Corps' plan.

B. Long-Term Levee Rehabilitation Plan

Based on current information, the following islands and tracts are considered to have the most urgent need of levee rehabilitation:

Andrus-Brannan	Hotchkiss	Rindge
Bacon	Jersey	Roberts, Lower
Bethel	Jones, Lower/Upper	Sherman
Bouldin	King	Staten
Brack	Mandeville	Terminous
Bradford	McDonald	Twitchell
Canal Ranch	Medford	Tyler
Dead Horse	Mildred	Venice
Empire	New Hope	Webb
Holland	Palm	Woodward

This list will probably change during the advanced planning stages of the project. (These tracts are shown in Figure 4.)

A joint state-federal levee rehabilitation project requires state legislative and congressional authorizations, funding for detailed planning, and funding for construction. Completion of these actions is expected to take from six to ten years. It is assumed that the funding would be at least 65 percent federal and that the nonfederal funding requirements would be shared 50 percent state and 50 percent local.

In some instances, individual districts have an insufficient economic base to provide even 15 to 20 percent of the cost of modernizing and protecting the island system. In these situations, consideration will be given to a greater State share of such costs, to be reimbursed from subsequent sale or transfer of property rights or value to the State. As an example, public acquisition of land for use in a wildlife management or

recreational program or acquisition of a flooded area for use as a reservoir as part of the State Water Project and Central Valley Project.

Cost sharing and funding must be resolved by the Congress and the State Legislature. The local share would be assigned to the individual districts in proportion to the cost to provide flood control to the island represented by the particular district.

PART VI. FUNDING SOURCES

A. General

All plans to preserve the Delta will require large increases in funding for levee rehabilitation.

B. Short-Term Levee Rehabilitation Plan

1. Local Districts

For the 1983-84 fiscal year, the local districts will continue to use their own revenues, supplemented by State contributions under the Delta Levee Maintenance Subventions Program (presently budgeted at \$1.5 million per year), and funds made available under the federal and state disaster assistance programs.

2. State of California

A number of legislative bills under consideration include proposals for increases in funding for the Delta Levee Maintenance Subventions Program. Pending action on these bills, the Department of Water Resources will recommend to the Legislature:

- a. An increase in funding for this program, beginning with the 1984-85 fiscal year, to a level of \$10 million per year from Tidelands Oil revenues; and
- b. A change in the formula for State participation to allow 75 percent State funds with 25 percent local matching funds to upgrade existing Delta levees.

3. Department of Water Resources

The Department of Water Resources will also request special language in a federal-state flood control project authorization that would allow credit to the State and to local districts for work done toward upgrading levees to federal standards before implementation of a federal-state-local flood control project.

C. Long-Term Levee Rehabilitation Plan

A U. S. Army Corps of Engineers report, "Draft Feasibility Report and Draft Environmental Impact Statement, Sacramento-San Joaquin Delta, California", October 1982, indicates federal interest in a Delta flood control project. Although the percentage of federal participation must be determined by the

Congress, the long-term mitigation plan for the Delta contemplates a federal-state-local sharing of costs for levee rehabilitation.

California has traditionally shared in the costs of federal flood control projects. The State is now contributing 75 percent and local flood control agencies are required to contribute 25 percent of the land, easement, and right-of-way costs of federal projects.

The federal government has traditionally paid 100 percent of the construction costs for flood control. Local agencies have been responsible for 100 percent of the cost of operating and maintaining flood control facilities. The Corps of Engineers' Draft Feasibility Report assumes the traditional federal-nonfederal cost sharing relationships.

Chapter 5 of the Emergency Delta Task Force report, dated January 12, 1983, also recommends a cost sharing plan that follows the traditional relationships, but it suggests that boating and commercial shipping should share in the nonfederal flood control costs. The report found that local districts are capable of raising from 15 to 20 percent of the necessary funds for levee rehabilitation projects. It is planned that the State and the local districts will equally share the nonfederal cost of a federal flood control project.

D. Nonfederal Funding

Without federal participation in a Delta levees flood control project, the state would be the logical level of government to implement a levee rehabilitation program. Special bond issues might be necessary to supplement the available Tidelands Oil and other State revenues to finance a long-term Delta levees rehabilitation project.

APPENDIX A

RELATIONSHIP OF DELTA LEVEES PLAN TO A WATER TRANSFER PLAN

The Delta is a point of diversion for both the Federal Central Valley Project and the State Water Project for exporting water to areas in California south and west of the Delta. The State's proposal for a Peripheral Canal to move water in an isolated channel across the Delta was rejected by the voters in June 1982. The State must now develop alternative methods for transferring water across the Delta. Some alternative Delta water transfer plans would require channel enlargements and levee setbacks in the South Fork Mokelumne River and channel enlargements near Clifton Court Forebay. To the extent that these enlargements and levee setbacks coincide with plans for levee rehabilitation, there would be an opportunity for cost sharing between the two projects.

In some areas, levee failures could be detrimental to water transfer operations. In these situations, cost sharing among various beneficiaries should be considered, up to an equitable amount of the benefits derived from the levee improvements.

APPENDIX B
LEGISLATIVE BILLS

<u>Bill and Author</u>	<u>Subject</u>
AB484 - Isenberg	Approve plan set forth in Bulletin 192-82
AB758 - Costa	Include New Hope Cross Channel in State Water Project Facilities
AB857 - Bradley	Immune State from liability in repairing Delta levees
AB1300 - Isenberg	Require exporters of water to enter into contracts with public agencies in Delta
AB1325 - Bradley	Prohibit expenditure for levee repair until cross-Delta water facilities are authorized
AB1607 - Waters	Approve Corps' System Flood Control Plan and authorize DWR to undertake work in advance of federal authorization
AB1612 - Waters	Require DWR to be project sponsor of federal flood control plan; request adoption of Modified System Plan.
AB1712 - Johnson	Require plans compatible with Emergency Delta Task Force plan; appropriate \$10 million from ERF funds to DWR for program
AB1731 - Costa	Nonsubstantive change in Central Valley Project Act
AB2112 - Isenberg	Require DWR to develop and submit to Reclamation Board recommended levee reconstruction standards and establish a yearly levee inspection program
AB2124 - Campbell	Create Delta Levee Maintenance Fund and deposit a percentage of fishing and hunting license fees, vessel registration fees, and motor vehicle fuel license taxes attributable to vessels
SB15 - Ayala	Authorize additional State Water Project facilities; create a Delta Levee Maintenance Fund; allocate \$25 million from Long Beach Oil and Dry Gas revenues to the fund
SB834 - Nielson	Convey title to swamp and overflow lands to purchaser of land including berms and borrow pits

6.5 Magnitude Earthquake 20-Island Failure Scenario



October 2018

California Department of Water Resources
FLOOD EMERGENCY RESPONSE PROGRAM

Delta Flood Emergency Management Plan

Supplement C

**Water Project Export Disruptions
for Multiple-Island Breach Scenarios
using the Delta Emergency
Response Tool**



Figure 1: Scenario 1 - 20 Island/ 50 Breach Scenario - Levee Breach Locations (JBA et al., 2005)

