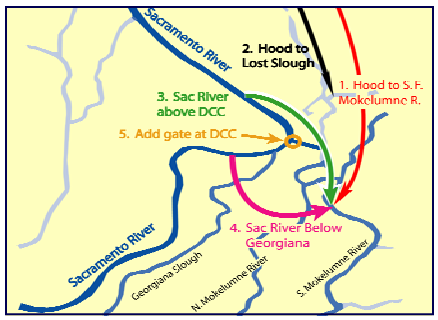
Delta Conveyance Improvement Studies
Summary Report

Franks Tract, Through-Delta Facility, and Delta Cross Channel Reoperation Projects



Prepared by:

EDAW | AECOM

December 7, 2007

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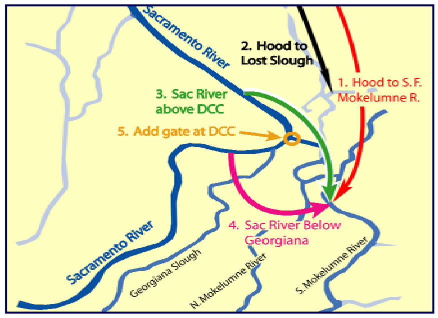

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December 7, 2007

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1 INTRODUCTION

1.1 BACKGROUND

The CALFED Bay-Delta Program (CALFED Program) is a cooperative interagency effort composed of 25 state and federal agencies with management or regulatory responsibilities for the San Francisco Bay/Sacramento-San Joaquin River Delta (Bay-Delta) system. The mission of CALFED is to develop a long-term comprehensive plan for restoring ecological health and improving water management for beneficial uses of the Bay-Delta system. The CALFED agencies undertook a comprehensive analysis of potential solutions to the ecosystem restoration, water quality, water supply reliability, and levee system integrity problems of the Bay-Delta. In August 2000, CALFED issued a programmatic record of decision (ROD) for the CALFED Program. The ROD established resource management objectives and the principles that would be applied to carry out these objectives. Implementation of the plan is expected to occur over a 30-year period, with Stage 1 covering the first 7 years (2000–2007) of this effort and building the foundation for long-term actions.

The CALFED ROD identified three projects in the north and central Delta to improve water quality and fish protection: Franks Tract, Through-Delta Facility (TDF), and Delta Cross Channel (DCC) Reoperation. Their ability to meet these purposes depends on how they are operated, both individually and jointly. Therefore, studies for these projects are designed to investigate the ways the projects interrelate or to ensure that linkages are not overlooked.

- **Franks Tract:** Through studies, pilot projects, and other actions, evaluate and implement, if appropriate and authorized, a strategy to significantly reduce fish entrainment and salinity levels in the south Delta and at the Contra Costa Water District (CCWD) and State Water Project (SWP)/Central Valley Project (CVP) diversion and export facilities, respectively, and improve water supply reliability by modifications in river channels and/or Delta circulation patterns around Franks Tract while accommodating recreational interests.

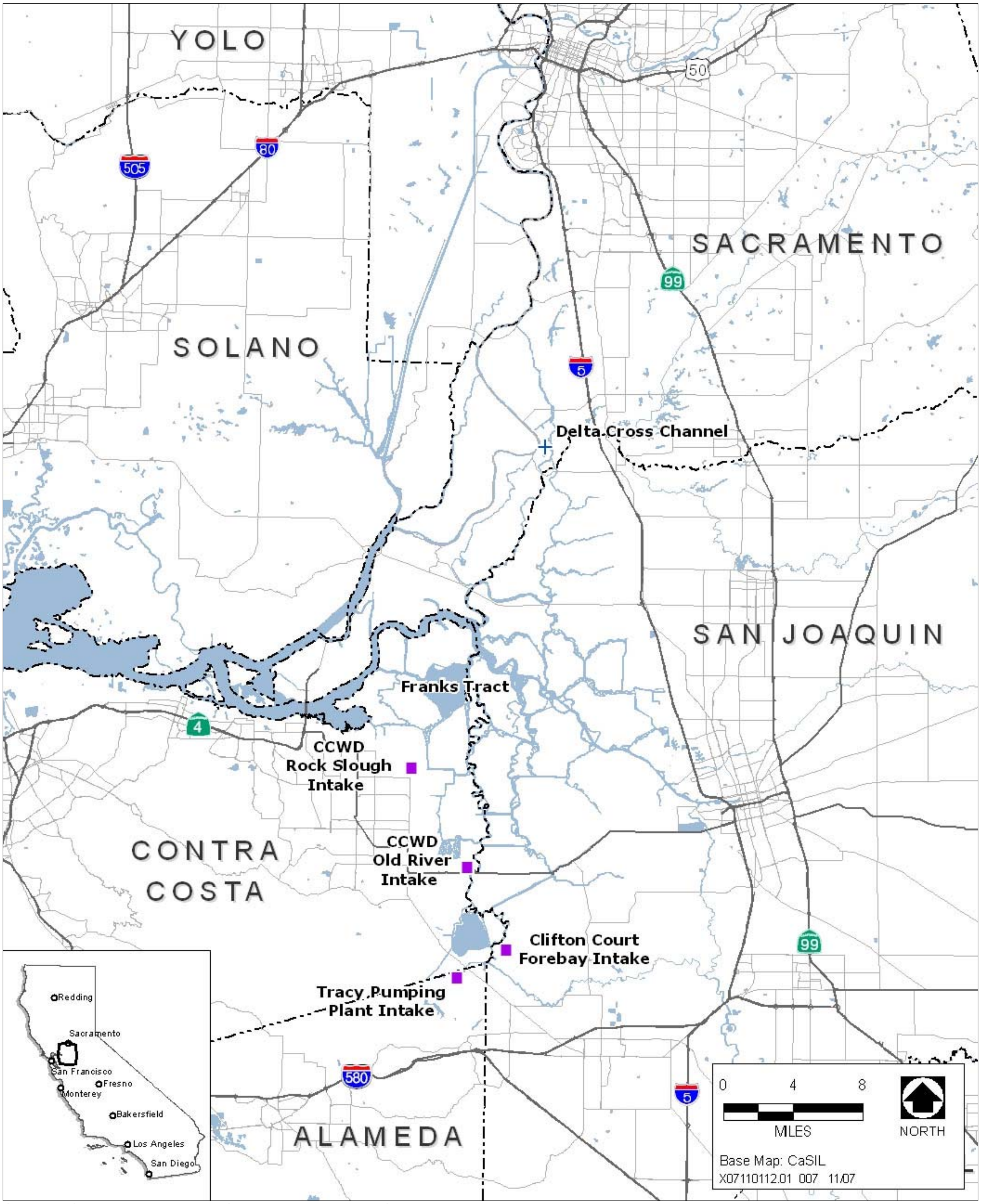
- **Through-Delta Facility:** Evaluate the feasibility of a 4,000-cubic-foot-per-second (cfs) diversion facility in the north Delta to assess its potential benefits and impacts on water quality, water supply reliability, and environmental conditions in the Delta.

- **Delta Cross Channel Reoperation:** Evaluate operational strategies for the DCC gates to improve water quality in the central and south Delta while improving fish passage through the north Delta.

The purpose of this summary report is to present key findings for Stage-1 studies and reports prepared by the California Department of Water Resources (DWR) in cooperation with the U.S. Bureau of Reclamation (Reclamation) to evaluate Franks Tract, TDF, and DCC Reoperation project actions. In addition, this report describes continuing and planned project studies.

1.2 REGIONAL SETTING

The Bay-Delta is located at the confluence of the Sacramento and San Joaquin Rivers and is created by the convergence of these two rivers with the waters of San Francisco Bay (Exhibit 1-1). The Delta region encompasses approximately 738,000 acres (295,200 hectares, or 1,150 square miles) and is the largest coastal plain estuarine system along the west coast of North America. The system is composed of approximately 60,000 acres of waterways, 57,238 acres of which are navigable. The main tributary streams that join in the Delta are the Sacramento, San Joaquin, Cosumnes, Mokelumne, and Calaveras Rivers. Additional rivers that enter the drainage system upstream of the Delta include the American, Yuba, Feather, Tuolumne, Merced, and Stanislaus Rivers. Levees ranging in height from 20 to 30 feet encircle many of the "islands" in the Delta with certain island interior elevations more than 20 feet below sea level as a result of land subsidence following reclamation in the



Sources: CALFED Independent Science Board 2002, ESRI 2005

Regional Map of Sacramento–San Joaquin Bay-Delta **Exhibit 1-1**

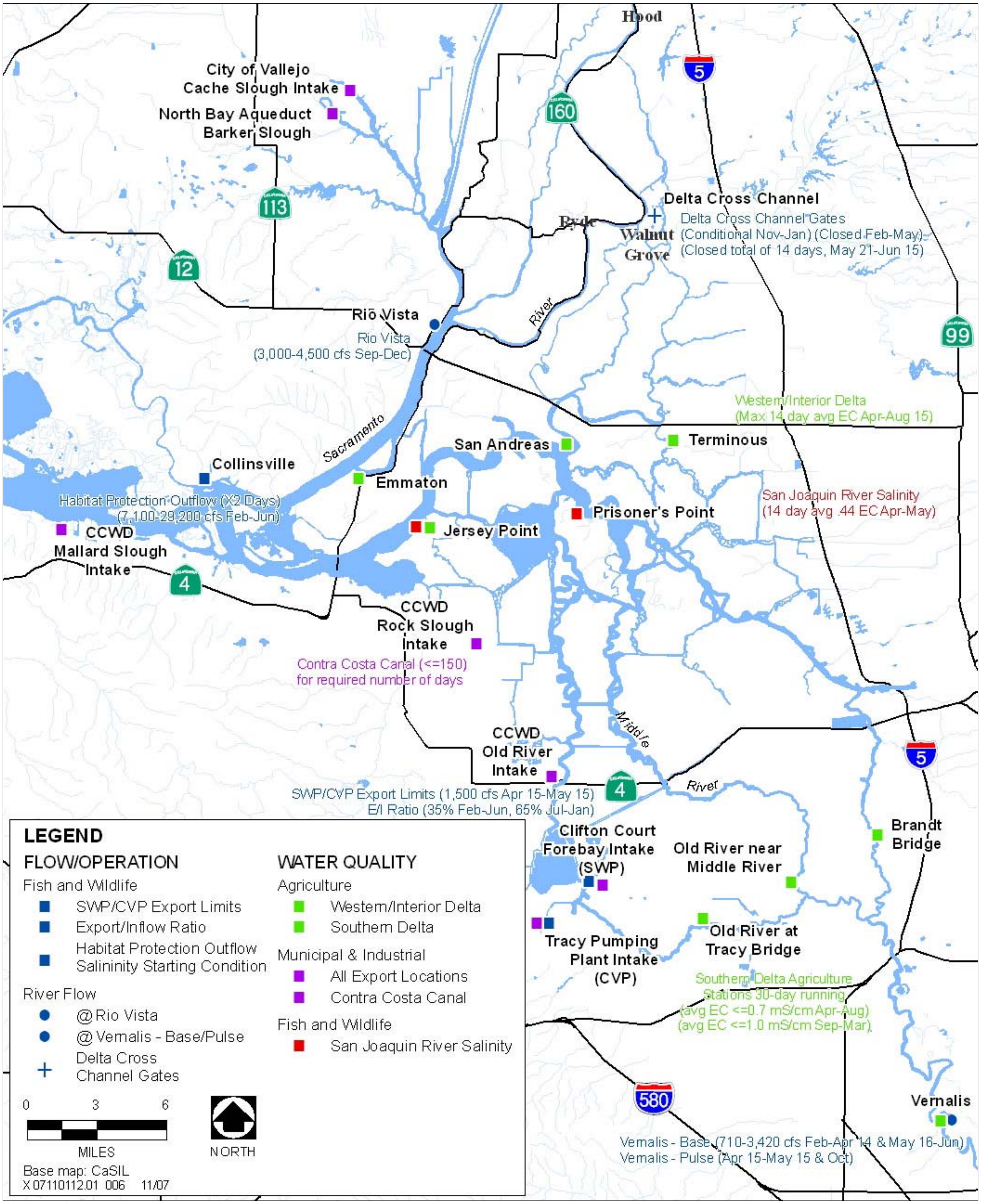
late 1800s. Tidal influence plays a major role in Delta water levels and flow velocities on a daily, seasonal, and annual time scale. This region supplies drinking water for two-thirds of the California population (approximately 23 million people); irrigation water for agriculture in the Delta and other parts of California; and habitat for many species of wildlife, including several native threatened and endangered fish, wildlife, and plant species.

The Delta is a critical component of California's water delivery system. Freshwater releases from storage reservoirs in northern California enter the Delta and are diverted by local municipal and agricultural water users, as well as exported to other areas of California by DWR and Reclamation. The remaining water flows westward in the Sacramento River and into San Francisco Bay, where it meets the Pacific Ocean. Water is exported from the south Delta by the SWP at Clifton Court and by the CVP near Tracy. A smaller volume of water is withdrawn from the south Delta by CCWD at intakes on Rock Slough and Old River near Byron. In winter and spring, freshwater inflows are high and the Delta water is generally fresh. In the summer months of dry years and the fall months of most years, when river flows decrease and/or water exports increase, tidal mixing causes water of higher salinity to intrude into the western Delta from San Francisco Bay. Operators of the SWP and the CVP must manage a careful balance between reservoir releases and water exports to meet water quality standards and objectives pursuant to the State Water Resources Control Board's (SWRCB's) Water Right Decision 1641 (D-1641). D-1641 was issued by the SWRCB on December 29, 1999, and amended on March 15, 2000.
The amendment added terms and conditions to five of DWR's water right permits that are intended to protect municipal and industrial, agricultural, and fish and wildlife beneficial uses of the Delta and implements the objectives contained in the SWRCB's *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary*. A map of the Delta with county boundaries is provided in Exhibit 1-1. A map of primary water diversion/export facilities and water quality standards stations is presented in Exhibit 1-2.

Fresh water is conveyed from the north Delta to the south Delta export locations primarily along a "freshwater corridor" via Middle River and Old River. Low-salinity water from the Sacramento River reaches the central Delta via Georgiana Slough and the Mokelumne River. When the gates on the DCC at Walnut Grove are open, additional water is transferred from the Sacramento River to the central Delta via the Mokelumne River system. During times of low net Delta outflow and high south Delta water diversions/exports, high-salinity water can intrude into the central Delta from the west and mix with the fresher water in West False River and Franks Tract as it is conveyed to the SWP and CVP pumps. The primary path of the salinity intrusion is east up the San Joaquin River near Jersey Island, east along the West False River channel and into Franks Tract, and southward down Sand Mound Slough and Holland Cut into Rock Slough and Old River in the south Delta. Increasing the net outward flow on the lower San Joaquin River (near Jersey Point) helps to repel the salinity intrusion from the west. This increase in net outward flow may be accomplished by reducing the south Delta diversions/exports, increasing the transfer of Sacramento River water to the central Delta, or increasing flows down the San Joaquin River. Currently, the DCC facility serves the critical role of transferring additional Sacramento River water to the central Delta. A generalized graphical explanation of the Delta salinity transport processes and the "freshwater corridor" is detailed in Exhibit 1-3.