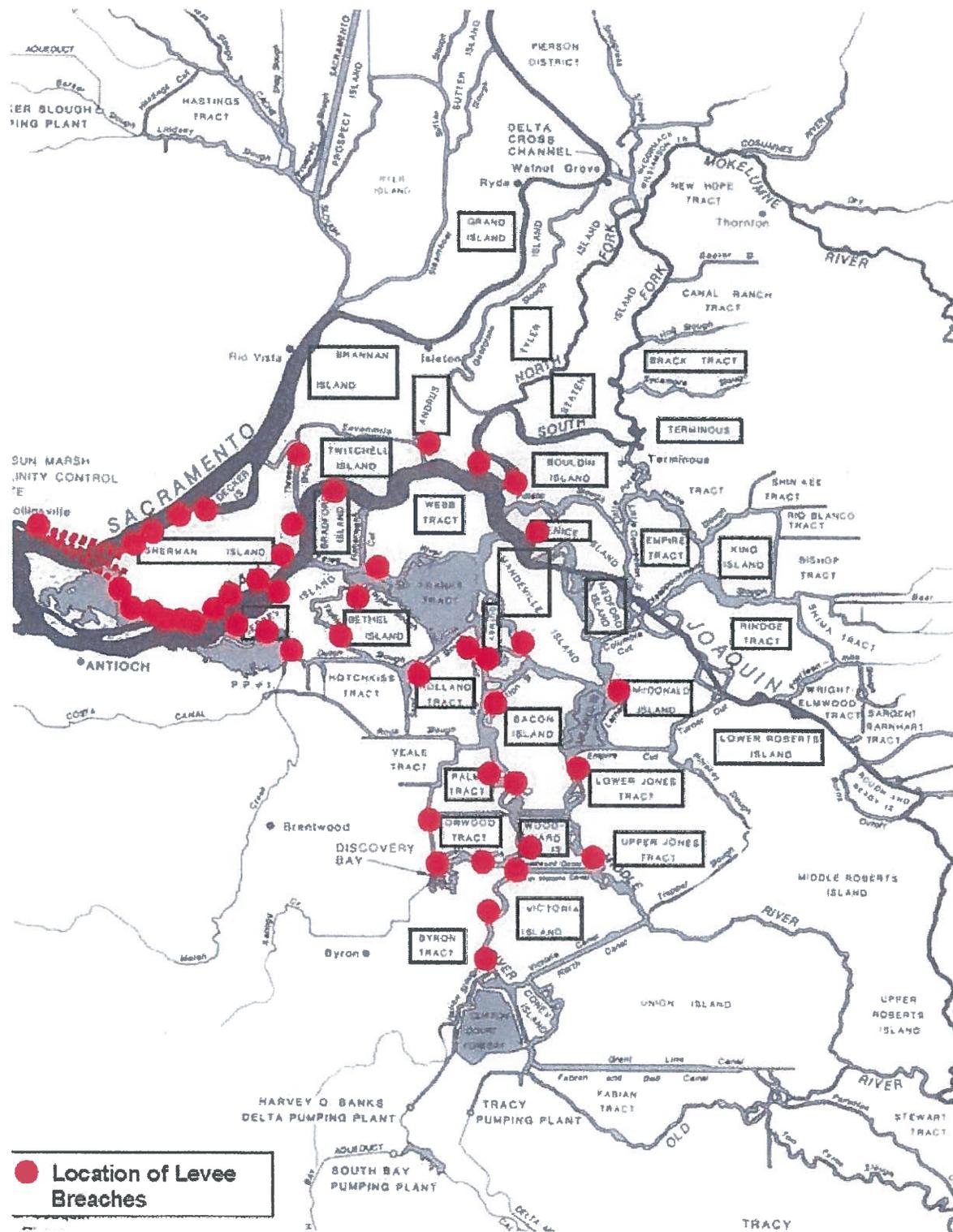


Figure 5: Island Groupings used for Scenarios 5 - 11

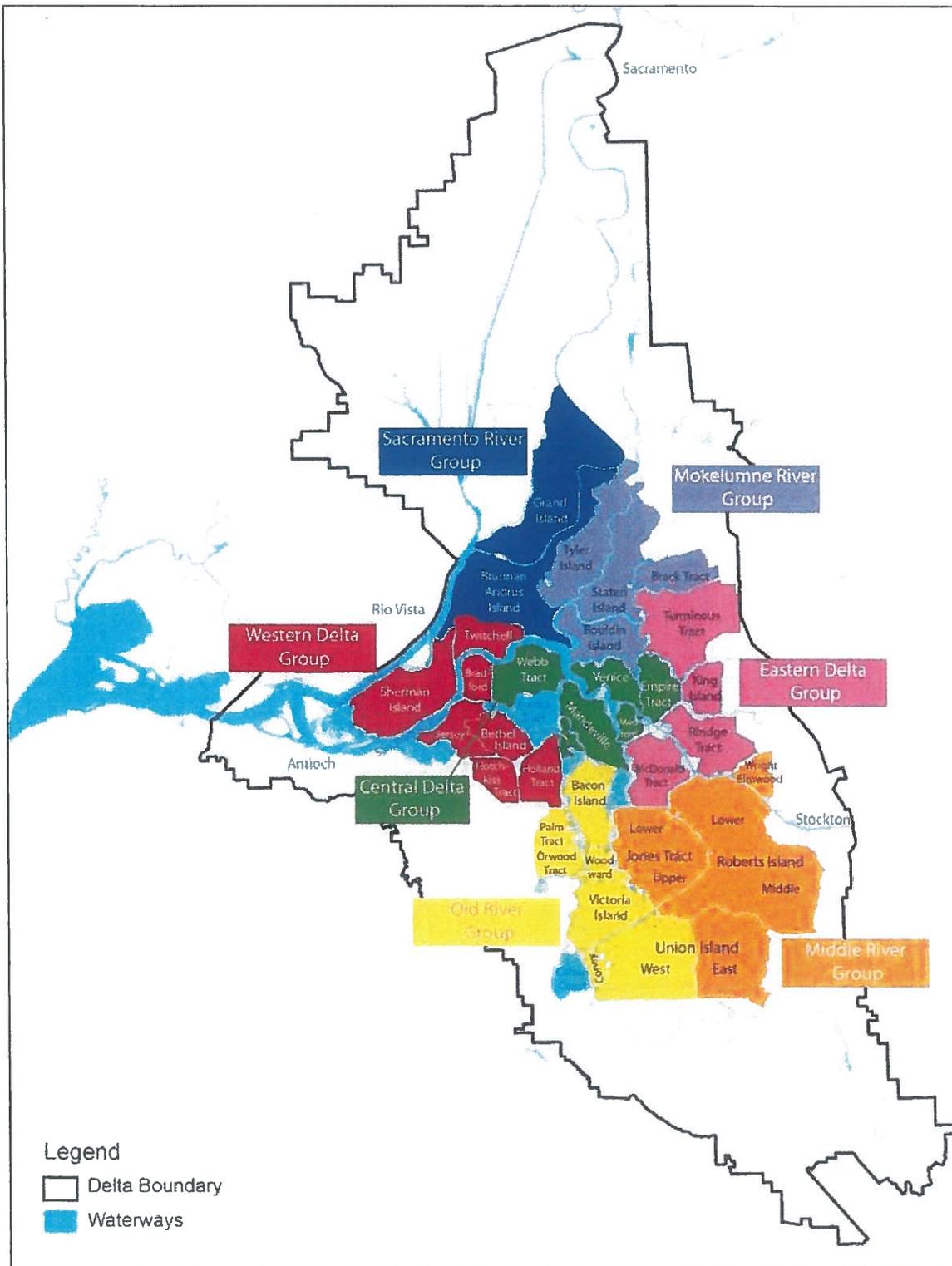
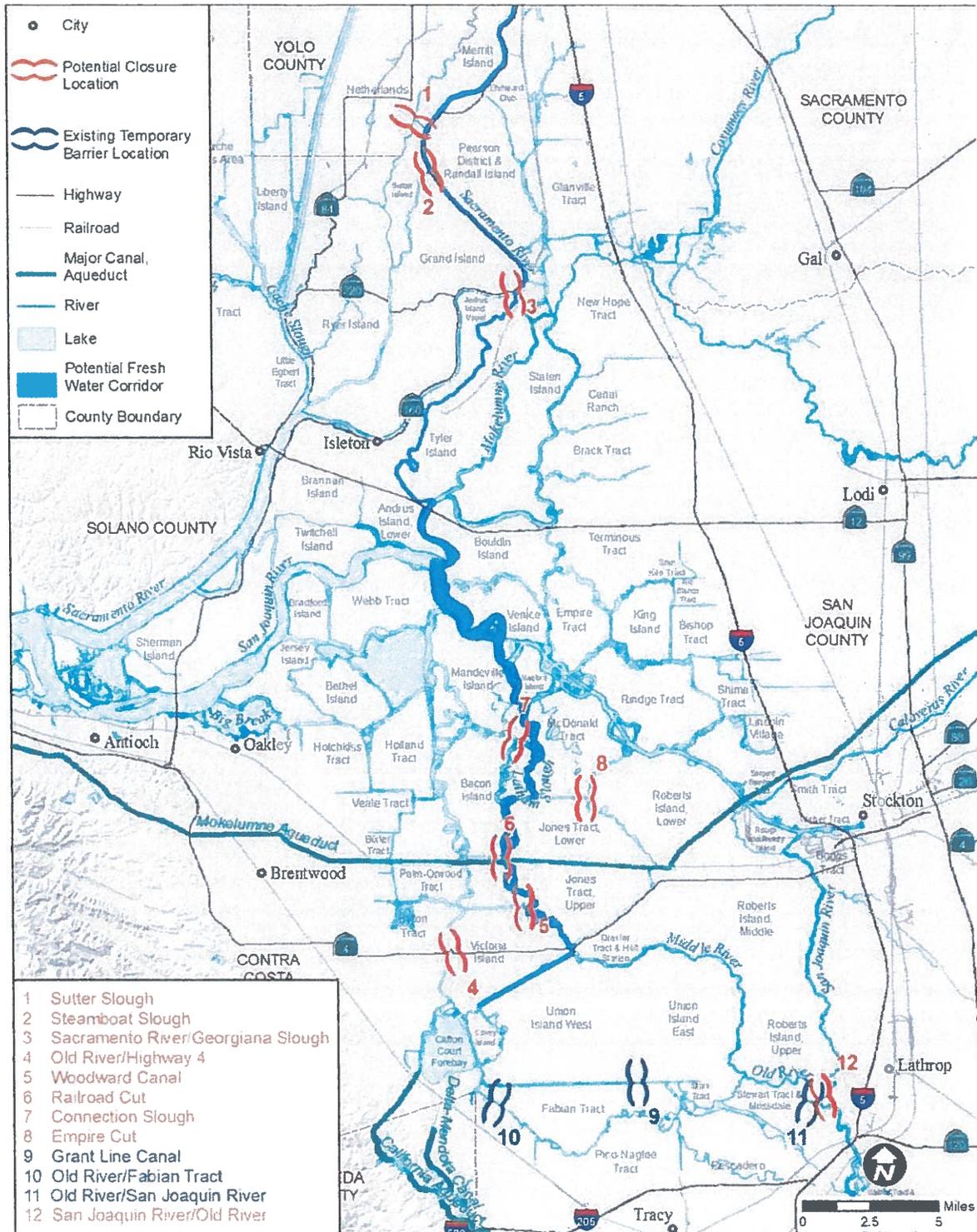