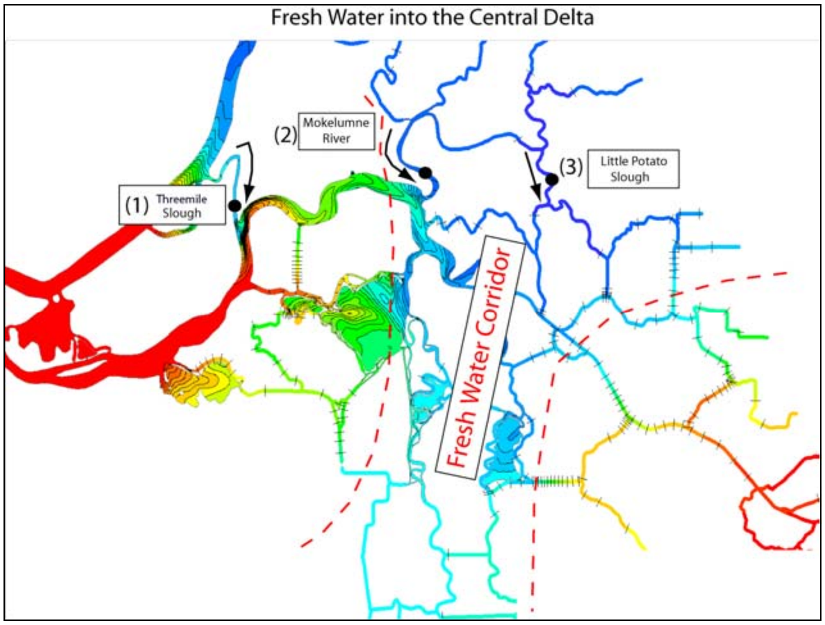
1.3 DELTA CONVEYANCE PROJECTS AND ALTERNATIVES CONSIDERED

The goals of the potential Franks Tract, TDF, and DCC Reoperation projects are to improve water quality at the south Delta export facilities and reduce fish entrainment into the central and south Delta.

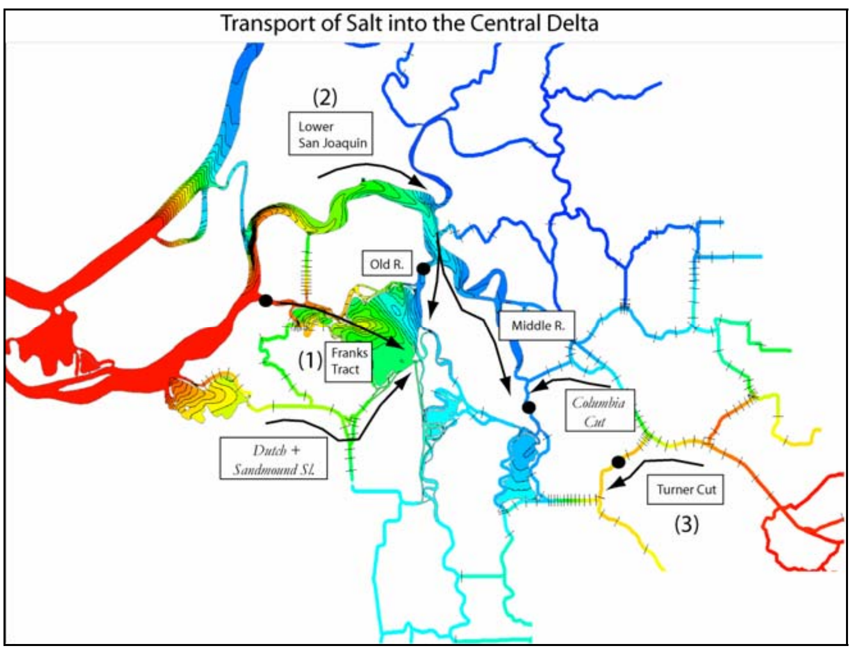


Source: CALFED Independent Science Board 2002

Water Diversion/Export Facilities and Delta D-1641 Water Quality Standards Stations **Exhibit 1-2**



Salt concentration from a numerical simulation is shown in terms of color. Cooler colors (blue) represent relatively fresh water, and warmer colors (red) represent saltier water. Fresh water is exchanged into the central Delta through three paths: (1) Threemile Slough, (2) the Mokelumne River, and (3) Little Potato Slough. Fresh water from these channels is mixed with saltier water from the west and south, creating a "freshwater corridor" represented by the north-to-south blue to cyan band.



Salt concentration from a numerical simulation is shown in terms of color. Cooler colors (blue) represent relatively fresh water, and warmer colors (red) represent saltier water. Salty water is exchanged into the central Delta through three main pathways: (1) False River into Franks Tract, (2) the lower San Joaquin River, and (3) Turner Cut. Secondary pathways through (a) Dutch and Sandmound Slough, (b) Old River and Middle River, and (c) Columbia Cut also convey salt into the central Delta.

Source: USGS and Resource Management Associates, unpublished

Delta Salinity Transport Processes **Exhibit 1-3**

Improved water quality would be achieved through the reduction of salinity concentrations at the south Delta export facilities by reducing or mitigating the salinity intrusion into the central Delta from the west (i.e., from the sea). The salinity improvement at the export locations would be accomplished primarily by three methods:

- reducing the tidal mixing of waters from the western Delta into Franks Tract and the central Delta;
- increasing the transfer of water from the Sacramento River to the central Delta, thus increasing the outward flow on the western San Joaquin River; and
- isolating the "freshwater corridor" along Middle and Old Rivers from the western Delta waters.

These facilities may also provide fishery benefits through their project operations by providing a physical barrier to the CVP and SWP pumps and/or negating the reverse flows in the central and south Delta. Potential sensitive fish species that could benefit from these project include delta smelt (*Hypomesus transpacificus*), chinook salmon (*Oncorhynchus tshawytscha*), and steelhead trout (*Oncorhynchus mykiss*). Many of the studies described in this summary report were conducted with the primary objective of better understanding Delta hydrodynamics and associated fish movement to improve the design of potential projects with respect to achieving fisheries benefits.

1.3.1 FRANKS TRACT PROJECT

Franks Tract, one of several flooded islands in the Delta, is the focus area for the Franks Tract project. Franks Tract is the largest of many land areas historically reclaimed for agriculture by constructed levees in the western and central Delta that subsequently flooded when the levees breached in the late 1930s. Franks Tract is connected to the rest of the Delta by False River, Fisherman's Cut, Old River, Holland Cut, Sand Mound Slough, and Piper Slough (Exhibit 1-4).

Analyses conducted by DWR as part of the Flooded Islands Pre-Feasibility Study (and predecessor studies) identified Franks Tract as a flooded island that, with modifications, could significantly improve water quality in the south Delta. A set of alternatives for modifying Franks Tract to improve water quality at the south Delta exports was identified during the prefeasibility study. Preliminary studies indicate that salinity reduction benefits could be achieved by constructing and operating one or more operable barriers in and around the Franks Tract area. In addition to the effects on Delta salinity, the proposed project alternatives were evaluated for effects on channel velocities, circulation, and residence time in Franks Tract and the central Delta.

DWR has further developed alternatives for implementing a project to explore the improvements in water quality and to monitor the effects of the project on fisheries and recreation (e.g., boat navigation and access). It is expected that with further project development, additional information will be developed through planning, monitoring, and adaptive management. Two alternatives for the Franks Tract project have been selected for further examination and are described below. Each of these alternatives could be operated in conjunction with a TDF or DCC Reoperation project.

- **Alternative 1: West False River.** The West False River Alternative involves installing an operable barrier that would be operated on both a seasonal and tidal basis to reduce the amount of higher salinity water moving from the western San Joaquin River into Franks Tract via the western end of False River. This alternative would create a longer path for salt water to reach south Delta export facilities via Old River. When tidal flow in False River is unimpeded, Franks Tract represents both a salt trapping and mixing basin and a shorter path to the export facilities for the higher salinity water. With the tidal flow in False River blocked, the high-salinity water is shunted on the flood tide farther up the San Joaquin River, around Bradford Island and Webb Tract. Operating the project to benefit fisheries would be an integral part of project development.

Source: CALFED Independent Science Board 2002

Franks Tract **Exhibit 1-4**

- **Alternative 2: Threemile Slough.** This alternative involves installing an operable barrier in the Threemile Slough channel to regulate flow between the Sacramento River and the San Joaquin River. The Threemile Slough Alternative would reduce salinity intrusion from the sea into south Delta export facilities by increasing net outward flows in the western part of San Joaquin River. The Threemile Slough Alternative would not alter the salt water path to the South Delta export facilities.

  The peak flow in Threemile Slough is approximately 25,000–30,000 cfs in both the ebb and flood tide directions. The Delta tides progress faster up the Sacramento River side of Threemile Slough than the San Joaquin River side. During the flood tide, the stage is higher on the Sacramento River side of Threemile Slough and water flows through the channel to the San Joaquin River. Conversely, during the ebb tide, flow moves from the San Joaquin River to the Sacramento River. Computer modeling has indicated that a net transfer of flow from the Sacramento River to the San Joaquin River can be increased by operating a physical barrier in Threemile Slough for a few hours during the ebb period to block the return flow to the Sacramento River.

  A significant feature of the Threemile Slough Alternative is the potential for operating the facility to provide substantial fisheries benefits. There are two potential operational scenarios for fisheries protection:

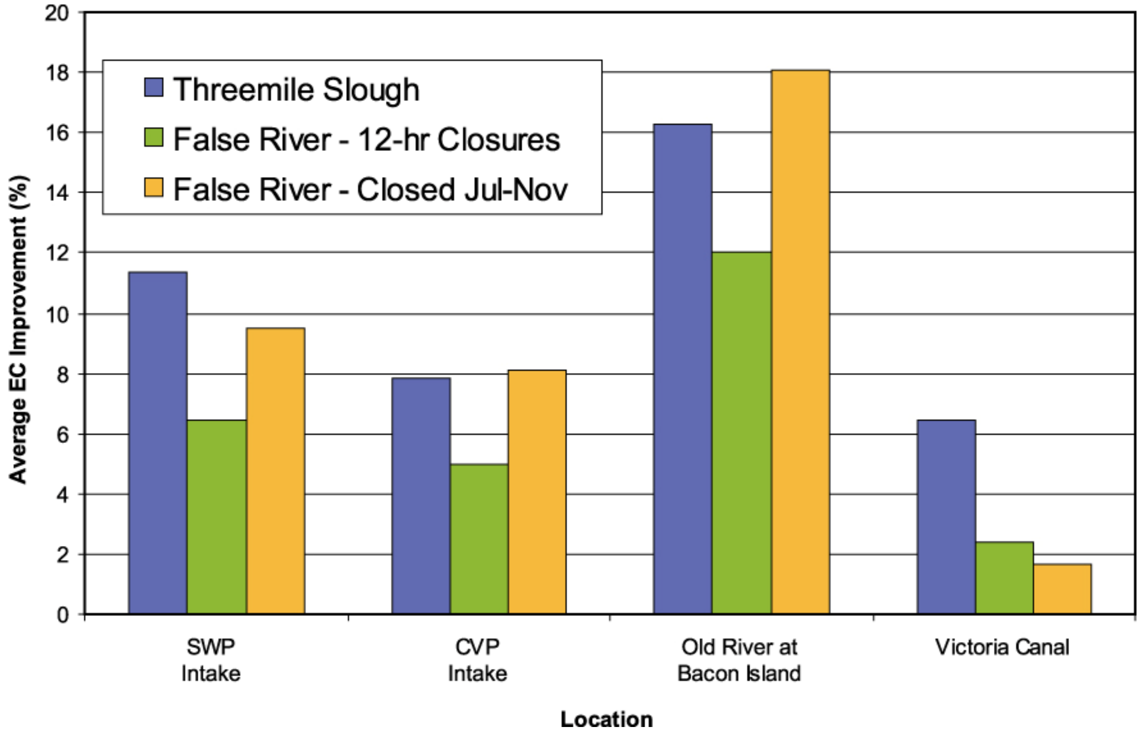
  - Close the Threemile Slough Barrier to deter entrainment of sensitive fish species (e.g., delta smelt) from the Sacramento River into the central and south Delta (i.e., prevent their movement into Threemile Slough).

  - Operate the Threemile Slough Barrier to control salinity intrusion into the central Delta while closing the DCC gates to protect outmigrating juvenile chinook salmon and steelhead.

  Preliminary computer modeling and analysis using 16 years of data (1976–1991) indicate that these alternatives provide salinity reduction at key locations: SWP intake, the CVP intake, Old River at Bacon Island, and Victoria Canal (Exhibit 1-5).

1.3.2 THROUGH-DELTA FACILITY

The CALFED ROD orders exploration of Delta conveyance projects that will improve Delta water quality while protecting the ecosystem and fishery recovery goals. Since the Sacramento River winter-run chinook salmon was listed as an endangered species in 1989, great care has been taken to protect its migration. Operating rules for the DCC gates have been developed to protect outmigrating salmon. In addition, several studies have monitored the salmon runs and the hydrodynamics in the Sacramento River. Study results indicate migration patterns, but they are not considered statistically conclusive for estimating operational and project impacts. To enhance the north and central Delta ecosystem, protect the salmon runs, and improve Delta conveyance in a Through-Delta Facility, more conclusive salmon studies would be necessary. Several studies (summarized in Section 4) have been conducted to understand the behavior of fish in the north and central Delta. In fall 2008, DWR will be conducting a regional north and central Delta study to obtain statistically significant patterns of salmon outmigration which will be utilized in the development of management tools. The tools will provide information for refinement of the DCC gate operations as well as investigations of alternative Through-Delta Facility intake locations, Franks Tract project operations, and future Delta facilities.



Franks Tract: Long-Term EC Reduction (July through November, WY 1976–1991) **Exhibit 1-5**

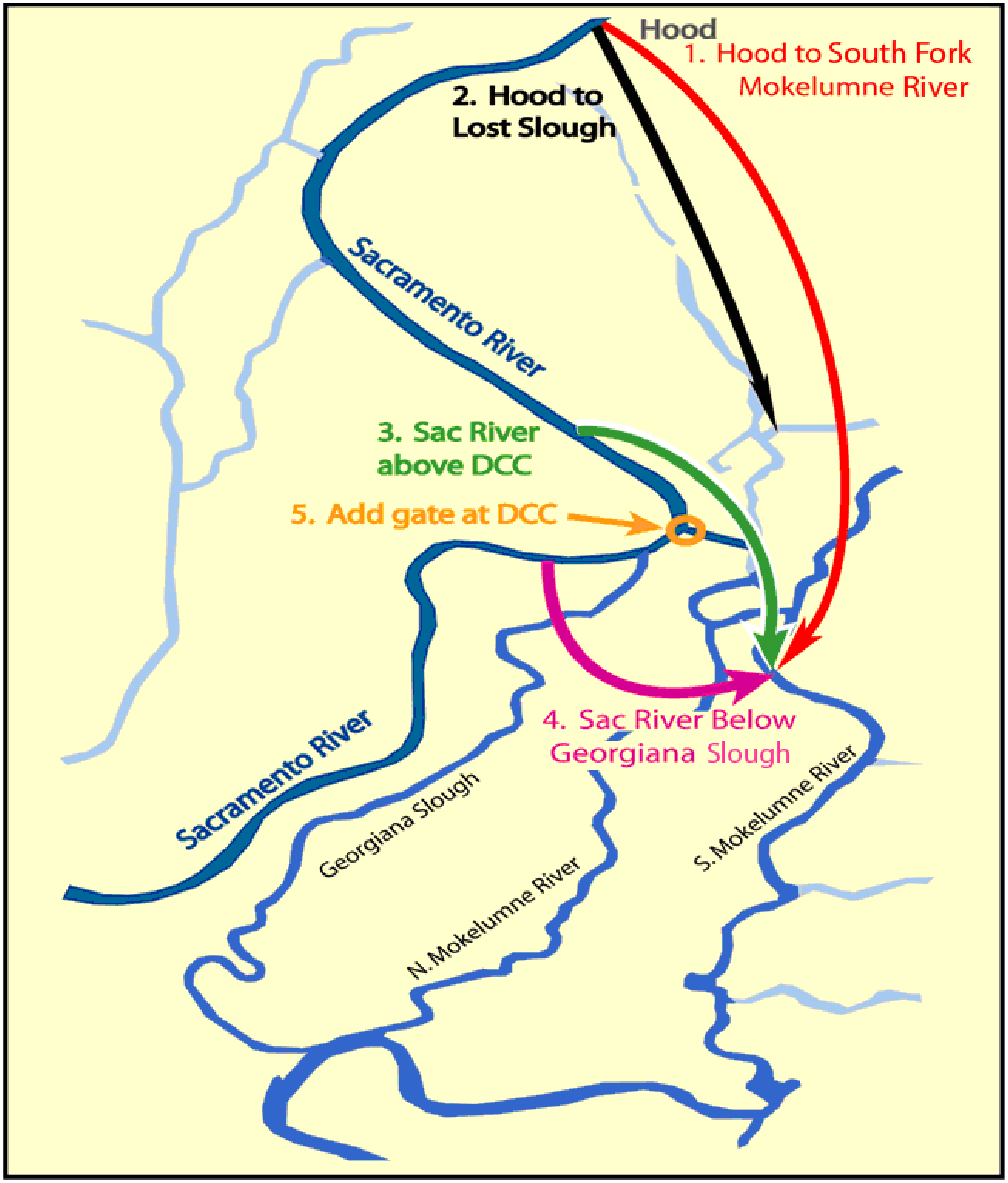
DWR has evaluated several alternative alignments (Exhibit 1-6) for a screened diversion facility to transfer up to 4,000 cfs between the Sacramento and Mokelumne Rivers. The additional freshwater flow into the central Delta would repel the salinity intrusion from the west and result in less-saline waters in the south Delta near the export facilities. Preliminary computer modeling indicates a monthly average of 17% reduction in salinity at Clifton Court Forebay in the fall. Each of these alignments could be operated in conjunction with Franks Tract and DCC projects. Currently, four alternatives for the TDF project have been identified for further review:

- **TDF Alignment 1:** This alternative would divert water from the Sacramento River at Hood and discharge into the South Fork of the Mokelumne River. It would include an intake facility, a fish screen structure, 14 miles of canal, siphons, and a pump station.

- **TDF Alignment 2:** This alternative would reduce the conveyance footprint and shorten the channel of the TDF. The channel would originate at Hood and discharge at Lost Slough, eliminating the Walnut Grove Road Bridge and Lost Slough and Mokelumne River siphons, thus shortening the channel by approximately 40%.

- **TDF Alignment 3:** This alternative would divert water from the Sacramento River near Walnut Grove and transport flows to the discharge point at the South Fork Mokelumne River. It includes a fish screen, a forebay, a trash barrier, a low head pump station, a floodgate, multiple pipes to the Mokelumne River, and an outlet structure.

- **TDF Alignment 4:** This alternative would divert Sacramento River water from below Walnut Grove to the South Fork Mokelumne River above Beaver Slough, bypassing Georgiana Slough. A 4.2-mile-long channel would be cut across Staten Island, and an on-river fish screen with a floating trash barrier would be included.



Source: DWR

Through-Delta Facility Alignments **Exhibit 1-6**

- **TDF Alignment 5 (DCC Gate Expansion):** This alternative would increase the conveyance capacity of the DCC gate structure by 50% by adding a third control gate to the structure. In addition, dredging downstream of the DCC in the Mokelumne basin would expand the channels, allowing higher flow.

1.3.3 DCC Reoperation

The DCC is a 0.75-mile-long, 25-foot-deep canal constructed by Reclamation in 1951 near the city of Walnut Grove to divert Sacramento River water into the central Delta through the Mokelumne River system (Exhibit 1-7). The channel was constructed with a design capacity of 3,500 cfs; however, summertime tidal flows in the DCC reach nearly 9,000 cfs daily, and the net flow in the DCC can exceed 10,000 cfs when the Sacramento River at Freeport is flowing near the 25,000-cfs mark. The pair of 30-foot by 60-foot radial gates at the Sacramento River end of the DCC usually are maintained in a fully open or completely closed position; they are often closed in fall to protect juvenile spring- and winter-run chinook salmon outmigrants from entrainment in the central and south Delta via Old and Middle Rivers. When the gates are open, water enters the Mokelumne River system through the DCC, exchanging with the central Delta to create a “freshwater corridor” in the central Delta (Exhibit 1-3). This corridor dilutes saline water entering from San Francisco Bay and is drawn to the SWP/CVP export facilities in the south Delta via Old and Middle Rivers. When the DCC gates are closed, this freshwater corridor is reduced because a portion of Sacramento River water flows downstream to Georgiana Slough and back into the Sacramento River. Evaluation of DCC Reoperation includes the examination of more flexible gate operations, which could improve Delta water quality and provide increased protection for certain Delta fishes.

Tasks for DCC Reoperation may consist of:

1. refurbishing the outdated DCC gates to allow for increased flexibility of DCC operations;

2. increasing the capacity of the DCC and downstream channels;

3. modifying the confluence design at the DCC to alter current hydrodynamics;

4. screening the widened DCC channel; and

5. using the DCC as an intake for the TDF project. In addition, the evaluation will include implementing different combinations of these options with other projects, including the Franks Tract and TDF projects.

1.4 SUMMARY OF STUDIES COMPLETED IN SUPPORT OF PROJECT WORK

Many studies have been completed to support the evaluation of the potential projects and their respective alternatives. Table 1-1 presents a summary of these studies and their key findings related to the three projects addressed in this report. Table 1-2 presents a summary of other (non-DWR–directed) studies relevant to the project work discussed in this report, and Table 1-3 presents summaries of continuing and planned actions under the direction of DWR in support of the project work.

Source: CALFED Independent Science Board 2002

Delta Cross Channel **Exhibit 1-7**

Table 1-1
Summary of Studies Completed under the Direction of DWR in Support of Project Work

Title	Prepared by and Date	Focus Area	Key Findings	Page Number
Screening Analysis of Delta Island Reclamation Alternatives for Ecosystem Restoration and Salinity Reduction	DWR 2000	Sherman Lake, Big Break, and Franks Tract	Reclamation of flooded islands such as Franks Tract and Big Break can result in reduced salinity in adjacent channels and in the central and south Delta.	2-1
Flooded Islands Feasibility Study, Baseline Report	DWR (EDAW) 2005	Franks Tract, Lower Sherman Lake, Big Break	This report characterized baseline conditions in each of the flooded islands and identified design phase data gaps.	2-1
Flooded Islands Conceptual Alternatives Report	DWR (NHI) 2005	Lower Sherman Lake, Franks Tract, and Big Break	This report identifies a series of Franks Tract alternatives to be further evaluated based on potential for salinity reduction.	2-2
Flooded Islands Pre-Feasibility Study Report	DWR (EDAW) 2005	Lower Sherman Lake, Franks Tract, and Big Break	This report identifies Franks Tract as the flooded island with the most potential to achieve goals of the Flooded Islands Project. It identifies and analyzes four alternatives to provide water quality, ecosystem, and recreation benefits.	2-2
Flooded Islands Pre-Feasibility Study, RMA Delta Model Calibration Report	DWR (RMA) 2005	Bay-Delta east of Martinez	This report describes calibration accuracy of the RMA Delta Model for phase, amplitude, flow, and salinity and identifies areas where further calibration is needed.	2-5
Flooded Islands Pre-Feasibility Report, Alternatives Modeling Report	DWR (RMA) 2005	Franks Tract and connecting water bodies	The East Levee and Two Gates Alternative was found to produce the greatest reductions in EC in Old River, but it increased salinity in Middle River.	2-5
Flooded Islands Pilot Project Study, Alternatives Modeling Report	DWR 2006	Franks Tract Region and south Delta export locations	Modeling results indicate that salinity reduction benefits of the project would be greatest in dry water years when Suisun Bay is the dominant EC source.	2-6
Technical Memorandum: Analysis of an Adaptive Management Framework to the Flooded Island Pre-Feasibility Study	DWR (NHI) 2006	Lower Sherman Lake, Franks Tract, and Big Break (Flooded Islands)	This technical memorandum characterizes the flooded islands pre-feasibility study's status relative to the adaptive management framework and provides a list of needed information for successful adaptive management.	2-6
Technical Memorandum: Hydrodynamic and Water Quality Modeling for Franks Tract Project Alternatives	DWR 2007	Franks Tract, adjacent channels, and the central and south Delta	Of the four alternatives modeled, only the Threemile Slough and the West False River alternatives provide salinity reduction in Victoria Canal in addition to other locations in the central and south Delta.	2-7

Table 1-1
Summary of Studies Completed under the Direction of DWR in Support of Project Work

Title	Prepared by and Date	Focus Area	Key Findings	Page Number
Franks Tract Value Engineering Study, Final Report	DWR 2007	Franks Tract, including Threemile Slough and False River	This summary report recommends the West False River and Threemile Slough alternatives for further analyses.	2-8
Technical Memorandum: Long Term Water Quality Modeling for Franks Tract Project	DWR 2007	Franks Tract region, central and south Delta	Modeling results show that the Threemile Slough alternative provides greater salinity reduction at the south Delta export facilities than the West False River alternative.	2-8
Through-Delta Facility White Sturgeon Passage Ladder Study	DWR (UC Davis) 2007	North Delta	The study resulted in the development of design criteria of a passage structure that helps wild adult white sturgeon to successfully migrate.	3-1
Technical Memorandum: Debris Rack Capture Efficiency and Fish Passage	DWR (UC Davis) 2007	North Delta	The study found that debris capture efficiency of trash racks is directly related to rack bar spacing and their installation angle.	3-1
Through-Delta Facility Prefeasibility Study, Draft Memorandum	DWR 2007	Sacramento River between Hood and the Mokelumne River	A 4,000-cfs TDF project from Hood to the South Fork Mokelumne River would require a 12-mile-long unlined canal; an intake facility with a floating trash deflector, floodgates, a service bridge, a service road, a fish screen, a fish bypass canal, and a pumping plant; five bridges; and an outlet structure. It would cost $360 million.	3-2
Through-Delta Facility Value Engineering Study, Final Report	DWR 2007	Sacramento River between Hood and Ryde	This report presents TDF designs and analyzes them for cost and potential water quality benefits. Several alternatives are recommended for further consideration. Increasing DCC capacity may be the most cost-effective alternative to convey Sacramento River water to the central Delta.	3-2
Technical Memorandum: Modeling of Value Engineering Study Alternatives for the Through-Delta Facility	DWR 2007	Sacramento River between Hood and Ryde and the Mokelumne River	Hood to the South Fork Mokelumne River and Sacramento River below Georgiana Slough to the South Fork Mokelumne River alignments produce the greatest modeled salinity reductions at Clifton Court Forebay.	3-4
Technical Memorandum: Modeling of a Delta Cross Channel Gate Extension	DWR 2007	Sacramento River at Hood	A combination of the expansion of the DCC gate and the opening of constricted channels in the lower Mokelumne River would provide substantial water quality improvements in the south Delta.	4-7

Notes: cfs = cubic feet per second; DCC = Delta Cross Channel; DWR = California Department of Water Resources; EC = electrical conductivity (salinity); NHI = Natural Heritage Institute; RMA = Resource Management Associates; TDF = Through-Delta Facility; UC Davis = University of California, Davis.