Figure 6: Channel Barrier Locations



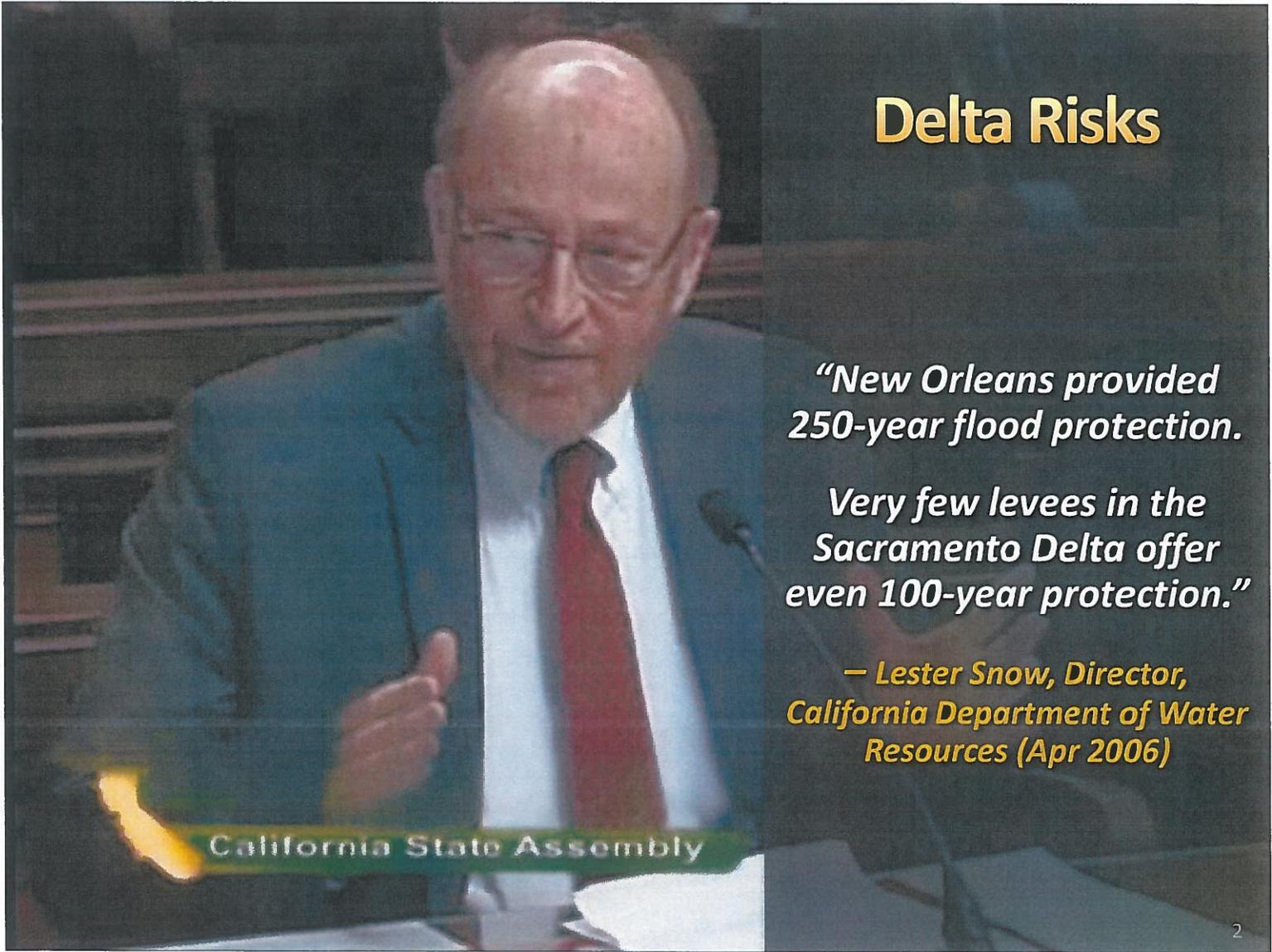


Update on In Delta Freshwater Pathway

Bay Delta Committee

Item 6a

January 26, 2021



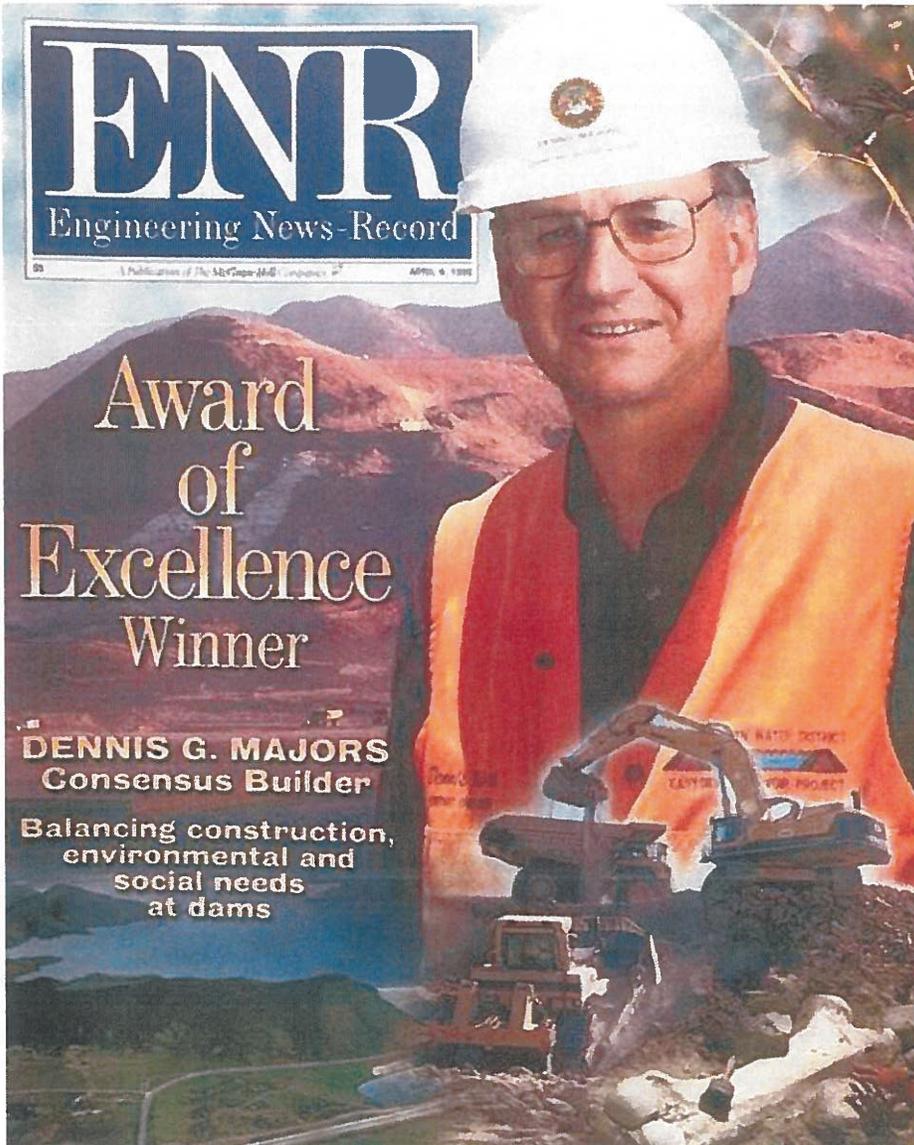
Delta Risks

*“New Orleans provided
250-year flood protection.*

*Very few levees in the
Sacramento Delta offer
even 100-year protection.”*

*— Lester Snow, Director,
California Department of Water
Resources (Apr 2006)*

California State Assembly

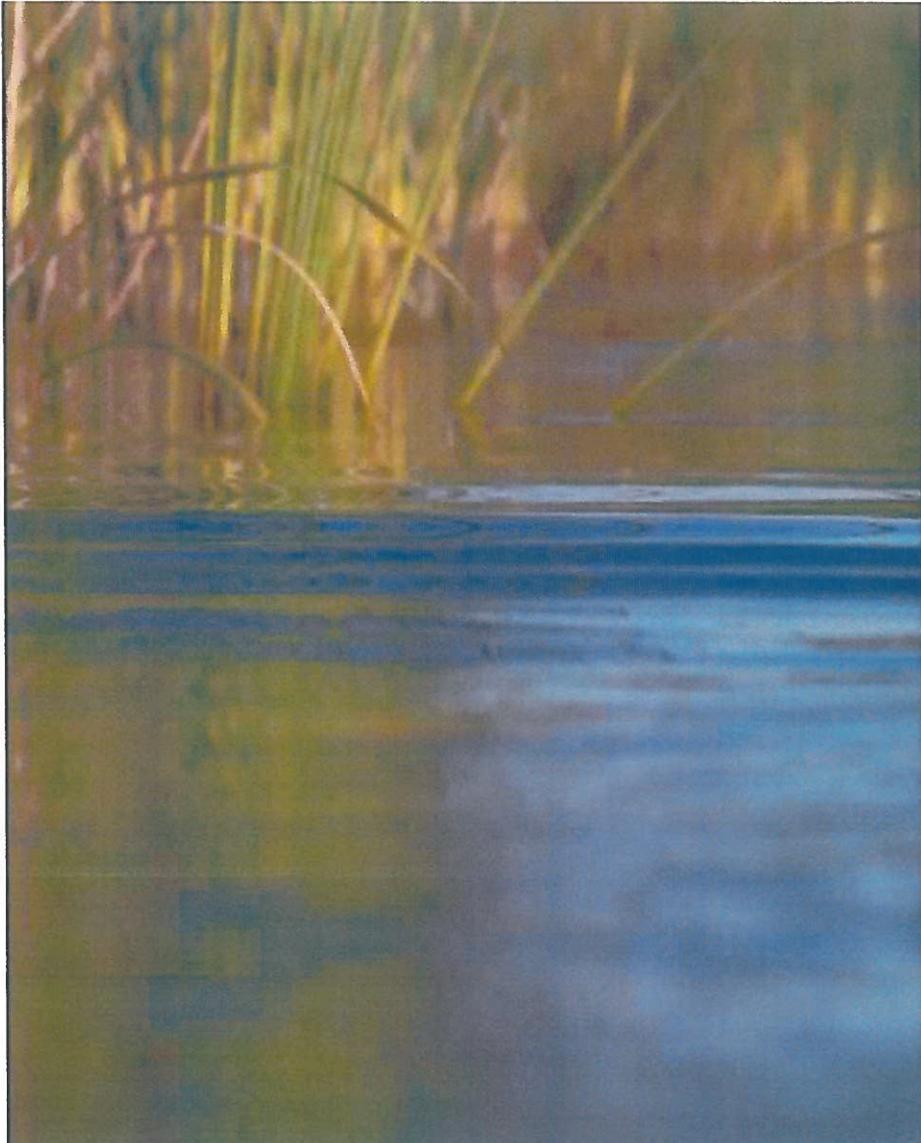


Delta Risks

“The Delta is the single greatest risk to interrupting SWP/CVP supplies”

– *Dennis Majors, MWD (2007)*

- *MWD Lead – Diamond Valley Lake*
- *USACE Lead – Seven Oaks Dam*
- *Recipient of four national planning, design & construction awards*



Update Topics

- Board Policies/Summary
- Risk Assessments
- Risk Mitigation Options
- Improvement Actions
- Summary