Table 1-2
Summary of Other (Non-DWR–Directed) Studies Relevant to Project Work

Title	Prepared By and Date	Focus Area	Key Findings	Page Number
Acoustic Tracking of Juvenile Chinook Salmon Movement in the Vicinity of the Delta Cross Channel, Sacramento River, California	USGS 2001	Sacramento River, DCC	The study showed that both diurnal and tidal cycles influence fish migration.	4-1
Acoustic Tracking of Juvenile Chinook Salmon Movement in the Vicinity of Georgiana Slough, Sacramento River, California	USGS 2003	Sacramento River at the confluence with the DCC and Georgiana Slough	Study results indicate that the location of fish entering a confluence below a bend is influenced by the strength of secondary circulation patterns upstream of the confluence.	4-1
Comparison of Relative Abundance of Adult Chinook Salmon in the Delta Cross Channel, Georgiana Slough, and Sacramento River	USFWS 2004	Sacramento River at the DCC and Georgiana Slough	Returning adult chinook salmon use the DCC as a migration corridor less than either Georgiana Slough or the Sacramento River, and Georgiana Slough less than the Sacramento River.	4-3
Movement of Juvenile Chinook Salmon in the Vicinity of the Delta Cross Channel, Fall 2001: Coded Wire Tag Recovery Component	USFWS 2004	Sacramento River at the DCC	Proportions of CWT chinook salmon recovered in the Sacramento River and DCC were significantly different, with an average of 10% recovered in the DCC.	4-3
Repeated Surveys by Acoustic Doppler Current Profiler for Flow and Sediment Dynamics in a Tidal River	USGS 2005	Sacramento River at the confluence with the DCC	ADCP mapping of flow vectors and river bathymetry was conducted to help understand juvenile chinook salmon movement in the vicinity of the DCC.	4-5
Relationship of Delta Cross Channel Gate Operations to Loss of Juvenile Winter-Run Chinook Salmon at the CVP/SWP Delta Facilities	DFG 2006	Sacramento River, DCC, and Georgiana Slough	The proportion of Sacramento River water diverted into the interior Delta via the DCC and Georgiana Slough is correlated with the proportion of juvenile winter-run chinook entrained at the pumps.	4-6
Estimating the Abundance of Sacramento River Juvenile Winter-Run Chinook Salmon with Comparisons to Adult Escapement	USFWS 2001	Sacramento River at Red Bluff	Estimates of escapement from carcass surveys were found to be a satisfactory replacement for Red Bluff Diversion Dam ladder counts.	5-1
Summary of Delta Hydrology Data, Water Years 1985–2004	USGS 2004	Delta	The Sacramento River contributed 84.5% of the fresh water to the Delta during the period examined.	5-1

Notes: ADCP = acoustic Doppler current profiler; CVP = Central Valley Project; CWT = coded wire tag; DCC = Delta Cross Channel; Delta = Sacramento-San Joaquin River Delta; DFG = California Department of Fish and Game; DWR = California Department of Water Resources; SWP = State Water Project; USFWS = U.S. Fish and Wildlife Service; USGS = U.S. Geological Survey.

Table 1-3
Summary of Continuing and Planned Actions under DWR Direction in Support of Project Work

Proposed Title	Participating Agencies and Date	Focus Area	Purpose	Page Number
Clarksburg Bend—Fish Study Results	DWR, USGS, Reclamation, and NRS ongoing	North and central Delta	Results will be used for planning of Regional Hydrodynamic and Salmon Outmigration Study.	6-1
Particle Tracking Modeling Results for Movement of Fish through the Delta	RMA and USGS ongoing	Franks Tract, TDF, DCC, and the entire Delta	This project is under way to evaluate the potential impacts of project alternatives on sensitive fish species, including salmon and delta smelt.	6-1
Regional Hydrodynamics and Salmon Outmigration Study in the Delta (TDF/DCC/Franks Tract)	DWR, USGS, Reclamation, USFWS, DFG 2008/2009	North and central Delta	This study will examine the effects of DCC gate operations on salmon outmigration and measure hydrodynamic and fish movement data to be used to develop participle tracking models.	6-1
Franks Tract NEPA/CEQA Documentation	DWR, Reclamation ongoing	Franks Tract, including Threemile Slough and West False River	The project will be initiated in January 2008 to conduct environmental review and prepare an environmental compliance document for the Franks Tract project.	6-2

Notes: CEQA = California Environmental Quality Act; DCC = Delta Cross Channel; DFG = California Department of Fish and Game; DWR = California Department of Water Resources; NEPA = National Environmental Policy Act; Reclamation = U.S. Bureau of Reclamation; RMA = Resource Management Associates; TDF = Through-Delta Facility; USFWS = U.S. Fish and Wildlife Service; USGS = U.S. Geological Survey.

2 FRANKS TRACT PROJECT

2.1 STUDIES AND KEY FINDINGS

Screening Analysis of Delta Island Reclamation Alternatives for Ecosystem Restoration and Salinity Reduction
C. Harrison, C. Enright, and K. Guivetchi
DWR, Suisun Marsh Branch
May 2000

Key Findings

Reclaiming existing breached islands such as Franks Tract can result in reduced salinity in adjacent channels. The DWR Delta Simulation Model Suisun Marsh Version (DSM1) results confirmed that tidal range and excursion are modified as the volume of the Delta fluctuates as a result of opening up existing Delta islands or closing existing openings in the Delta. Changes in tidal range vary based on the unique site conditions, size of openings, location, inundated volume, and overall geometry. In general, increased tidal range leads to increased tidal excursion and the resulting mixing of salt. Alternative configurations at Big Break and Franks Tract show potential for substantial salinity reductions in the south Delta, whereas Sherman Lake alternatives would provide marginal salinity reduction.

Background

DWR conducted a reconnaissance-level DSM1 modeling analysis to evaluate impacts of island reclamation alternatives on ecosystem restoration and salinity control in the western Delta. The following alternative configurations for Franks Tract, Big Break, and Sherman Lake were analyzed:

- Franks Tract: complete reclamation and small breaches on the east and west sides.
- Big Break: complete reclamation and complete reclamation with a 100-foot breach on the north side remnant of Dutch Slough channel.
- Sherman Lake: complete reclamation (no levee breaches); small breaches on the Sacramento River, Broad Slough, and San Joaquin River side of Sherman Lake; and alternative configurations of the remnant east side channel. These alternatives were explored in conjunction with widening Threemile Slough.

The downstream tidal boundary for the model is at the Golden Gate Bridge, thus removing the influence of the boundary on the solution. A historical condition simulation (base case, conducted for the period between October 1990 and September 1992) was used to provide a basis for comparison to the reclamation scenarios. All reclamation scenarios were simulated for the period between October 1991 and September 1992.

Flooded Islands Feasibility Study, Baseline Report
DWR (EDAW)
February 2005

Key Findings

The Baseline Report for the Feasibility Study of Ecosystem and Water Quality Benefits Associated with Franks Tract, Sherman Lake, and Big Break (Flooded Islands Feasibility Study) provides a comprehensive description of resources contained in or provided by the three study areas (Franks Tract, Big Break, and Sherman Lake). Data gaps were identified for the study areas that include soil types/mapping, multidimensional hydrodynamic and salinity modeling, information on water residence time, vegetation mapping for emergent portions of the study areas, site-specific information on fisheries community structure, and ownership of land areas in the study areas.

Further data gaps are identified for subsequent phases of the projects, including the effects of climate and global warming on the Delta; salinity modeling data; information on the sources, presence, and methylation of mercury in wetlands; the role of restored wetlands on dissolved organic carbon; and site-specific descriptions of the aquatic food web.

Background

The purpose of the Baseline Report for the Flooded Islands Feasibility Study was to evaluate the potential to create ecosystem, water quality, recreational, and other benefits at the flooded islands. The baseline report is a collection of information regarding issues to be considered in evaluating potential restoration alternatives and a description of the physical environment conditions at the study areas and in the Delta. Existing baseline descriptions and analyses for the flooded islands cover bathymetry; topography and sedimentation; geology, soils, and seismology; meteorology and climatology; water quality; aquatic, wetland, and terrestrial vegetation and habitats; the food web; fish and wildlife; invasive species of concern; land use; water use; recreation; and materials for restoration.

Flooded Islands Conceptual Alternatives Report
DWR (Natural Heritage Institute)
May 2005

Key Findings

The report outlined a series of preliminary alternatives for salinity reduction projects at Franks Tract, Big Break, and Sherman Lake. Several Franks Tract alternatives were identified as feasible and were recommended for further evaluation. None of the Big Break or Sherman Lake alternatives demonstrated significant reductions in salinity at the pumps and therefore were not analyzed further in the Flooded Islands Feasibility Report.

Background

The purpose of the *Flooded Islands Conceptual Alternatives Report* was to identify and screen a broad range of opportunities for modifying flooded islands, adjacent lands, and waters to improve ecosystem values, drinking-water quality, and recreational amenities through levee repairs, permanent barriers, operable tide gates, and large-scale marsh restoration. The report is divided into water quality elements, ecosystem elements, and recreation elements. Alternatives were evaluated based on water quality improvement elements, hydrodynamics, ecosystem parameters, water quality parameters, and recreation parameters.

Flooded Islands Pre-Feasibility Study Report
DWR (EDAW et al.)
June 2005

Key Findings

Preliminary modeling runs identified Franks Tract as the most effective location of the three flooded islands for modifications and improvements to achieve the stated goals of the Flooded Islands Feasibility Study. From a list of preliminary alternatives, four final preferred alternatives were identified and analyzed: West False River Gate, North Levee and Two Gates, East Levee and Two Gates, and Operable Gates on Holland Cut and Old River (Cox Alternative). The four preferred alternatives were developed, described, and evaluated based on modeling, evaluations against objectives, and fatal-flaw analyses (Table 2-1). Additional refinement and optimization of each of the preferred alternatives was recommended before a single preferred alternative is chosen.

The report briefly evaluated the results of a comparative analysis of the preferred alternatives for potential effects on fisheries. Four topics of concern were addressed: a potential increase in predatory fish species, delay in and impediment to fish movement and migration during summer and fall, reduction of connectivity and passage, and

Table 2-1
Screening Matrix and Summary Comparison of Fatal Flaws of the Preliminary Alternatives

	West False River Gate	North Levee, Two Gates	East Levee and Two Gates	Cox
Water Quality				
Reduction in average monthly EC at SWP pumps	↓	↓	↓	↓
Reduction in average monthly EC at CVP pumps	↓	↓	↓	↓
Reduction in average monthly EC at CCWD Old River	↓	↓	↓	↓
Reduction in average monthly EC at CCWD Rock Slough	↓	↓	↓	↓
Reduction in average monthly EC at Jersey Point	↓	↓	↓	↑
Reduction in average monthly EC at Middle River	↑	↑	↑	↑
Reduction in average monthly EC at Collinsville	↑	↑	↑	↑
Reduction in average monthly EC at Emmaton	↑	↑	↑	↑
Reduction in average monthly EC at Victoria Canal	↑	↑	↑	↑
Change in peak residence time in Franks Tract	■	↓	↑	↑
DOC (in Franks Tract)	↑	↑	↑	↑
DOC (at pumps)	■	■	■	■
Ecosystem				
Acres of tidal marsh habitat created	438	481	473	438
Protection of existing remnant levee and channel island habitat	Low	High	Medium	Low
Likely impact on *Egeria* (assumes no effective *Egeria* control)	■	↓	↑	↑
Recreation				
Navigation	↓	↓	↓	↓
Number of beaches	4	4	5	4
Acres of beaches	44	44	55	44
Number of mooring areas	5	6	8	6
Island Stability				
Adjacent island stability (reduction of wind fetch)	↑	↑	↑	↑
Stage maximums	■	■	↑	■
Implementation				
Cost of water quality features	$192,513,000	$200,826,000	$173,452,000	$176,812,000
Cost of ecological features*	$90,919,000	$96,904,000	$96,818,000	$90,918,000
Cost of beaches	$26,508,000	$26,508,000	$26,508,000	$26,508,000
Feasibilty	Yes	Yes	Yes	Yes

Legend

- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.
* Incidental habitat benefits are also included in costs of levees and beaches.

Source: Data provided by NHI in 2005

adverse effects from gates when open throughout winter and spring. Table 2-2 illustrates that all four alternatives appear to have adverse effects on fisheries in the Delta. However, having the gates open throughout winter and spring in the West False River Gate, East Levee and Two Gates, and Operable Gates on Holland Cut and Old River (Cox) alternatives would not be expected to adversely impede the downstream migration of juvenile chinook salmon or steelhead or the movements or distribution of fish eggs, larvae, juveniles, or other life stages of migratory or resident species. The specific effects of gate operation on fish migration would depend on seasonal and daily operations, water velocities and turbulence associated with gate opening, and the seasonal timing of fish movement in the area.

Table 2-2
Potential Effects on Fisheries of the Preliminary Alternatives

Alternative	Increase in Predatory Fish Species	Delay of and Impediment to Fish Movement and Migration during Summer and Fall	Reduction in Connectivity and Passage Opportunities	Adverse Effects from Gates Open throughout Winter and Spring
West False River Gate	Yes	Yes	No	No
North Levee and Two Gates	Yes	Yes	No	No
East Levee and Two Gates	Yes	Yes	Yes	No
Operable Gates on Holland Cut and Old River (Cox Alternative)	Yes	Yes	No	No

Background

The *Flooded Islands Pre-Feasibility Study Report* was initiated to develop and evaluate site concepts, individually and in combination, for their ability to provide water quality, ecosystem, and recreation benefits. The prefeasibility study followed a proven resource planning model with all the following components:

- definition of baseline conditions
- development of objectives
- identification of preliminary alternatives
- explanation of conclusions
- definition of a preferred project (or projects) and pilot program with recommended next actions for achieving three goals:
  - enhancing ecosystem values
  - improving water quality conditions at the CVP and SWP pumps
  - enhancing recreation opportunities

Flooded Islands Pre-Feasibility Study, RMA Delta Model Calibration Report
DWR (RMA)
June 2005

Key Findings

Resource Management Associates' (RMA's) Bay-Delta Model stage calibration for phase and amplitude proved to have high accuracy, with tidal amplitude within 5% of observed data and phase errors within 4 minutes. Flow and salinity calibration for the model are also very good, with predicted tidal flow amplitude typically within 5–10% of observed data, linear regression R2 values of 0.97 and greater, and tidally averaged electrical conductivity (EC) at the CVP intake matching observed data very closely. Several areas were identified where additional calibration efforts are needed, including areas where frictional resistance to flow causes net flow errors in Fisherman's Cut, False River, Threemile Slough, and the Mokelumne River. Specifically, it appears that too much flow is being conveyed from False River to the San Joaquin River via Fisherman's Cut rather than going through Franks Tract. Further, the model does not show enough variability in EC at the SWP and CVP export facilities.

Background

RMA developed a finite element model for one-, two-, and three-dimensional simulation of flow, salinity, water quality, and sediment transport in the Delta. This document serves to describe the calibration process and demonstrate the ability of the calibrated model to predict flow, stage, and EC (salinity) in the Delta. The objective of the calibration effort was to prepare the model for detailed evaluation of flow and salinity impacts associated with alternative configurations proposed in the Flooded Islands Pre-Feasibility Study. April through October 2002 was selected for the detailed calibration period because of the availability of extensive monitoring data collected by the U.S. Geological Survey (USGS) as part of a special study of the Franks Tract region.

Flooded Islands Pre-Feasibility Study, Alternatives Modeling Report
DWR (RMA)
June 2005

Key Findings

Simulation results showed potentially significant improvements in water quality in the Delta with implementation of Franks Tract project alternatives. The alternative producing the most significant overall reductions in EC, the East Levee and Two Gates Alternative, was found to reduce EC by as much as 19% at the SWP intake, 15% at the CVP intake, 27% at the CCWD Old River intake, 31% at the CCWD Rock Slough intake, and 16% at Jersey Point. These results stem from a reduction of salinity in Old River south of Franks Tract; however, EC is increased by as much as 8% in Middle River. The East Levee and Two Gates Alternative produced the longest residence times in Franks Tract (15 days), which is of concern because of the potential for associated increases in water temperatures and stagnation. Velocities in False River adjacent to Webb Tract are increased under the North Levee alternatives.

Background

The calibrated RMA finite-element model of the Delta was used to evaluate 10 alternatives for managing Franks Tract to improve water quality in the south Delta. Ten alternative scenarios were simulated to examine the impacts around Franks Tract on EC, stage, velocity throughout the Delta, and residence time in Franks Tract. April through December 2002 was selected as the analysis period for the prefeasibility alternative simulations because this period corresponded with the most recent detailed calibration period for the RMA Delta Model and the extensive field monitoring program by USGS in the Franks Tract region.

Flooded Islands Pilot Project Study, Alternatives Modeling Report
DWR (RMA)
January 2006

Key Findings

The results of RMA modeling indicate that the maximum EC reductions at the SWP intake were found to occur during August and July, when monthly average EC was reduced by 13%. Furthermore, the results indicate that the salinity reduction benefits of the project are greatest for dry water years and are reduced in wet years. DSM2 "fingerprint" analysis shows that the San Joaquin River and agricultural return water are the dominant EC sources at Clifton Court during wet months and wet years, whereas Suisun Bay salinity is the dominant source in dry years.

Background

The calibrated RMA finite-element model of the Delta was used to evaluate three initial study alternatives for management of Franks Tract to improve water quality in the Delta. This document describes the alternatives and reports results on predicted EC changes in the Delta. The three alternatives analyzed in the modeling report are West False River Gate Alternative 1, Eastside Levees Alternative 2, and Eastside Levees Alternative 3. Eastside Levees Alternative 2 includes closing (i.e., repairing) the southeast Franks Tract levees along Old River and Sand Mound Slough, whereas Eastside Levees Alternative 3 involves closing the east Franks Tract levees along Old River and isolating Franks Tract, False River, and Sand Mound Slough.

Historic conditions selected for analysis were:

- April 1, 1991, to December 31, 1992 (21 months),
- April 1, 1995, to December 31, 1995 (9 months),
- April 1, 2000, to December 31, 2000 (9 months), and
- April 10, 2002, to December 31, 2003 (21 months).

Technical Memorandum: Analysis of an Adaptive Management Framework to the Flooded Islands Pre-Feasibility Study
DWR (Natural Heritage Institute)
April 2006

Key Findings

A list of needed information was provided regarding the problem statement, measurable objectives, conceptual models, numerical modeling, and field research and pilot projects. The list identifies the need for more detail regarding the location and timing of elevated salinity problems at the drinking water diversion, specific quantifiable measures of salinity reduction, more explanation for justifying the focus on constraining tidal excursion in Franks Tract with gates, additional fine-tuning and data collection, additional hydrodynamic data from stations around Franks Tract, and improved model calibration and modeling of multiple year classes under varying water year types.

Background

This technical memorandum reexamines the core elements of the prefeasibility study in the context of the adaptive management framework in the anticipation of guiding development of subsequent planning and pilot project implementation. It evaluates the water quality, ecosystem function, recreational deficiencies, and flooding components based on information and insights derived from the prefeasibility study. It also discusses the need to refine previous measurable objectives for the aforementioned components and addresses issues of interconnection between the different actions/efforts detailed in the conceptual model. The memorandum emphasizes the need for additional fine-tuning, data collection necessary to calibrate models, and field research for the flooded islands study.

Technical Memorandum: Hydrodynamic and Water Quality Modeling for Franks Tract Project Alternatives
B. Shrestha, DWR
October 2007

Key Findings

Of the four alternatives for the Franks Tract project, modeling showed that the Threemile Slough Alternative and the West False River Alternative reduce sea water intrusion and provide the most salinity reduction (Table 2-3) at key export locations in the south Delta. The Threemile Slough Alternative provides relatively greater salinity reduction in Victoria Canal compared to the other three alternatives. The East Levee and Two Barriers Alternative and the Cox Alternative increase salinity in the Victoria Canal. The Threemile Slough Alternative may provide additional benefits: (1) reducing salinity in the central and south Delta if DCC gates are closed to enhance fish migration and (2) reducing salinity during small to medium levee failures in the central and south Delta by increasing net flow in the San Joaquin River to prevent seawater intrusion.

Table 2-3
Comparison of Average EC Reduction for July 15 to November 30, 2002

Alternative	SWP Intake	CVP Intake	CCWD Intake (Old River)	CCWD Intake (Rock Slough)	Victoria Canal
West False River	12.7%	9.5%	16.6%	18.9%	1.6%
East Levee + 2 Barriers	4.0%	0.9%	10.9%	9.4%	-16.5%
Cox Alternative	5.2%	1.3%	12.7%	17.9%	-17.9%
Threemile Slough	20.9%	16.7%	23.7%	24.3%	12.7%

Background

The RMA Bay-Delta model was used to evaluate the potential salinity reductions of four Franks Tract project alternatives at south Delta locations. The four alternatives modeled in this study were:

- West False River Barrier Alternative,
- East Levee and Two Barriers Alternative,
- Cox Alternative (barriers on Holland Cut and Old River), and
- Threemile Slough Operable Barrier Alternative.

Simulations were performed for April 10, 2002 (dry year), through January 1, 2003, for all four alternatives.
A comparative result showed that the West False River and Threemile Slough Alternatives outperformed the other two alternatives in reducing salinity at south Delta export facilities. A second series of simulations was performed for the West False River and Threemile Slough Alternatives. These simulations were performed for critical water years 1992 and 1994 and for dry water year 2001. The results from this study were presented to the Value Engineering (VE) team to evaluate the cost-effectiveness and feasibility of the four alternatives.

Franks Tract Value Engineering Study, Final Report
DWR
June 2007

Key Findings

Out of the four alternatives for the Franks Tract project, the two most valued alternatives are the West False River Alternative and the Threemile Slough Alternative. The study evaluated several types of barriers for use in those river channels, and it concluded that pneumatically operated bottom-hinged gates are the most suitable. The study recommended using "in-the-wet" construction methods for installing the gates. The estimated construction cost for the Threemile Slough Alternative would be $43 million and for the West False River Alternative would be $62 million, not including boat passage. These costs do not include costs of design, permits, and construction management.

Background Report

The VE team included experts in the field of hydraulics, environment, fisheries, levees, design and construction of hydraulic structures, and hydraulic gates. These experts had an understanding of and experience working in the Delta and were independent of the DWR in-house planning team.

A VE study was conducted to evaluate the four Franks Tract project alternatives: (1) West False River Alternative, (2) East Levee and Two Gates Alternative, (3) Operable Gates on Holland Cut and Old River (Cox Alternative), and (4) Threemile Slough Gate Alternative. The VE team was supplied with hydrodynamics and water quality results, conceptual designs of the water control facilities, and construction cost estimates. The team brainstormed several additional alternatives and evaluated various types of barrier/gate structures and construction methods, fish passage effects, and project operations.

Technical Memorandum: Long Term Water Quality Modeling for Franks Tract Project
B. Shrestha, DWR
October 2007

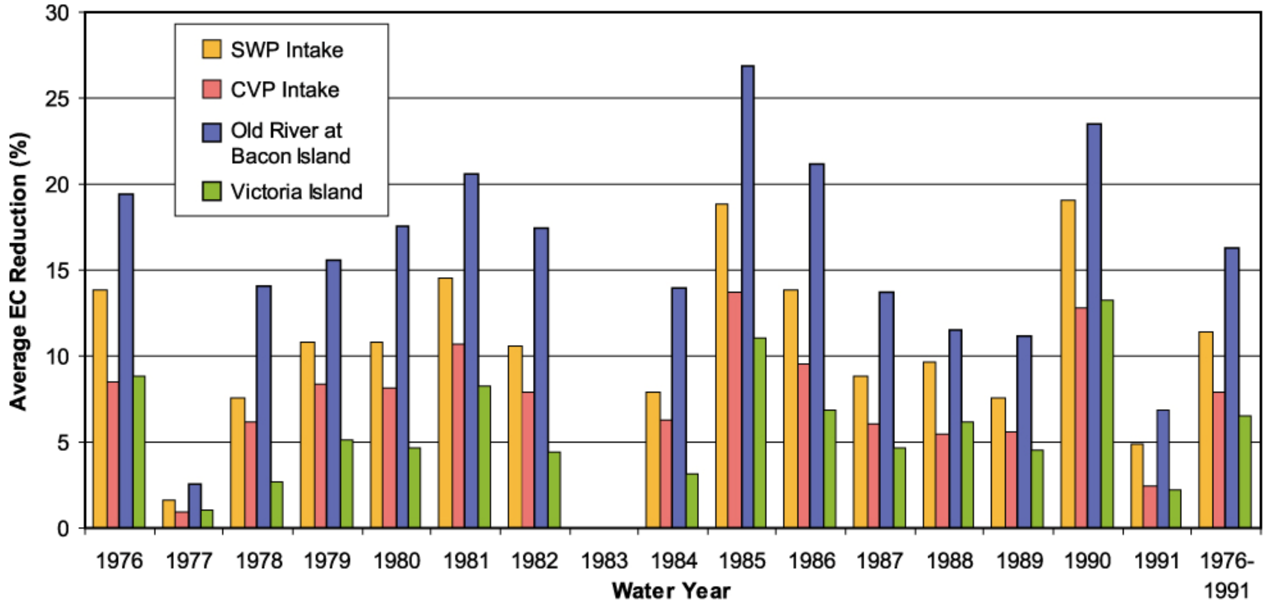
Key Findings

The Threemile Slough and the West False River Alternatives would provide salinity reductions at four key locations: SWP intake, CVP intake, Old River at Bacon Island, and Victoria Canal. The 16 years of modeling results (Exhibits 2-1 and 2-2) show that the Threemile Slough Alternative provides salinity reductions on the order of 6–16% and that the West False River Alternative provides salinity reductions on the order of 2–12% at key locations.

Background

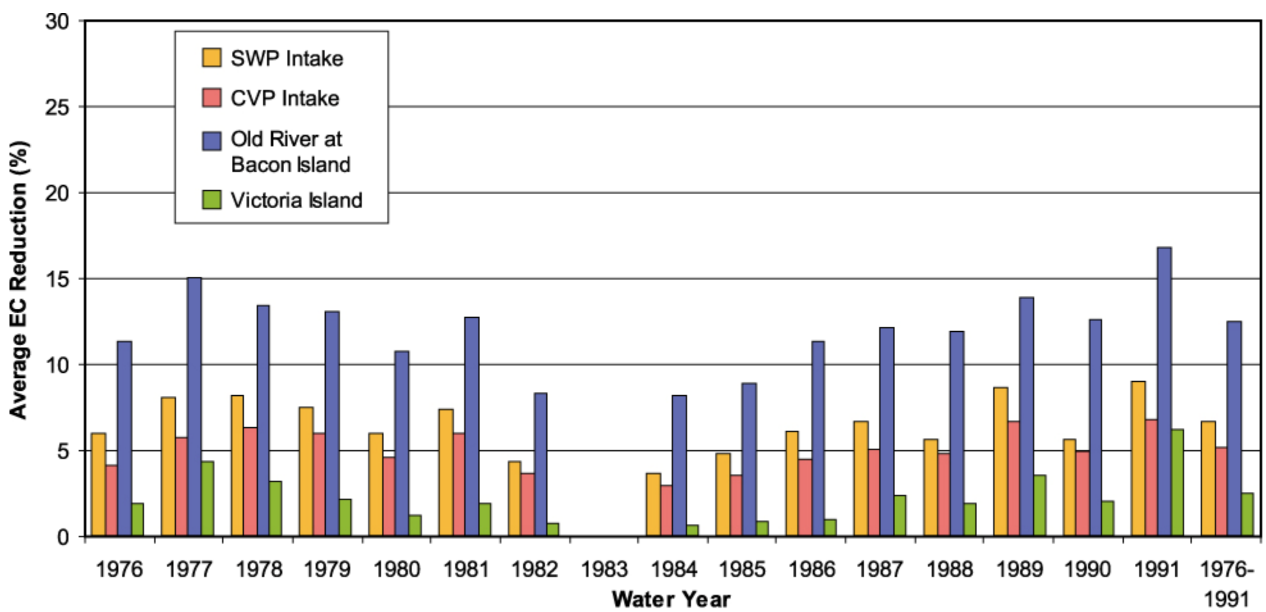
DSM2 hydrodynamics and water quality modeling runs (water years 1976–1991) were performed for the Threemile Slough and the West False River Alternatives. Delta inflows and exports were obtained from the California Simulation Model (CALSIM). The CALSIM simulation was based on CVP/SWP Operation Criteria and Planning for a 2001 level of development.

The Threemile Slough barrier was operated on a tidal basis, with the barrier closed for a few hours (usually approximately 2–6 hours) during ebb tides with the objective of balancing net (tidal) flows in the Sacramento River (at Emmaton) and the San Joaquin River (near Jersey Point). Two operational schemes were considered for the West False River barrier: (1) opening and closing the West False River barrier on a 12-hour cycle and (2) keeping the barrier closed from July through November.



Note: Water year 1983 was an extremely wet year with no salinity intrusion in the central and south Delta; therefore, modeling results showed no salinity reductions.

Average Yearly EC Reduction with Threemile Slough Alternative (WY 1976–1991) **Exhibit 2-1**



Note: Water year 1983 was an extremely wet year with no salinity intrusion in the central and south Delta; therefore, modeling results showed no salinity reductions.

Average Yearly EC Reduction with West False River (Open/Close Gate Operation) Alternative (WY 1976–1991) **Exhibit 2-2**

3 THROUGH-DELTA FACILITIES

3.1 STUDIES AND KEY FINDINGS

Through-Delta Facility White Sturgeon Passage Ladder Study
Fishery Improvements Section, DWR (UC Davis)
December 2007

Key Findings

The TDF White Sturgeon Passage Ladder Study resulted in the development of design criteria of a passage structure that would help adult white sturgeon to successfully migrate. A series of guidelines was developed that addresses the key components of a successful sturgeon passage ladder, including water velocities, depths, slope, and minimum dimensions. The study also identified the optimal conditions for passage success and the most extreme conditions (high/low velocities, slopes) under which sturgeon passage could occur. The prototype ladder passage structure used energy-dissipating baffles that contracted the flow, used a flow-straightening section in the baffle, and then obtained additional energy losses from the expansion of the flow. The baffle design also minimized turbulence and eddies along the downstream face of the baffle and prevented fish collisions by using a sloping face on the leading face of the baffle.