Board Policies

Bay Delta – System Reliability

Status

Seek emergency response plan approval

Complete

Complete emergency preparedness measures

Complete

Secure levees along freshwater pathway

Complete on major portions
of Middle River

Improve water quality & supply reliability

Continuous Effort

Limit land subsidence

Continuous Effort

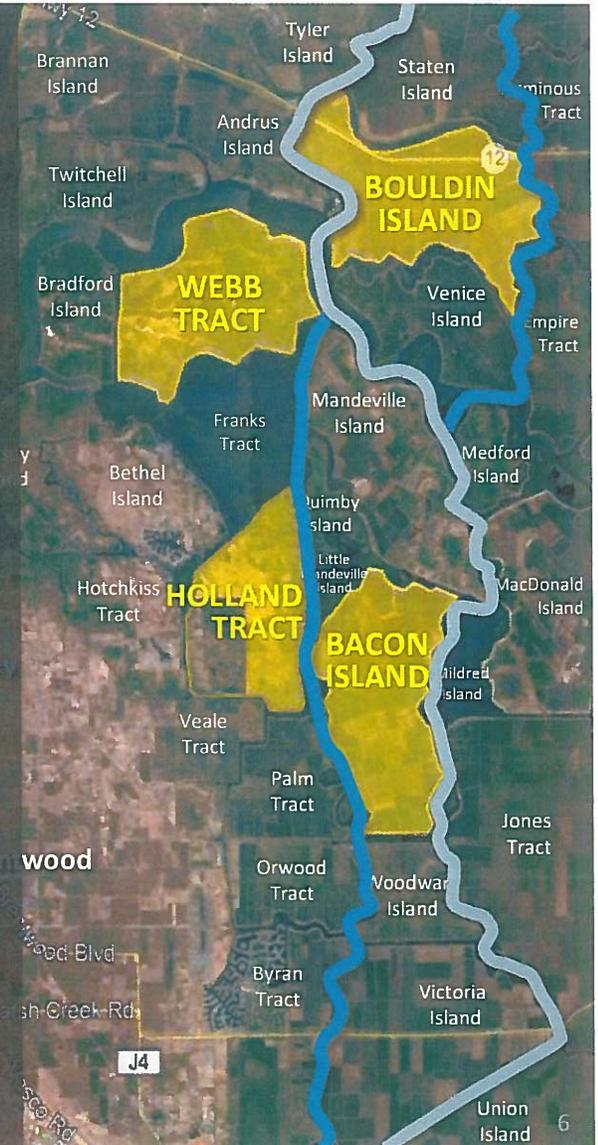
Board Summary

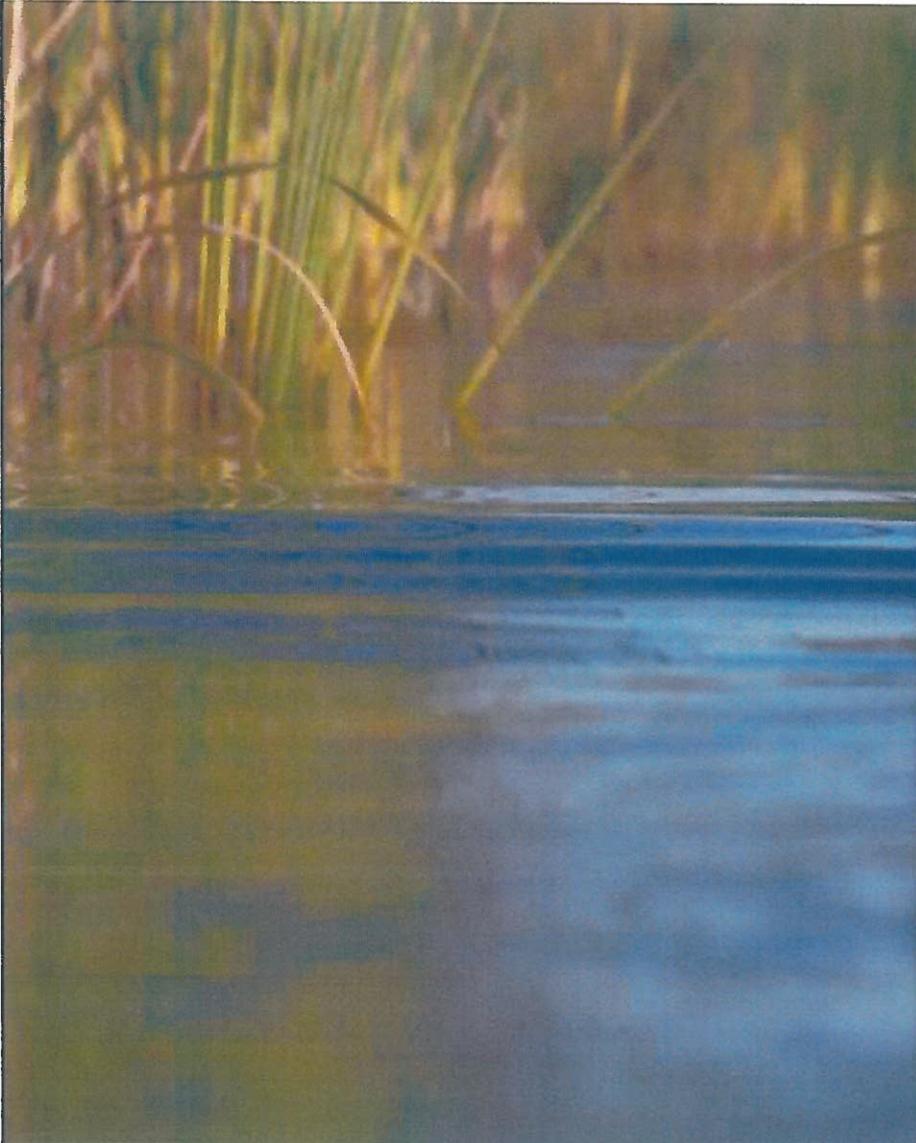
Accomplishments

- Freshwater Pathway approach included in State Emergency Response/Preparedness Plan
- Regional warehouses & stockpiles completed
- Regional & local Delta seismic vulnerability analyses conducted
- Potential 3-yr outage reduced to < 6 months
- Major portions of Middle River levee improved to meet mitigate flood and seismic events

Ongoing Activities

- Evaluate new levee monitoring technologies
- Continue developing on-island stockpiles
- Further analysis of improving Old River levees
- Recommend update of 1982 State levee std.
- Continue targeted levee improvements





Update Topics

- Board Policies/Summary
- Risk Assessments
- Risk Mitigation Options
- Improvement Actions
- Summary



Subsidence



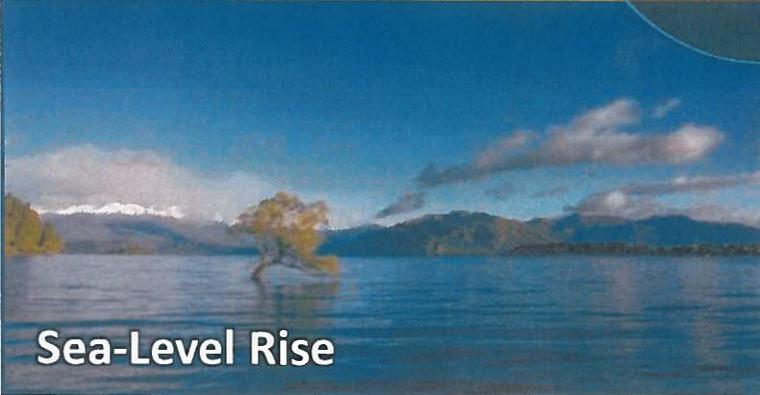
Seismic Risk



Fishery Declines



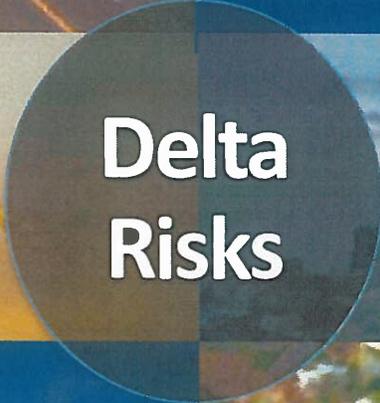
Flooding



Sea-Level Rise



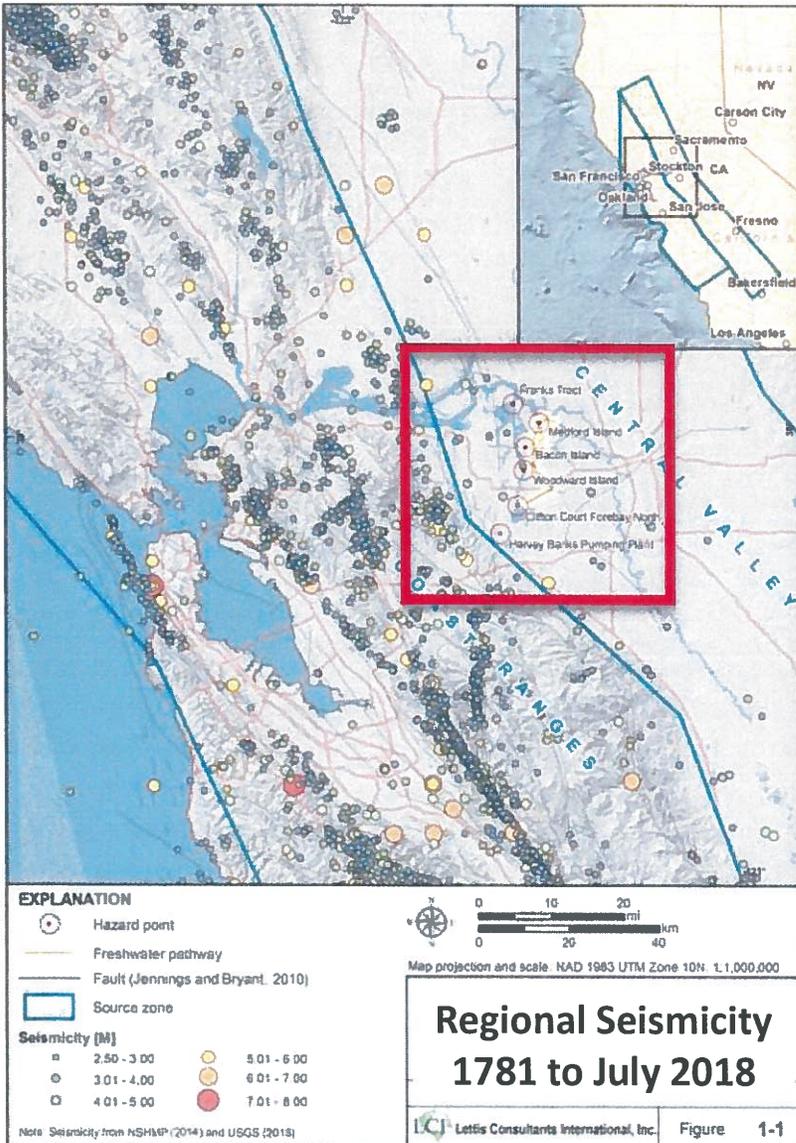
Invasive Species / Levee Voids



**Delta
Risks**

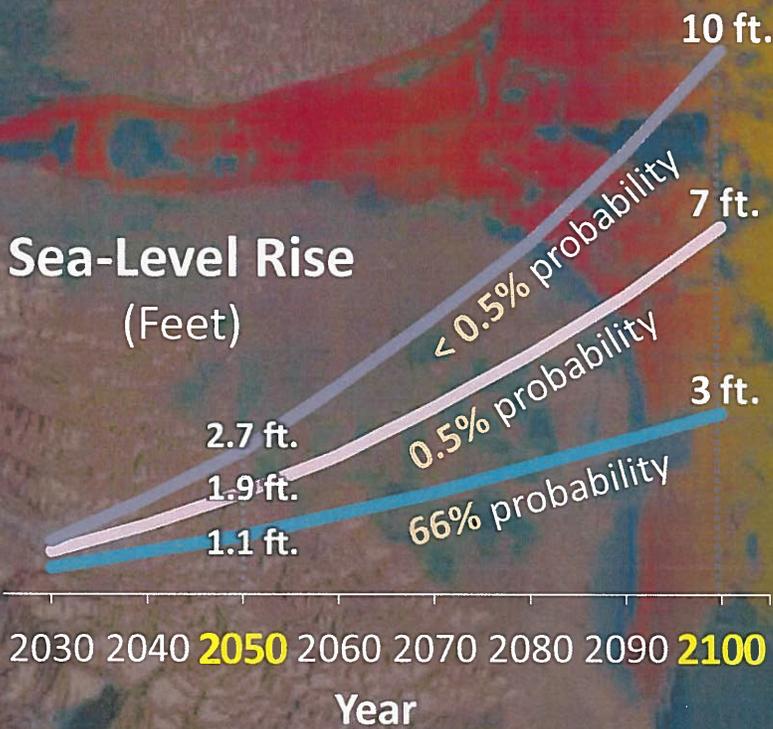
Seismic Risk Assessment

- Regional Seismic Analyses
 - 32 earthquakes > 5.0 M since 1781
 - 2016 USGS predicts 72% chance of 6.7M earthquake in next 30 years
 - Cause widespread damage
- Local Delta Risk Analysis
 - Multiple analyses 2007 – 2020:
 - DWR, USACE, Cal OES, DSC, UCLA, URS, Lettis, JBA, RMA
 - In 2019, Lettis International model predicts seismic potential of:
 - 6.8 M earthquake on Southern Midland Fault in west Delta
 - 6.6 M earthquake on West Tracy Fault in south Delta
 - Peak ground accelerations that cause liquefaction (0.2 - 0.5 g)



Sea-Level Rise Assessment

Sea-Level Rise (Feet)



Low Risk Aversion = 66% probability of sea-level rise (based on Kopp et al 2014)
Med-High Risk Aversion = 0.5% probability of sea-level rise (based on Kopp et al 2014)
Extreme Risk Aversion = Single scenario of sea-level rise (based on Sweet et al 2017)

- Historical
 - 0.64 feet rise in last 130 years
- Future Probability
 - 2018 projection update by Cal Resources Agency & Ocean Protection Council
 - 1.1 to 2.7 feet by 2050
 - 3 to 10 feet by 2100

Flood Risk Assessment

• Historical

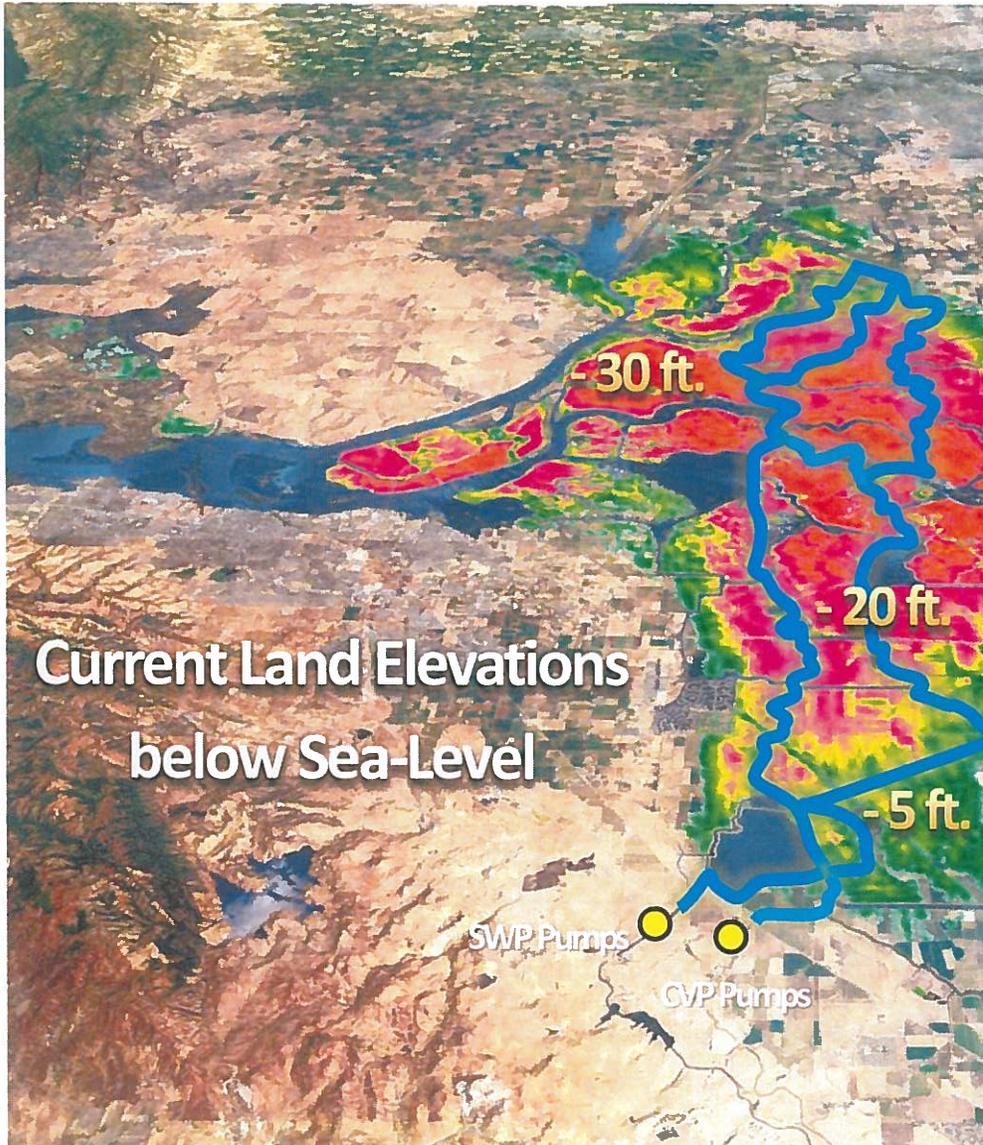
- 162 levee failures in last 100 years
- 10 levee failures since 1982 when State began funding levee improvements

• Future Probability

- Peak storm runoff estimated to increase by 44% by 2050 and 77% by 2100¹
- Will concentrate within core winter months when high tides also occur¹

1. Info from Delta Stewardship Council 2020





Subsidence Risk Assessment

- Historical ¹
 - Subsidence 10 to 30 feet (- 0.5 to 1.5 inch/year)
 - Responsible for emissions of 2,200,000 million tons of carbon annually
 - Equivalent of 500,000 vehicles annually
- Future Probability
 - 3 to 10 ft. more subsidence by 2100 without change in agricultural practices

1. Info from Deverel, Leighton, Lucero – journal publication 2017

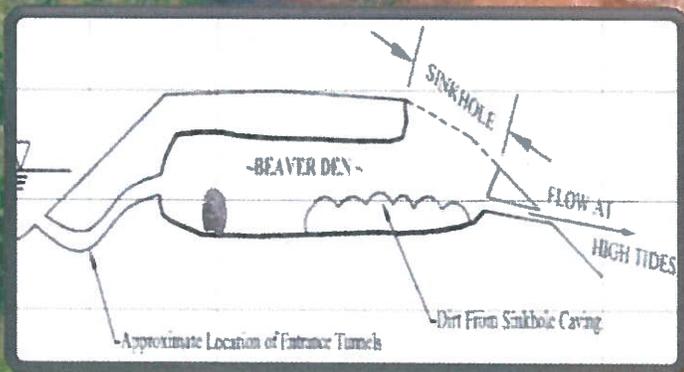
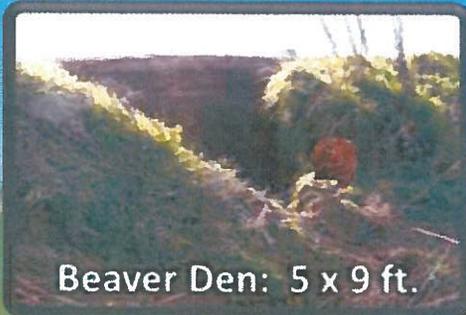
Invasive Species Risk Assessment

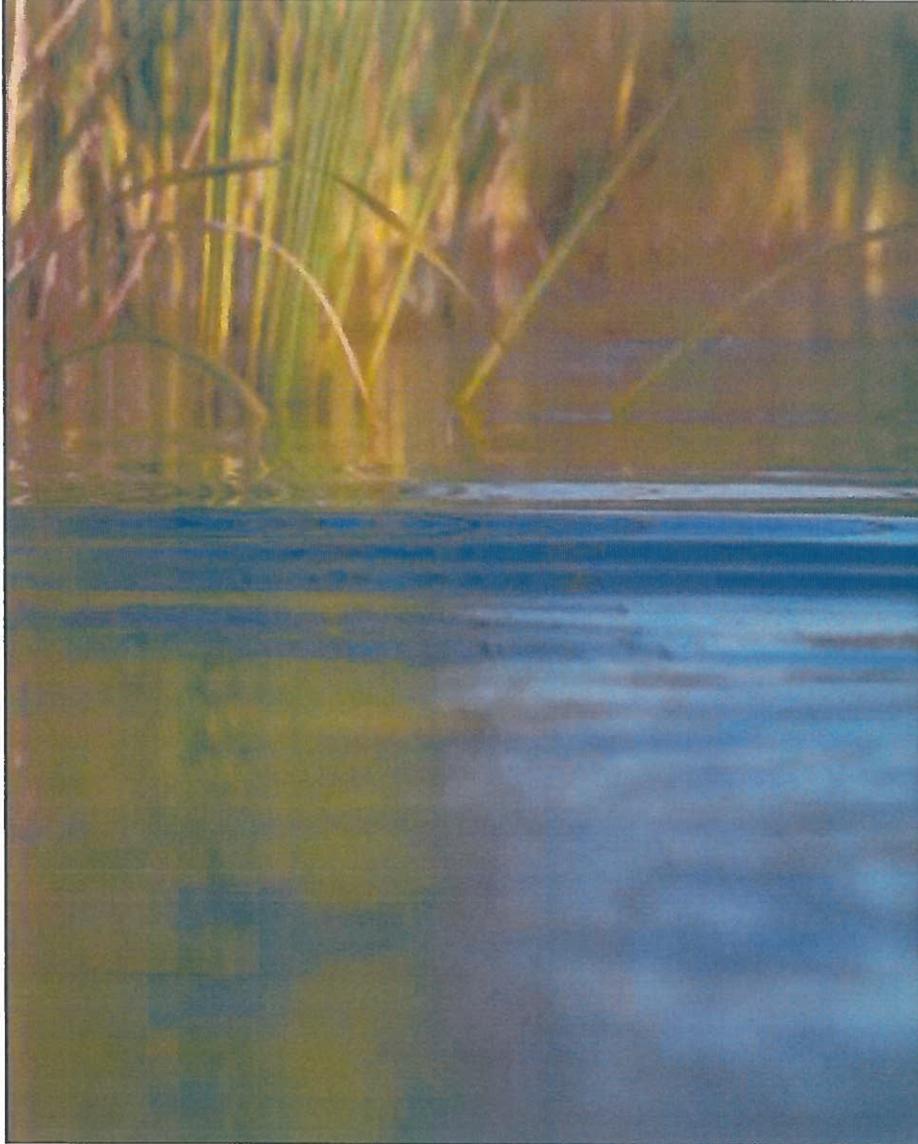
• Historical

- Beaver dens cause significant levee damage
- Visual detections difficult
- 2004 Jones Tract levee failure cause – beaver den

• Future Probability

- New invasive species (Nutria) could exacerbate problem
- One female can produce up to 200 offspring per year



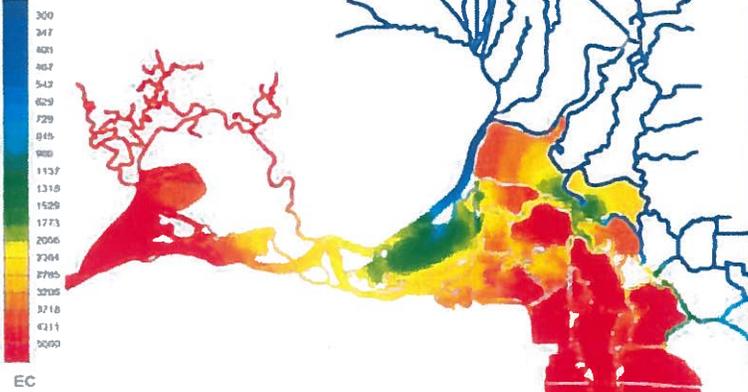


Update Topics

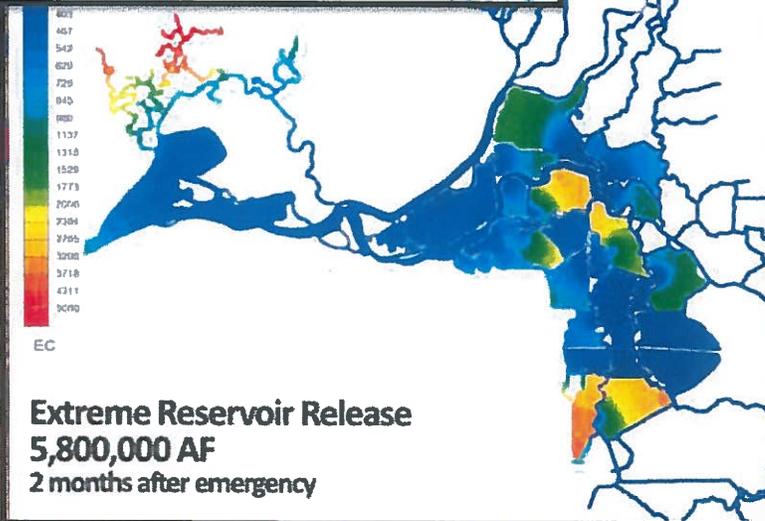
- Board Policies/Summary
- Risk Assessments
- Risk Mitigation Options
- Improvement Actions
- Summary