Background

The swimming performance of wild-caught white sturgeon (*Acipenser transmontanus*) was tested in a large aluminum flume at the University of California, Davis, J. Amorocho Hydraulics Laboratory beginning in 2003 and continuing through 2005. The test flume and prototype passage ladder were constructed to determine the feasibility of a sturgeon ladder passage and to evaluate its use with the DCC or a TDF. Swimming performance tests were conducted to quantify the swimming capabilities of adult wild-caught white sturgeon and to identify physiological and behavioral parameters that may be used to design fish passage structures. In addition to the performance, physiological, and behavioral parameters, the hydraulic requirements of a passage structure were evaluated to determine the necessary energy dissipation essential to support sturgeon passage. The first 2 years of the study evaluated the behavior and swimming performance of adult wild-caught white sturgeon and their interaction with barriers, hydraulics, flow control, and other key components of a passage ladder structure. In the final year, a prototype random midsection of a sturgeon ladder was constructed and evaluated.

Technical Memorandum: Debris Rack Capture Efficiency and Fish Passage
Fishery Improvements Section, DWR (UC Davis)
December 2007

Key Findings

This DWR technical memorandum presents the summary of the trash rack study performed by the UC Davis research team in 2001–2003. The study looked into the debris removal performance of different bar spacing and rack inclination angles. The study found that the debris capture efficiency of racks is directly related to rack bar spacing and installation angle. As the debris rack bar spacing is decreased, capture efficiency increases. The highest capture efficiency is produced with 1.5-inch bar spacing. As the debris rack incline angle (from vertical plain) is decreased, the capture efficiency increases. In other words, as the debris rack is progressively lowered in the direction of the flow, the capture efficiency decreases. Increased flow velocity also contributed to a reduction in capture efficiency. As the approach velocity was increased from 1 foot per second to 2 feet per second, capture efficiency decreased for all bar spacings and all incline angles.

Background

The largest diversions in California's Delta are at the CVP's Tracy Pumping Plant/Delta-Mendota Canal and the SWP's Banks Pumping Plant/California Aqueduct. These facilities divert as much as 65% of the total Delta outflow, drawing large numbers of fish into the south Delta. Many of these fish are listed as threatened or endangered. To aid in the survival of these species, CALFED identified several programs, such as an alternative through-Delta conveyance facility action. To help in designing new diversion facilities on the Sacramento River, DWR and the University of California, Davis, J. Amorocho Hydraulics Laboratory jointly developed the debris rack study in 2001. The goal of the study was to research, evaluate, and recommend a debris rack configuration for effective debris removal and fish passage by testing several debris rack configurations with variations in bar spacing, incline angle, and flow velocity).

Through-Delta Facility Prefeasibility Study, Draft Memorandum
DWR
March 2007

Key Findings

The memorandum identifies design components, engineering considerations, channel alignment and geometry, intake facility components, bypass facilities (including bridges and siphons), operation and maintenance issues, and project cost estimates for the proposed alignment (Exhibit 3-1) of the TDF project. Hydrology and geology were considered in the investigation, including river stage, groundwater, suspended sediments, cross drainage, and foundation condition. The project components deemed necessary include a 12-mile-long unlined canal with sides sloped at 3H:1V on the inside and 2H:1V on the outside and a longitudinal slope of 0.0001; an intake facility with a floating trash deflector, floodgates, a service bridge, a service road, a fish screen, a fish bypass canal, and a pumping plant consisting of five axial pumping units with capacities of 833 cfs each; three siphons to cross Stone Lake Drain, Lost Slough, and the Mokelumne River; five bridges; and an outlet structure with a riprap floor. The estimated capital cost of the project is $360 million.

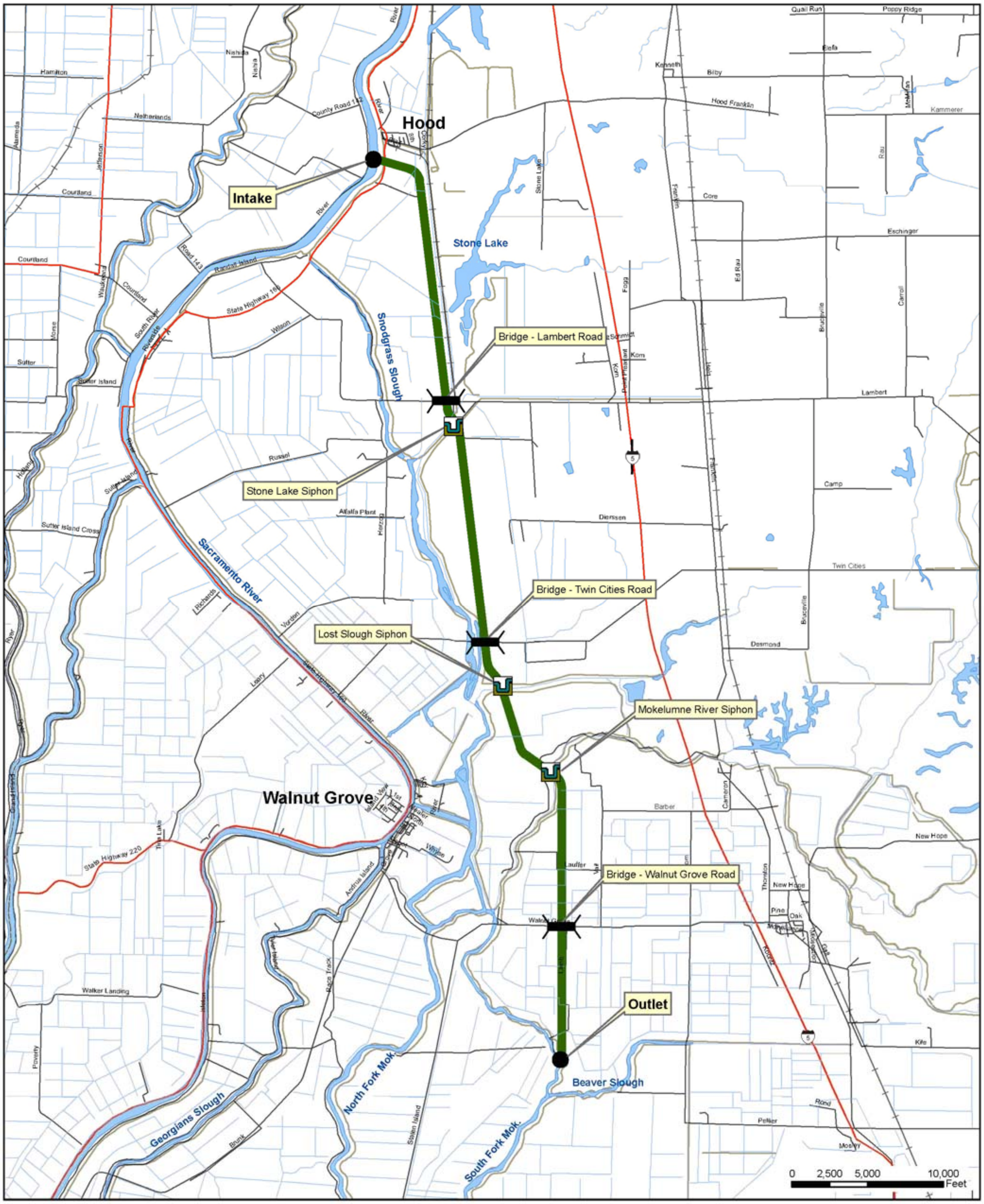
Background

The Division of Engineering at DWR conducted a prefeasibility study for a 4,000-cfs screened diversion facility on the Sacramento River. The alignment considered in the study would divert Sacramento River water from Hood to the South Fork of the Mokelumne River upstream of Beaver Slough. As part of the CALFED ROD, the TDF project is envisioned to divert 4,000 cfs of Sacramento River water at Hood and convey the water to the Mokelumne River system. Exhibit 3-1 shows the alignment of TDF project and its various components.
A preliminary cost estimate also was prepared as part of the study.

Through-Delta Facility Value Engineering Study, Final Report
DWR
June 2007

Key Findings

The scope of the VE study was to evaluate the TDF alignment developed by DWR and identify improvements and propose additional alternatives that would convey 4,000 cfs of Sacramento River water to the central Delta. The TDF alternative originally proposed by DWR involved diverting water from Sacramento River at Hood and discharging it into the South Fork of the Mokelumne River. Several TDF alignments were identified for further analysis; however, an increase in DCC capacity was recommended as the most cost-effective alternative. In-canal V-shaped fish screens were recommended as the most economically feasible fish barrier. A fish barrier on the discharge end was recommended to reduce upstream migration.



Source: TDF Pre-Feasibility Study Draft Report

TDF Project Location **Exhibit 3-1**

Background

The VE team included experts in the field of hydraulics, the environment, fisheries, design and construction of low-head pumping stations, fish screen structures, fish passage, and hydraulic structures. These experts had an understanding of and experience working in the Delta and were independent of the DWR in-house planning team.

The objectives of the study were to:

- determine the technical feasibility of the proposed plan, including fisheries impacts;
- recommend a preferred alignment;
- provide any relevant criteria for design and construction; and
- provide any relevant criteria for operations.

The TDF alignment originally proposed by DWR begins on the Sacramento River near Hood and ends at the South Fork of the Mokelumne River, near Beaver Slough or at Snodgrass Slough near Lost Slough. The alignments recommended by the VE team are detailed below in Table 3-1 and in Exhibits 3-2 and 3-3.

Technical Memorandum: Modeling of Value Engineering Study Alternatives for the Through-Delta Facility
J. Wilde, DWR
September 25, 2007

Key Findings

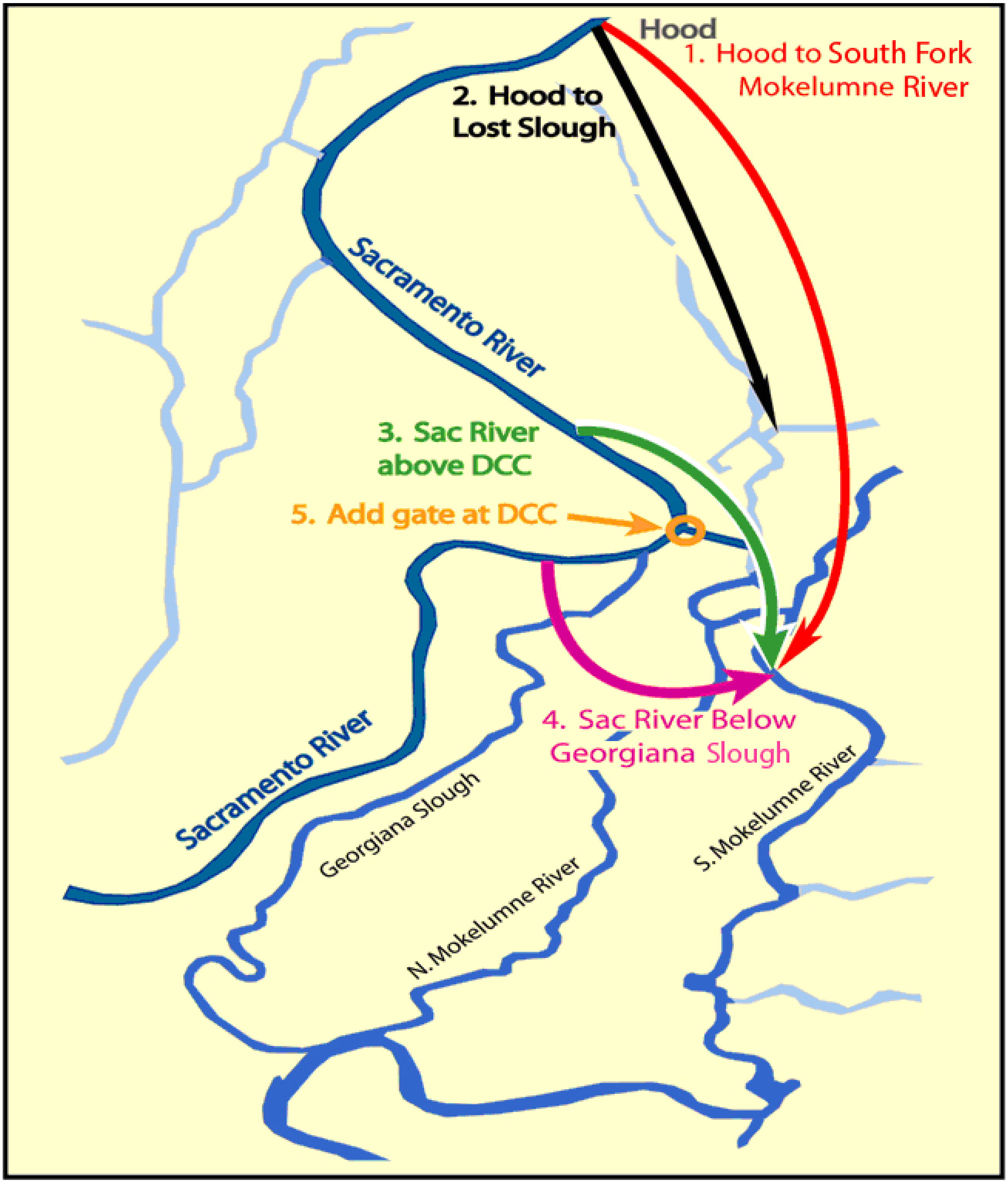
An alignment from Hood to South Fork Mokelumne River and an alternative alignment across Georgiana Slough would produce the largest reductions in salinity of the modeled TDF alternatives identified for further investigation in the VE report. Although all the TDF pumping projects would reduce transfer flow through the DCC, these two alignments would produce a monthly average 17% reduction in salinity at the Clifton Court Forebay in fall. Modeled dissolved organic carbon levels, however, were not greatly reduced under any of the TDF alternatives.

Background

DWR is exploring alternative designs for the TDF to transfer 4,000 cfs of Sacramento River water to the central Delta. Using the Delta Simulation Model (DSM2), RMA modeled the higher ranked alternatives identified by the VE study completed in March 2007. Results of four TDF alternatives are summarized in Exhibit 3-4.