Risk Mitigation Options

Oroville Reservoir



Normal Reservoir Release
1,000,000 - 1,500,000 AF
2 months after emergency



Extreme Reservoir Release
5,800,000 AF
2 months after emergency

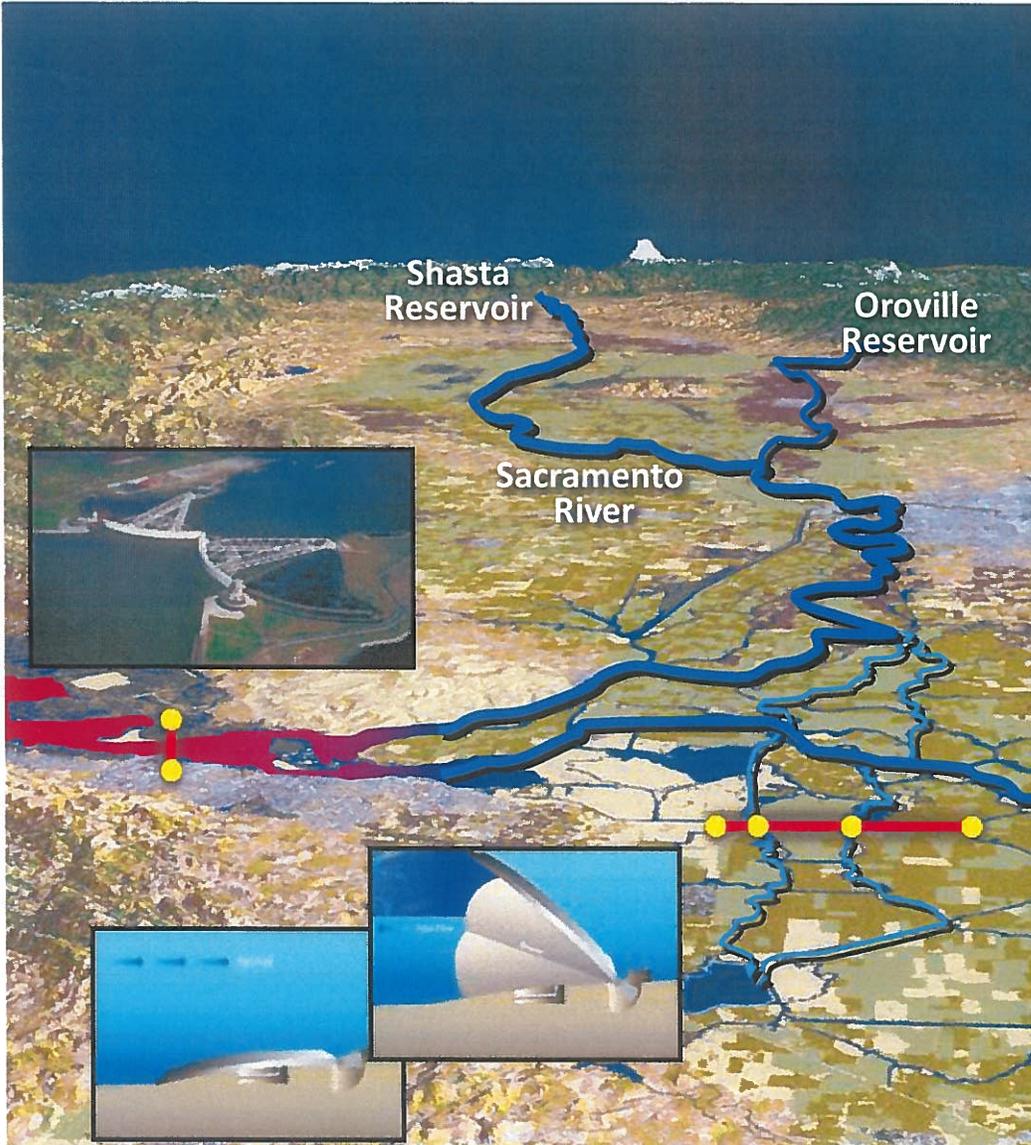
Storage Releases

- Normal releases has minimal impact on reducing salinity
- Extreme releases reduces salinity but causes severe agric./urban/fishery water supply problems

Operable Barriers

Freshwater Pathway

Risk Mitigation Options



Storage Releases

Operable Barriers

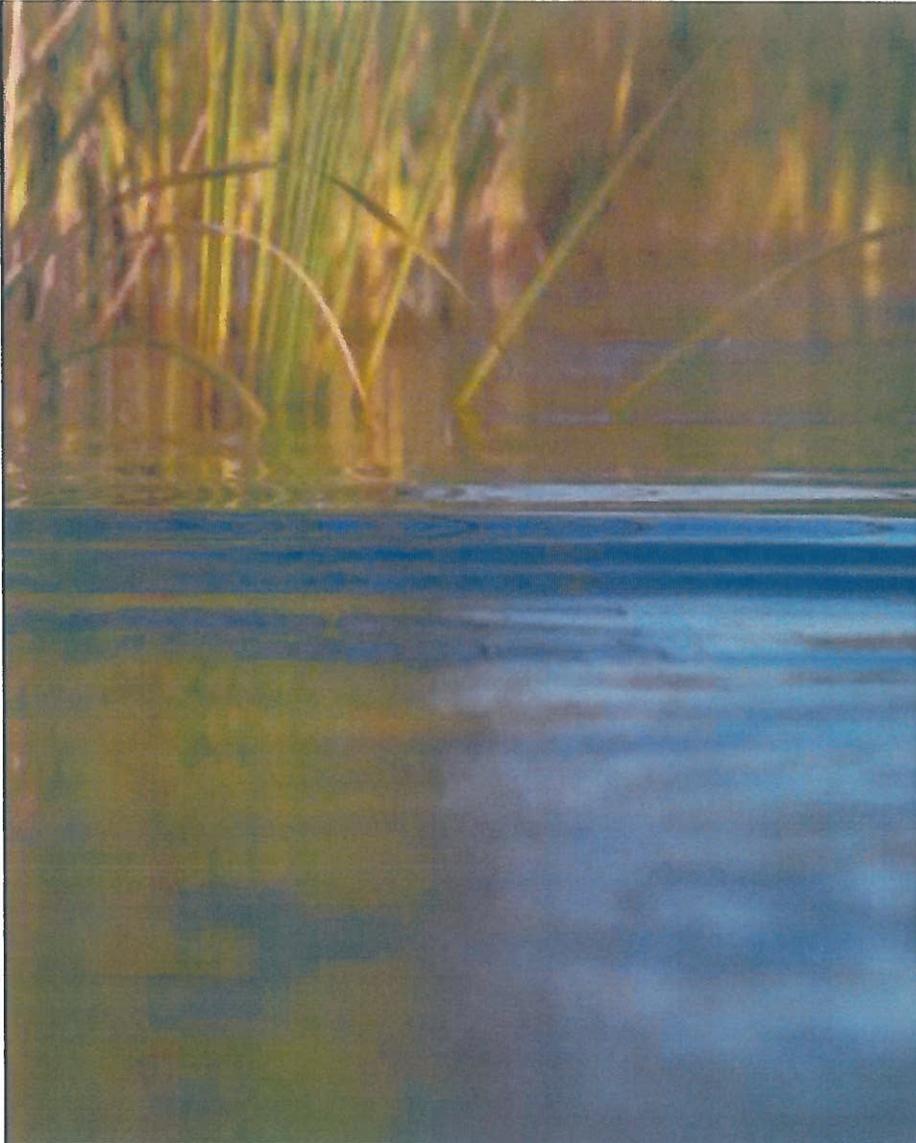
- Reduces salinity after seismic event
- High cost for infrequent use
- Fishery concerns
- Seismic operability concerns

Freshwater Pathway

Risk Mitigation Options

- Storage Releases
- Operable Barriers
- Freshwater Pathway
 - Pre-Event
 - Levee improvements
 - Material stockpiles
 - Integrated County, State, Fed Plans
 - Post-Event
 - Repair levees
 - Close side channels
 - Recovery <6 months





Update Topics

- Board Policies/Summary
- Risk Assessments
- Risk Mitigation Options
- Improvement Actions
- Summary



State-Federal Flood Operation Center Briefing



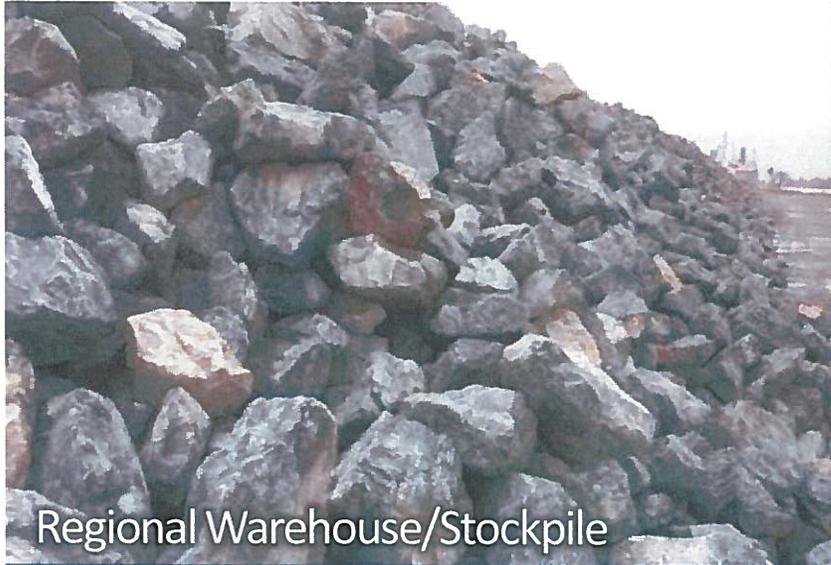
Bacon Island Levee Special Project

Improvement Actions

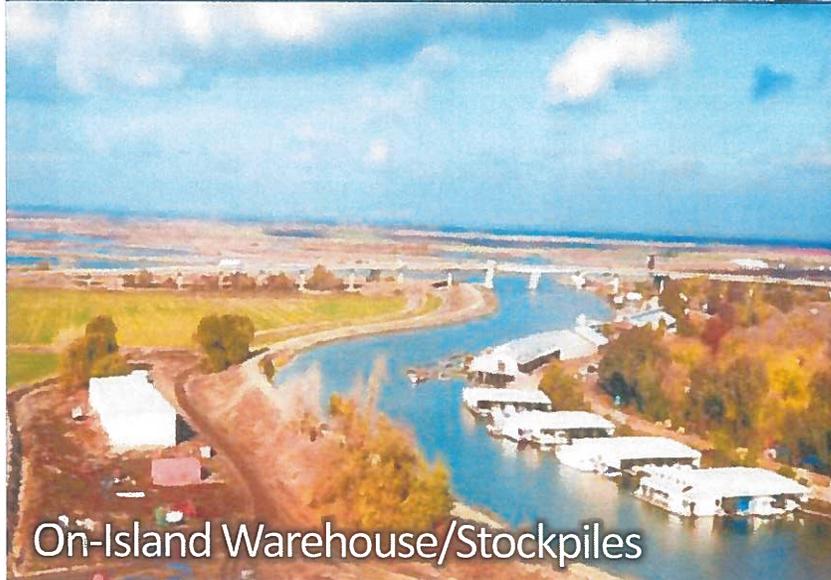
System Reliability

- State Levee Investments
 - Annual Maintenance
 - Special Projects: Levee Rehab
- Interagency Coordination
 - Unified command structure
 - Annual live emergency drills
 - Expedited contracts for materials and repairs
 - Fed/State/County agreements
- Levee Improvements
 - Bacon Island West Levee
 - Bacon Island North/South Levee¹
 - Bouldin Island North Levee¹