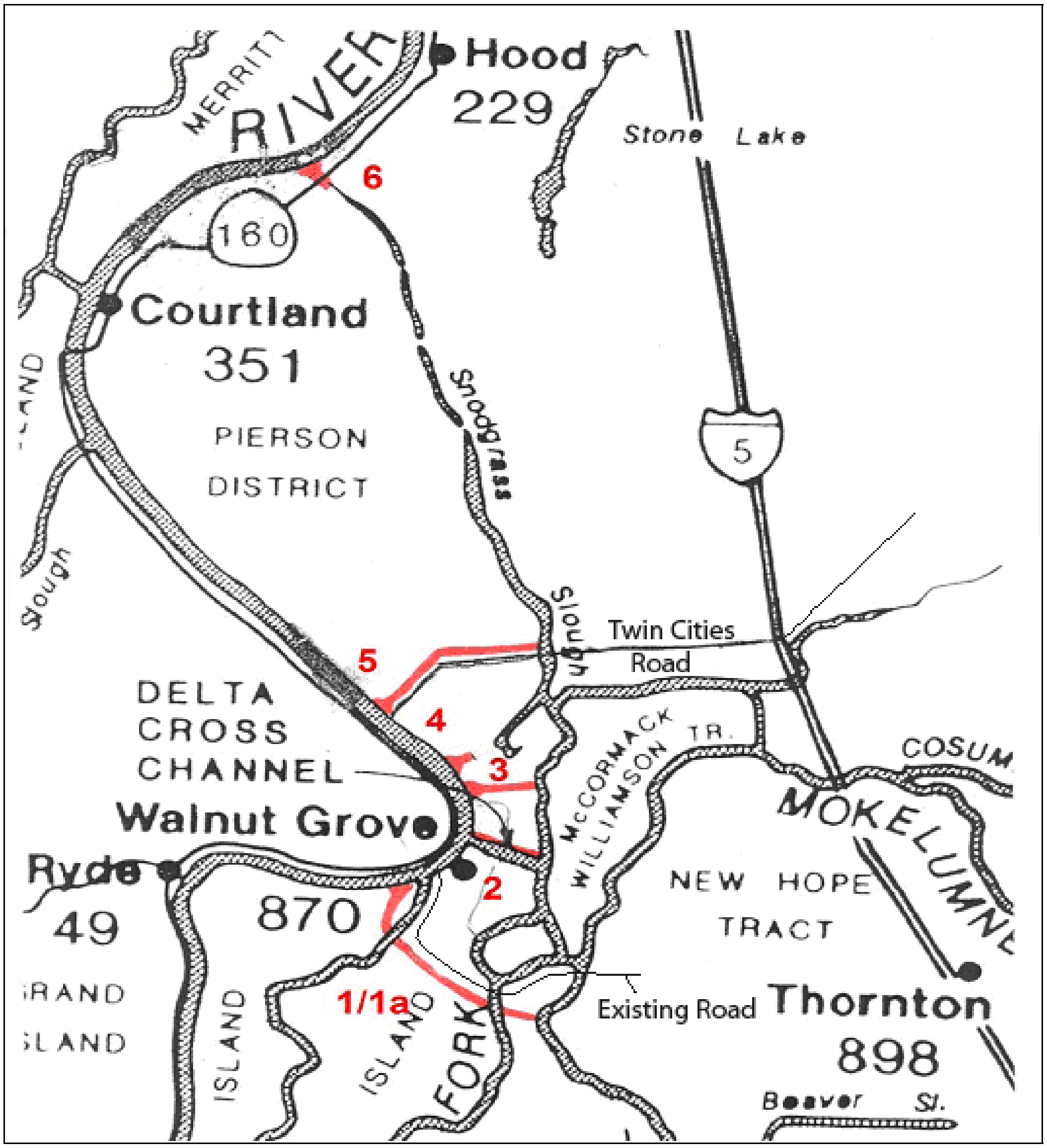
Table 3-1
Details of Selected TDF Alternatives in the VE Report

Details of Alternative 1	
Description:	Divert 4,000 cfs from the Sacramento River at Hood, and convey the water in an open channel to the South Fork Mokelumne River.
Advantages:	Would convey water from higher upstream on the Sacramento River to the South Fork Mokelumne River, so this alternative may provide the best water quality of the examined alternatives.
Disadvantages:	This is a costly alternative. It is the longest conveyance alternative and requires a higher degree of engineering and right-of-way activities.
Details of Alternative 2	
Description:	Divert 4,000 cfs from the Sacramento River at Hood, and convey the water in an open channel to Lost Slough.
Advantages:	Would reduce cost by eliminating 40% of the Alternative 1 alignment, two siphons, and one bridge and would reduce footprint by having a shorter, narrower channel.
Disadvantages:	May provide a reduced water quality benefit, would deliver flows to an area with hydrologic constraints, and may cause a backwater at the DCC.
Total Estimated Cost:	$358,935,570
Details of Alternative 3 A, B, and C	
Description:	Divert 4,000 cfs from Walnut Grove/Locke and discharge the water into (A) the Mokelumne River, (B) Snodgrass Slough, or (C) the South Fork Mokelumne River.
Advantages:	Would reduce cost; would not use the site at Hood, which may be needed for a future canal; and would strengthen levees along a portion of the Sacramento River from Hood to Locke.
Disadvantages:	May provide a reduced water quality benefit, possible increased public/environmental impacts, and possible impacts on the hydraulics of the DCC.
Total Estimated Cost:	(A) $389,861,010, (B) $232,555,653, (C) $450,430,610
Details of Alternative 4	
Description:	Divert 4,000 cfs from the Sacramento River below Georgiana Slough, and cut a channel across Staten Island to the South Fork Mokelumne River.
Advantages:	Would require a shorter channel to be cut (4.2 miles versus 12 miles), fewer siphons and bridges, and no trash barrier.
Disadvantages:	Would provide a slight reduction in water quality benefit, would be slightly outside of ROD limits, and certain components would have greater construction costs.
Total Estimated Cost:	$316,554,000
Details of Alternative 5	
Description:	Refurbish DCC gates, increase diversion capacity by up to 4,000 cfs, and add fish screens.
Advantages:	Would increase reliability of DCC diversions, increase flexibility of canal operations, and reduce diversion of fish.
Disadvantages:	Would provide potential downstream channel improvements, which may be costly and result in potential changes in downstream surface elevations.
Total Estimated Cost:	12,000 cfs, $369,383,000; 4,000 cfs, $140,583,000
Details of Alternative 6	
Description:	Divert a total of 4,000 cfs from the Sacramento River at multiple locations between Hood and Ryde. The location, size (capacity), and configuration of each diversion would be based on the capacity of the receiving channel.
Advantages:	Would require shorter and smaller conveyance channels, would preserve the site at Hood, and could be constructed in phases.
Disadvantages:	Would provide a possible reduction in water quality improvement and have marginally greater operation and maintenance costs.
Total Estimated Cost:	Site 1, $60,653; Site 1a, $49,450; Site 2, $57,633; Site 3, $57,105; Site 4, $54,513; Site 5, $52,490; Site 6, $55,655



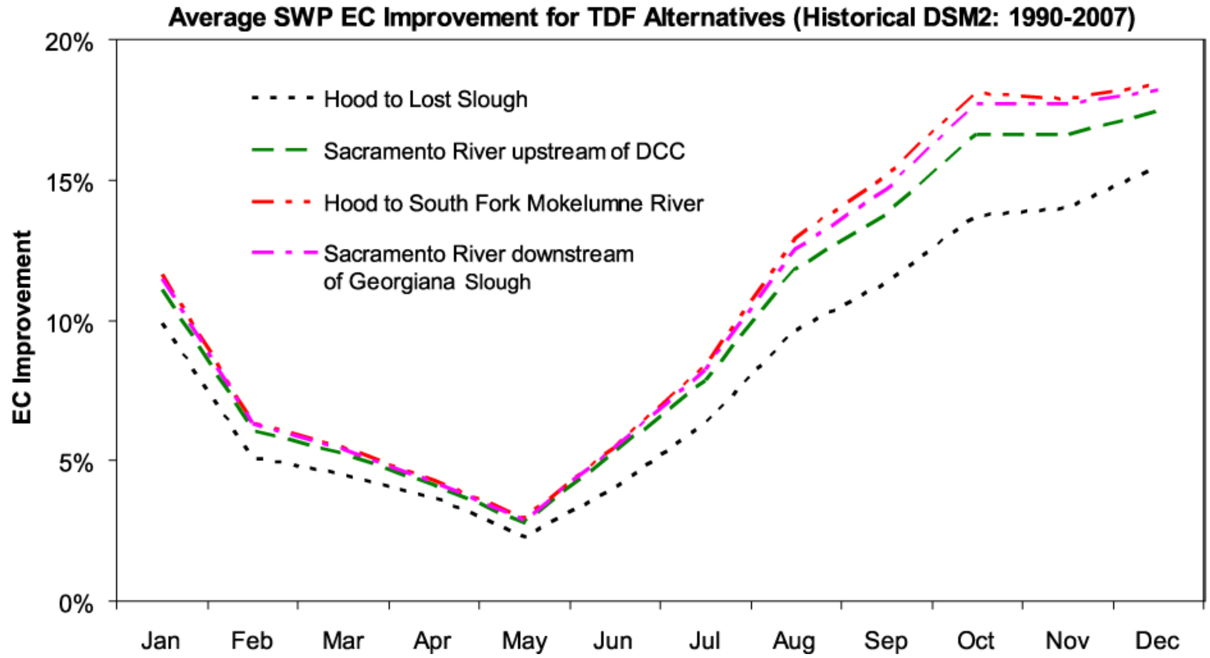
Source: DWR

Drawing of Alternatives 1–5 **Exhibit 3-2**



Source: Value Engineering Study, Through-Delta Facility

Drawing of Alternative 6 **Exhibit 3-3**



Average Long-Term TDF Alternative Salinity Improvements at Clifton Court Forebay Compared to the Historical Simulation as Modeled with DSM2 **Exhibit 3-4**

4 DELTA CROSS CHANNEL REOPERATION

4.1 STUDIES AND KEY FINDINGS

Acoustic Tracking of Juvenile Chinook Salmon Movement in the Vicinity of the Delta Cross Channel, Sacramento River, California
U.S. Geological Survey
2001

Key Findings

This study of two releases of Sacramento salmon smolts in 2001 found that increased fish in the water column at night combined with an approaching flood tide noticeably increased entrainment into the DCC when the gates are open. There seemed to be little daytime smolt movement into the DCC. Nighttime movement into the DCC, however, was noticeable, indicating crepuscular activity. The study showed that both diurnal and tidal cycles influence fish migration. Most smolts in the local vicinity of the DCC gates are entrained by a combined Sacramento River flow pushing downstream and an incoming flood tide pushing upstream into the cross channel. High entrainment into the DCC did correlate with flow, but there were times of smolt movement into the cross channel when there was little flow into the cross channel. The data also indicate that the smolts are not evenly distributed across the Sacramento River cross section. Secondary cross current around the river bends may be the cause.

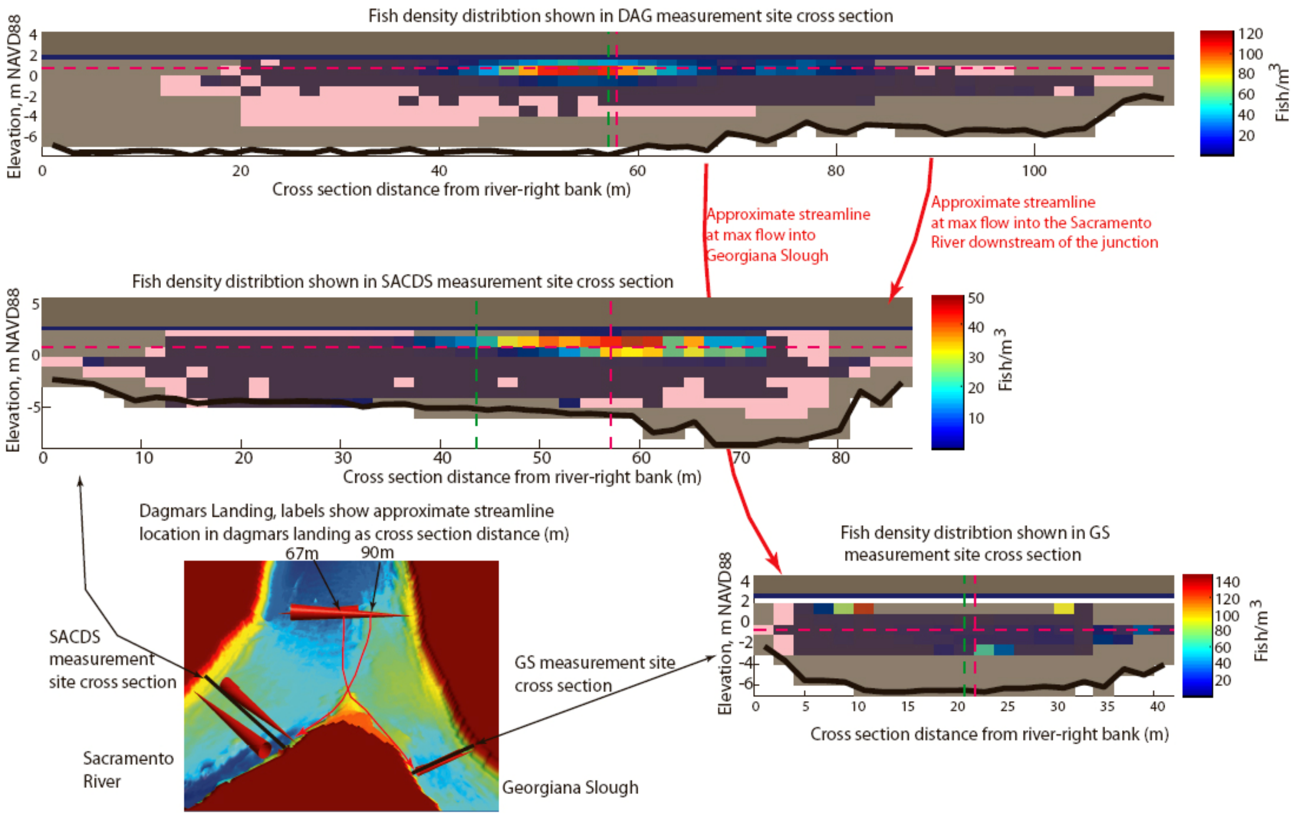
Background

A 2001 multiagency hydrodynamic and fish study in the Sacramento River and DCC vicinity consists of two replicate studies that involved releasing juvenile salmon with coded wire tags (CWT) along with some passive drifters over 30-hour periods upstream of the DCC. The local vicinity of the DCC junction was monitored with stationary hydroacoustic fish-tracking units, as well as acoustic Doppler current profilers (ADCPs) for hydrodynamics. The analysis of the field study incorporated spatial and temporal variation and pattern examination of hydrodynamic, fisheries, and environmental data.