1. Currently in design phase



Regional Warehouse/Stockpile

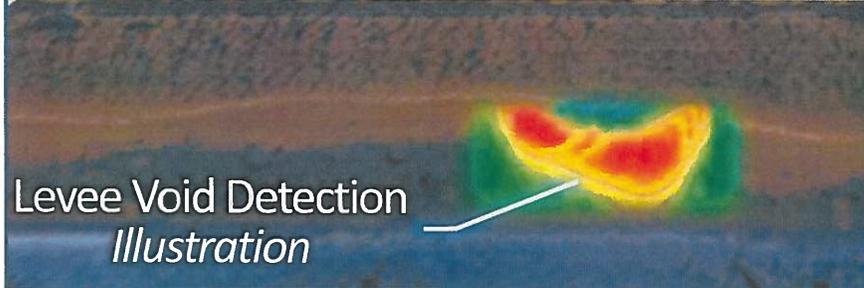
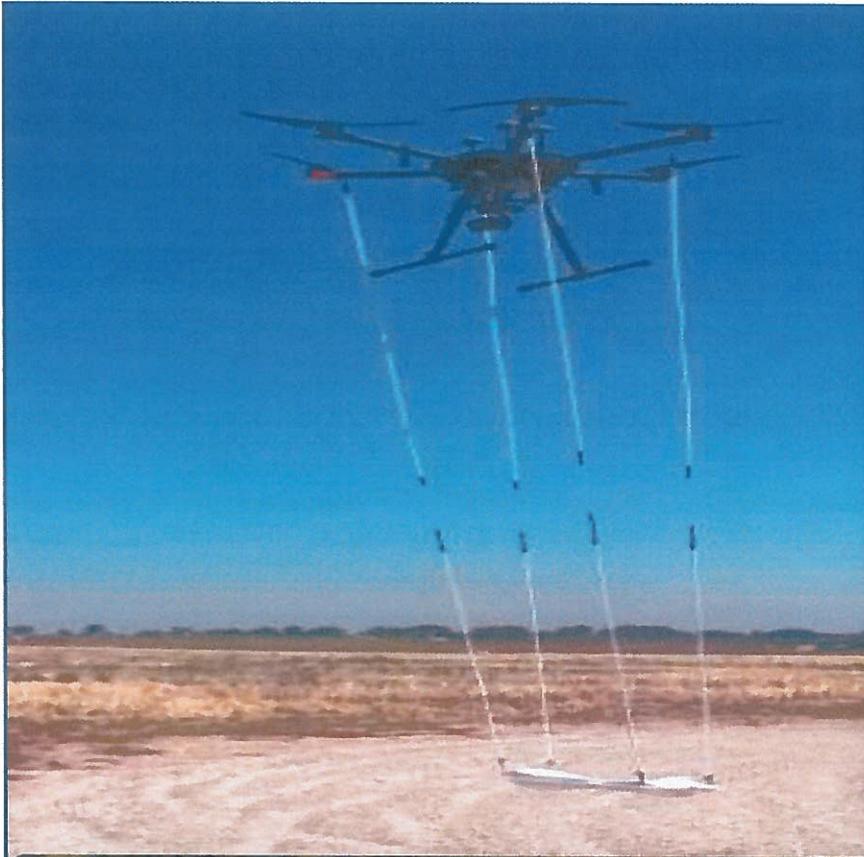


On-Island Warehouse/Stockpiles

Improvement Actions

System Reliability

- Regional Stockpiles
 - Levee improvements projects along Delta freshwater pathway
 - DWR rock stockpiles complete
- On-Island Stockpiles
 - Initiating smaller rock stockpiles on MWD properties
 - Reclamation District & DWR Flood fight storage units
 - Grant in process from County to purchase & store additional flood fighting materials



Levee Void Detection
Illustration

Improvement Actions

System Reliability

- New Technology Testing
 - MWD's Delta islands allows new cost-effective approaches improving system reliability
 - Analyzing new levee void detection monitoring technologies
 - Continuing seismic analyses to better understand levee risks and focus solutions

Invasive Species Control

The Guardian

This is a **nutria**.



Invasive species control detection dogs
Mel Tucker – Farm security, dog handler

Improvement Actions

System Reliability

- Invasive Species Control
 - Working with California Department of Fish & Wildlife
 - Camera detection station setup on Bacon Island & Holland Tract
 - Coordinating with State/federal agencies on use of detection dogs

Reduce Subsidence

Carbon sequestration & regenerative agriculture

Enhance Habitat

Integrated landscape management

Improve Reliability

Levee improvements

Soil Accretion
+1 to 2 inch/yr.¹
(+ 7 to 14 ft. by 2100)

Widen crown
for habitat

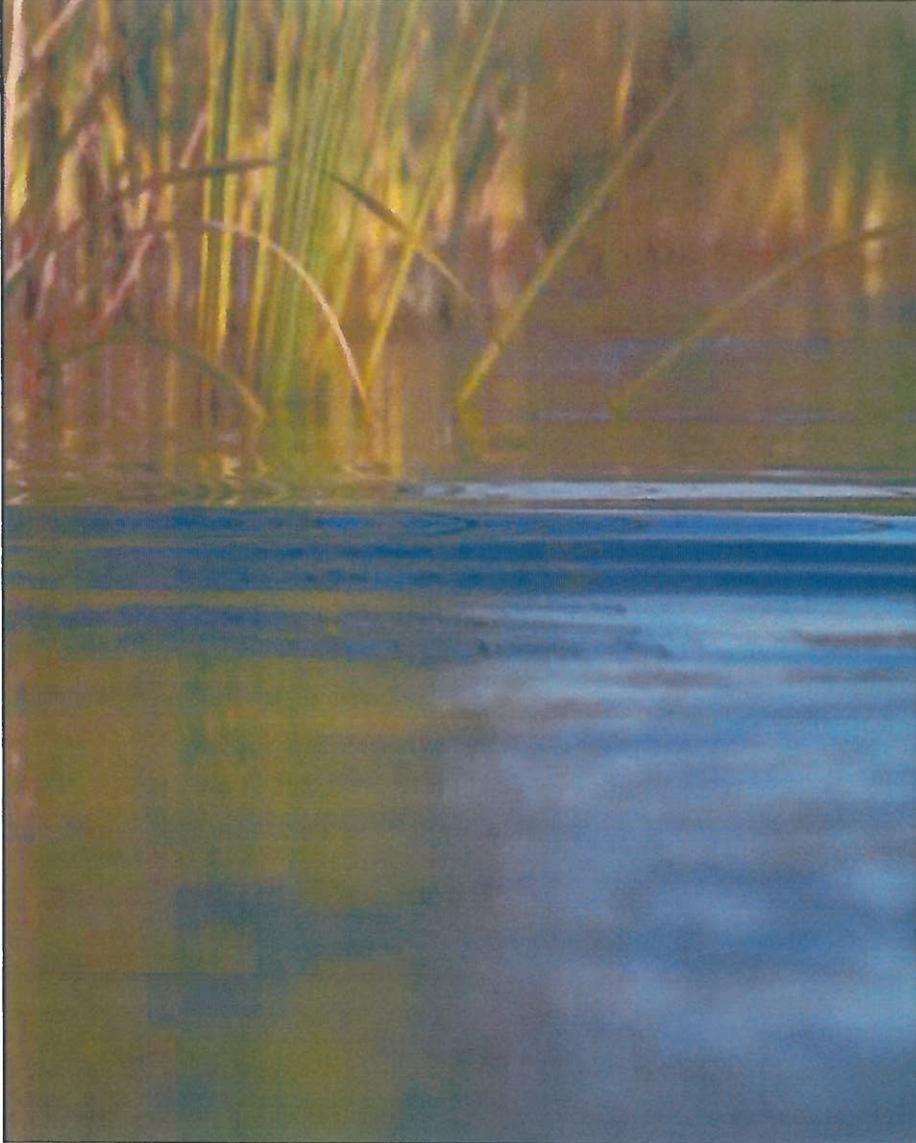
Levee
Improvements

Improvement Actions

System Reliability

- Environmental Integration & Agriculture Sustainability
- Benefits
 - Reduce land subsidence
 - Enhance marginal farmland
 - Reduce sea-level rise impacts
 - Secure carbon capture credits
 - Enhance habitat restoration
 - Limit herbicide & pesticide

¹ Based on Twitchell Island and other habitat restoration projects



Update Topics

- Board Policies/Summary
- Risk Assessments
- Risk Mitigation Options
- Improvement Actions
- Summary

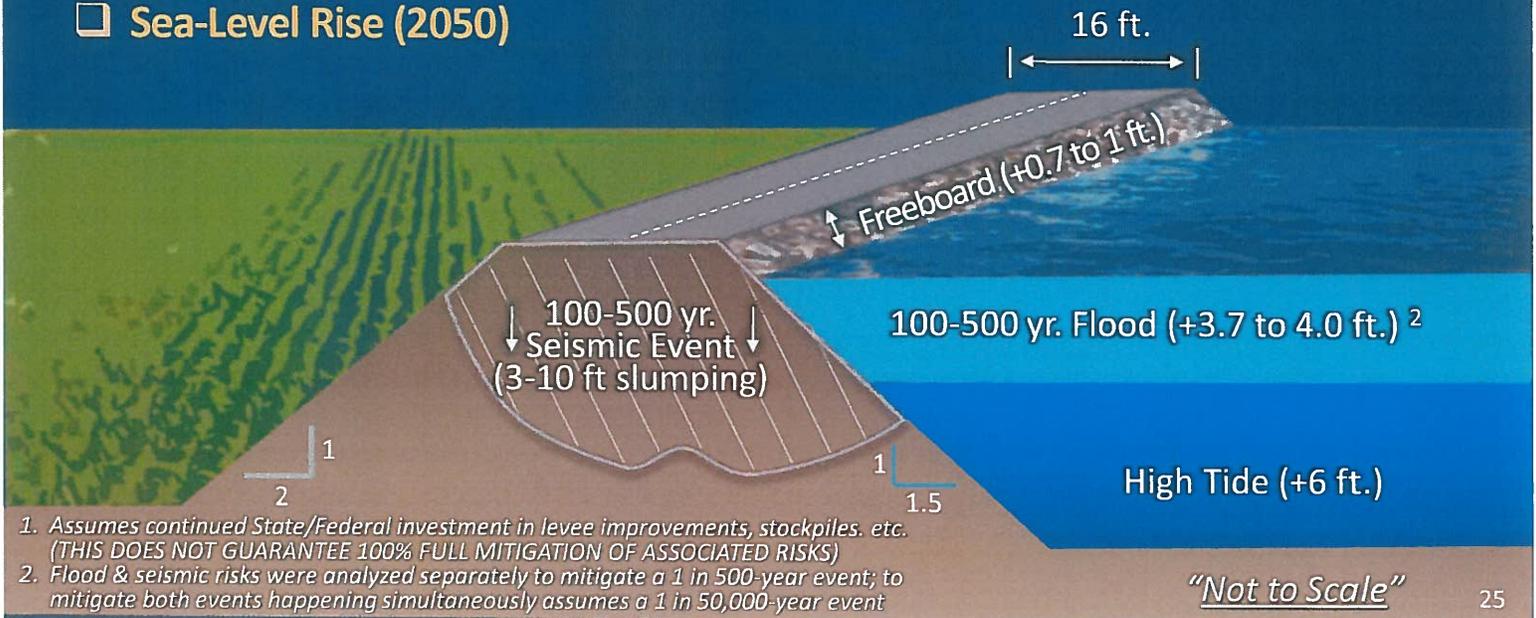
Freshwater Pathway

“Base Case” Reliability (Year 2000)

Potential Impact
3-year export disruption

- Mitigates ¹

- Flood Risk
- Earthquake Risk
- Sea-Level Rise (2050)



1. Assumes continued State/Federal investment in levee improvements, stockpiles, etc. (THIS DOES NOT GUARANTEE 100% FULL MITIGATION OF ASSOCIATED RISKS)
2. Flood & seismic risks were analyzed separately to mitigate a 1 in 500-year event; to mitigate both events happening simultaneously assumes a 1 in 50,000-year event

Freshwater Pathway

“Current” Reliability (Year 2020)

Potential Impact
<6-months export disruption

• Mitigates ¹

- Flood Risk
- Earthquake Risk
(on major portions of Middle River)
- Sea-Level Rise (2050)



1. Assumes continued State/Federal investment in levee improvements, stockpiles, etc. (THIS DOES NOT GUARANTEE 100% FULL MITIGATION OF ASSOCIATED RISKS)

2. Flood & seismic risks were analyzed separately to mitigate a 1 in 500-year event; to mitigate both events happening simultaneously assumes a 1 in 50,000-year event

“Not to Scale”

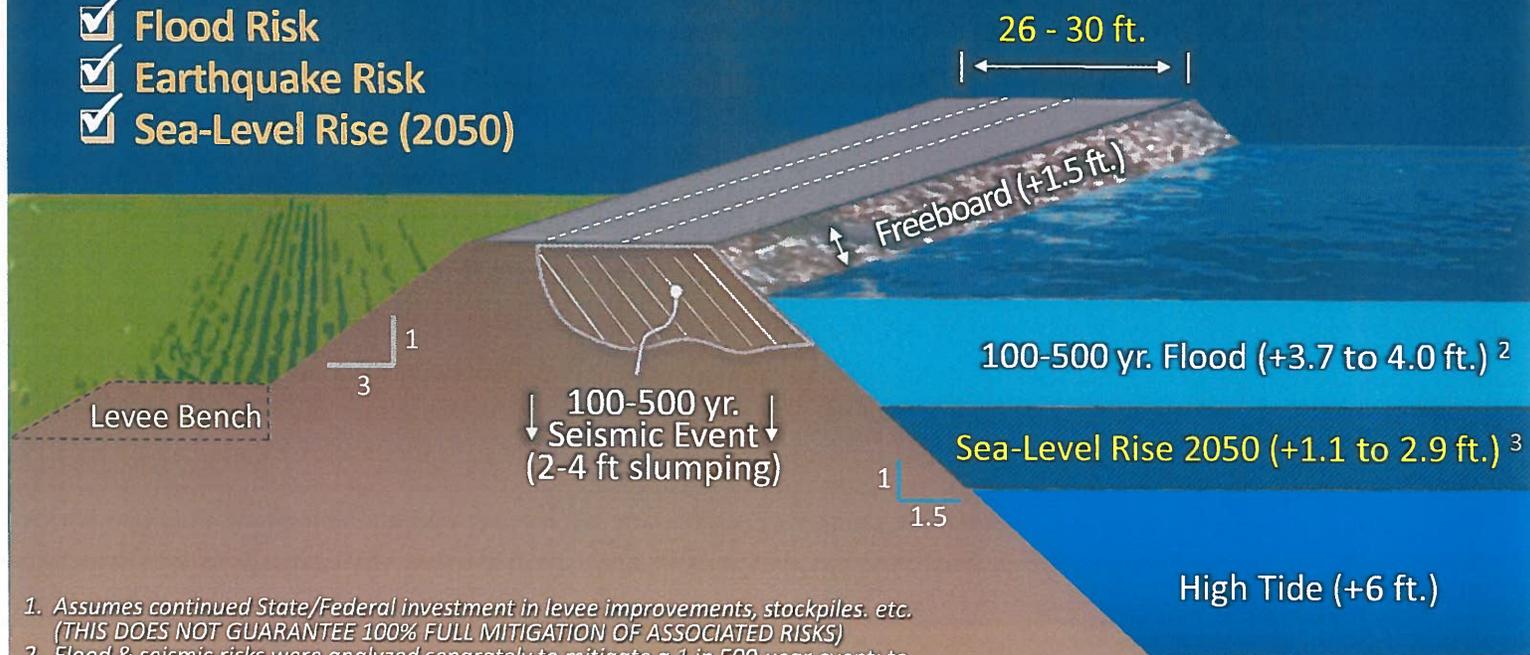
Freshwater Pathway

"Meeting Future Risks" (Year 2050)

Concept ...
Under Analysis

• Mitigates ¹

- ✓ Flood Risk
- ✓ Earthquake Risk
- ✓ Sea-Level Rise (2050)



1. Assumes continued State/Federal investment in levee improvements, stockpiles, etc. (THIS DOES NOT GUARANTEE 100% FULL MITIGATION OF ASSOCIATED RISKS)
 2. Flood & seismic risks were analyzed separately to mitigate a 1 in 500-year event; to mitigate both events happening simultaneously assumes a 1 in 50,000-year event
 3. Could be mitigated through an adaptive design with incremental levee raises.

"Not to Scale"



Summary

• Accomplishments

- Freshwater Pathway approach included in State Emergency Response/Preparedness Plan
- Regional warehouses & stockpiles completed
- Regional & local Delta seismic vulnerability analyses conducted
- Potential 3-yr outage reduced to < 6 months
- Major portions of Middle River levee improved to meet mitigate flood and seismic events

• Ongoing Activities

- Evaluate new levee monitoring technologies
- Continue developing on-island stockpiles
- Further analysis of improving Old River levees
- Recommend update of 1982 State levee std.
- Continue targeted levee improvements



**Technical Memorandum:
Delta Risk Management Strategy (DRMS) Phase 1**

**Topical Area:
Impact to Infrastructure
Final**

Prepared by:
URS Corporation/Jack R. Benjamin & Associates, Inc.

Prepared for:
California Department of Water Resources (DWR)

June 15, 2007

Topical Area: Impact to Infrastructure

7.2 Summary

The total estimated replacement costs for infrastructure assets within the Delta are summarized in Table 7-8 for the current (2005) and 2050 conditions, for MHHW and 100 year inundation levels. This table accounts for infrastructure assets that could be damaged as a result of levee breaching and island flooding (see Section 1.2). The costs are based on the results presented in Tables 7-1, 7-2, 7-4 and 7-5.

Table 7-8 Comparison of Total Replacement Costs of Delta Infrastructure - Current and 2050^a

Inundation Level	Current (2005) ^c	2050	Cost Ratio: 2050/Current
Within Mean Higher High Water (MHHW) Limits ^b	\$6.7 billion	\$8.5 billion ^e	1.3
Within 100-year Flood Limits ^{b,c}	\$56.3 billion	\$67.1 billion ^e	1.2

^a Costs in this table are for infrastructure assets and their contents that could be damaged as a result of levee breaching and island flooding.

^b See Section 4.1.2 and Figure 4-1 for limits of inundation.

^c Flood plain limits were developed from FEMA Flood Insurance Rate Maps.

^d Costs are in 2005 dollars.

^e Costs are in 2005 dollars; not escalated to 2050.

As indicated in Table 7-8, the total replacement cost of assets within the 100-year flood limits significantly exceeds (about 8 times) these costs for assets within the MHHW limits. The reason for this large difference is explained by referring to Figure 4-1. This figure shows that the 100-year flood event has the potential to inundate major urban areas such as Sacramento and Stockton that have a large inventory of infrastructure assets. However, the MHHW limits do not extend to these large urban areas. Smaller towns and rural/agricultural areas mainly fall within the MHHW limits. The largest differences between damages for the 100-year flood event and other events would be for infrastructure that is located near the edge of the floodplain in urban areas (areas with topographic relief).

Table 7-8 also indicates that over the next 50 years, the total replacement cost of assets could increase by about 20 to 30 percent within the MHHW limits and the 100-year flood plain limits. Likewise, the overall damage repair costs of assets as a result of levee failure are also expected to increase over the next 50 years due to the (1) increase in the amount of infrastructure assets as a result of population growth, (2) Delta water level rise due to climate change, and corresponding increase in MHHW and 100-year flood levels, and (3) decrease in island elevation levels due to subsidence. The increase in water levels, coupled with the decreasing island elevations, would increase the amount of inundation of Delta assets in the future. The damage would therefore increase, resulting in greater future repair costs and repair times.

The repair costs for infrastructure assets will be based on the number of island failures and resulting inundation, and the repair costs will vary from island to island. For both current and 2050 conditions, the overall results of the repair and replacement costs presented in the asset tables indicate that the repair costs due to inundation could be on

Topical Area: Impact to Infrastructure

the order of 30 percent (for MHHW) and 50 percent (for the 100-year food) of the asset replacement costs, considering all Delta islands and tracts.

7.3 Limitations

As stated in Section 1.2, we consider damage to infrastructure assets that could result from levee breaching and island flooding. Infrastructure assets that would not be damaged by levee failure (e.g., pumping plants and power plants) are beyond the scope of the TM.

As stated in Section 3, because some asset types lack attribute information, it was not always possible to estimate asset costs from the GIS data. In these cases, there is insufficient definition of quantitative attributes to evaluate reliable replacement and repair costs and assumptions had to be made so that damage loss could be estimated. Also, some assets were not available in the GIS database. Further characterization of the Delta infrastructure assets would reduce the uncertainty in the damage estimates.

Because of the lack of information on repair times (due to the absence of historic experience), especially for multi-island failures, judgment was used to estimate repair times.

8. References

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- California Department of Water Resources (DWR). 1999. California State Water Project Atlas, June.
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