Acoustic Tracking of Juvenile Chinook Salmon Movement in the Vicinity of Georgiana Slough, Sacramento River, California
A. Blake and M. J. Horn
U.S. Geological Survey
2003

Key Findings

Study results indicate that the location of fish entering a flow split downstream of a bend is influenced by the strength of secondary circulation patterns upstream of the flow split. Data obtained from acoustic transducers showed consistent patterns in the location and timing of fish detections, seemingly determined by physical signals, such as upstream water velocity and the amount of flow entering Georgiana Slough. Given the study area's geometry, these predictive relationships suggest that an increase in the strength of secondary circulation currents causes fish density to move toward the outside of the bend about the junction with Georgiana Slough. Fish entering the control volume at Dagmar's Landing were found to hold in the top 2 meters of water in one of two horizontal locations: in the center of the channel or along the left bank. These findings reinforce the importance of considering the interplay between channel geometry, hydrodynamic processes, and fish behavior when designing or reconfiguring diversions and intake structures. In addition, the evidence of juvenile holding behavior and preferential selection of outmigration periods suggests that juvenile entrainment in diversions could be reduced through diurnal gate operations because fish exhibited holding behavior until dusk when migration takes place during crepuscular periods. A graphical representation of river cross sections and fish density is provided in Exhibit 4-1.



River cross sections at the measurement site showing all the fish density detected for the analysis period. Fish density is shaded by magnitude. Areas in the cross sections with beam coverage but no fish detections are shown in light pink. Areas of the river cross section that were wet during the study but that did not have beam coverage are shown in gray. The elevation of the river bottom is drawn in a thick black line. The elevation of maximum stage is drawn as a thick, horizontal blue line. The horizontal center of the river cross section (0.0 Horizontal first moment) is shown as a dashed green line. The fish-density distribution center of mass (horizontal and vertical first moment) is located with dashed purple lines. The cross sections are aligned based on approximate streamlines at maximum flow into each confluence, so that each downstream distribution is located underneath the portion of the Dagmar's Landing site (DAG) expected to contribute the bulk of water entering it.

Source: Data provided by USGS in 2003

River Cross Sections and Fish Density **Exhibit 4-1**

Background

During winter 2003, USGS researchers conducted a pilot study of emerging technologies and techniques for monitoring juvenile salmon movement in junctions of tidal confluences. One of the techniques tested in the study was the deployment of multiple active split-beam hydroacoustic target tracking systems to create a "control volume" around a junction. Two side-looking, split-beam acoustic transducers were located in each branch of the Sacramento River–Georgiana Slough junction before four groups of 10,000 CWT juvenile chinook salmon were released over a period of 35 hours upstream of the study site. A set of passive drifters equipped with global positioning system loggers was released with each group to track the movement of the parcel of water in which fish were released. Fish densities and distribution were observed and analyzed along with movement (upstream, downstream, and holding), with the ultimate goal of predicting juvenile salmon entrainment at confluences. The ”entrainment zone” conceptual model for juvenile salmon transport in tidal confluences resulted from these observations. The model couples processes that occur upstream of the confluence with processes that occur in the confluence by proposing that at any given instant, the velocity patterns in a given junction dictate a spatial entrainment zone for each downstream branch.

Comparison of Relative Abundance of Adult Chinook Salmon in the Delta Cross Channel, Georgiana Slough, and Sacramento River
U.S. Fish and Wildlife Service
June 2004

Key Findings

Results indicate that returning adult chinook salmon use the DCC as a migration corridor less than either Georgiana Slough or the Sacramento River, and Georgiana Slough less than the Sacramento River. DCC gate operations were not successfully related to fyke trap catches because of the frequency with which the gates were opened and closed and the longer intervals between fyke trap sets. Because a smaller percentage of returning adult chinook salmon use the DCC, reductions in spawning success caused by delays in migration may be minimal.

Background

To quantify the number of salmon using the DCC and Georgiana Slough versus the Sacramento River and further examine potential impacts on spawning success, USFWS collaborated with USGS, Reclamation, and DFG on a pilot study in 2000, with a more extensive effort in 2001. Whereas components of this study included hydroacoustic, sonic tagging, and fyke trap data, the USFWS component of the study involved only the use of fyke traps. Seven fyke traps were set among the three study sites for 4 days at a time from September 4 through November 15, 2001. Traps were checked daily, and captured fish were identified to species and measured to the nearest 5 millimeters (mm) (fork length [FL]). In 262 total trap days, 155 chinook salmon were captured, with 80 captured in the Sacramento River, 53 in Georgiana Slough, and 22 in the DCC. A photograph of a fyke trap used to collect adult chinook salmon (and other fish) in the DCC, Georgiana Slough, and Sacramento River is provided in Exhibit 4-2.

Movement of Juvenile Chinook Salmon in the Vicinity of the Delta Cross Channel, Fall 2001: Coded Wire Tag Recovery Component
U.S. Fish and Wildlife Service
July 2004

Key Findings

This study evaluated the movement of juvenile chinook salmon in the vicinity of the DCC. Caution is advised in evaluating and applying the results of the study because recovery rates of CWT chinook salmon were low and statistical variances were large. Key findings are as follows:

- The proportions of catch recovered from the DCC and the Sacramento River were significantly different, with far fewer fish recovered in the DCC relative to the Sacramento River.
- No apparent relationships were identified between tidal phase and release times versus recovery rates of chinook salmon at either station.
- Significantly more CWT juvenile salmon were recovered at night (Exhibit 4-3). Nearly 99% of the CWT juvenile salmon were captured at night.

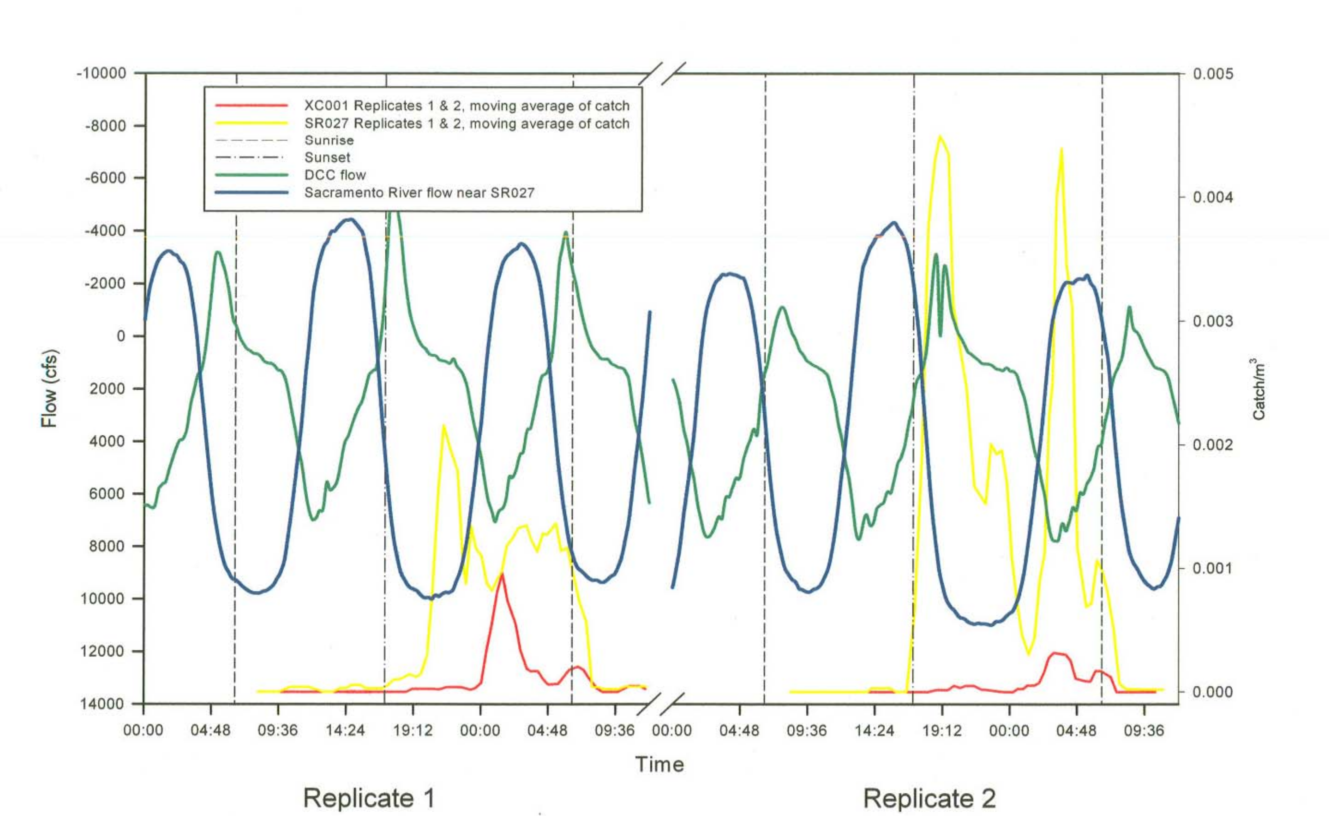
Source: Data provided by USFWS in 2004

Photograph of a Fyke Trap Used to Collect Adult Chinook Salmon (and Other Fish) in the DCC, Georgiana Slough, and Sacramento River (September 4 through November 15, 2001) **Exhibit 4-2**

- Although statistically significant differences in a number of the patterns of recovery of CWT juvenile chinook salmon were identified, given the low recoveries and large variances in the recoveries of CWTs, caution must be exercised in evaluating and applying these findings.

Background

- It is believed that the survival rate of juvenile Sacramento River chinook salmon that enter the Delta through the DCC is significantly less than those that do not enter the Delta via the DCC (i.e., they continue migrating down the mainstem Sacramento River). A multiagency, multidisciplinary team conducted a study to examine the movements of hatchery-reared juvenile chinook salmon in the Sacramento River and the DCC. Juvenile salmon that enter the DCC are much more likely to enter the central and south Delta than those that remain in the mainstem Sacramento River. The goal of the study was to determine the effects of time of day and tidal phase on the downstream movement of salmon into the DCC. The results discussed in the report are based on the CWT recovery component of the study conducted by USFWS. The CWT recovery was conducted during two replicates of approximately 36 hours each, from October 28, 2001, to November 2, 2001, a period of optimal neap tides, resulting in similar tidal profiles during the day and night. Fish released were divided into four batches, ranging in number from approximately 29,000 to 33,000. The fish were recovered by conducting midwater trawling simultaneously at two locations: one in the DCC approximately 460–610 meters below the Sacramento River and the other in the Sacramento River downstream of the DCC and upstream of the mouth of Georgiana Slough.



Flows in the Delta Cross Channel (DCC) and the Sacramento River immediately below the DCC, and moving averages of the catch/m^3 of marked and coded wire-tagged juvenile chinook salmon captured at each station during each replicate (Sacramento River trawl site = SR027 and DCC trawl site = XC001). The moving average was calculated using four consecutive tows for each point. The scale for the left axis was reversed to indicate the relative tidal conditions; negative flows were associated with a flood (high) tide, and positive flows were associated with an ebb (low) tide. Note the break in the x-axis, which reflects the sampling periods of the two replicates and that the tidal conditions were out of phase between locations.

Source: Data provided by USGS in 2004

Delta Cross Channel Flows and Salmon Recovery **Exhibit 4-3**

Repeated Surveys by Acoustic Doppler Current Profiler for Flow and Sediment Dynamics in a Tidal River
R. L. Dinehart and J. R. Burau, USGS, Sacramento
March 2005

Key Findings

Repeated ADCP surveys documented complex three-dimensional flow patterns in response to the tidal cycle at the intersection of the Sacramento River and the DCC. During flood tide in the fall, flows enter the DCC, whereas flows briefly reverse direction back into the Sacramento River during ebb tide. Streamtraces indicated the range of possibilities for salmon smolts to be diverted into the DCC during rising tides, to the extent that salmon smolts act like massless particles. This includes diversion from the outer bank into the DCC during each diurnal tidal cycle for a total of 4 hours at flood tide. Streamtraces also revealed the vertical movement of midchannel particles up and into the DCC. Spatial distribution of backscatter intensity, an indicator of suspended sediment transport, showed that during ebb tide, suspended sediment migrated across the DCC and entered the canal as tide stage rose.

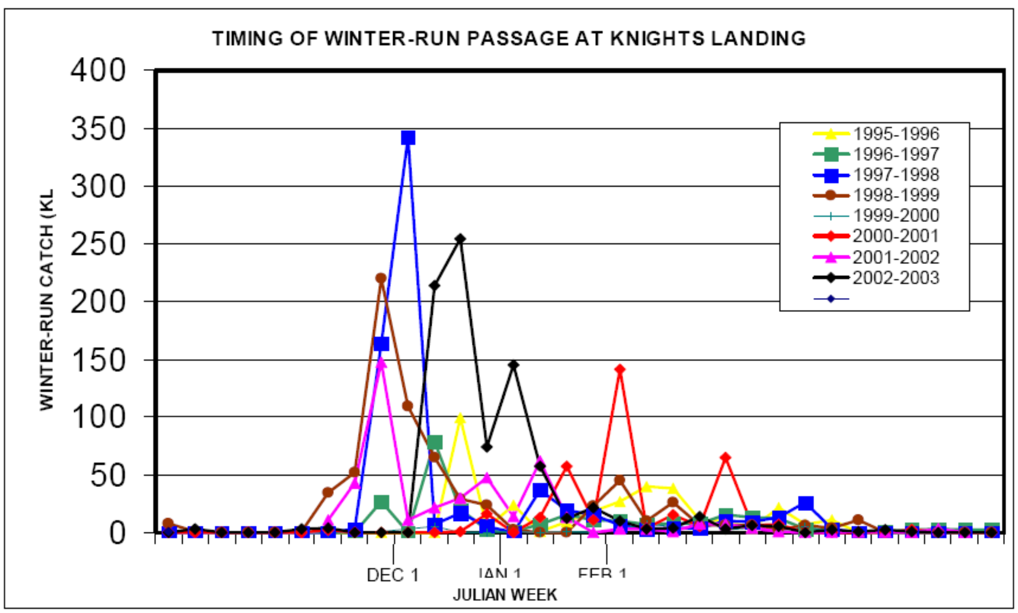
Background

USGS, in conjunction with other fisheries management agencies, used ADCP to map velocity vectors in a reach of the Sacramento River. The Sacramento River at the confluence with the DCC was surveyed repeatedly in 2000 and 2001 along flow-defining paths to document flow dynamics associated with fish migration past the DCC entrance. To evaluate effects of the DCC on migrating salmon smolts, three-dimensional vector grids were created from repeated ADCP surveys in the channel confluence at the Sacramento River. When opened, swing gates allow river water into the DCC and into the San Joaquin River via the Mokelumne River. Time-based visualizations of flow and sediment dynamics were derived from sequences of ADCP data surveys as velocity vectors were interpolated to a three-dimensional Cartesian grid that conformed to local bathymetry. The spatial analyses of ADCP data show that a strategy of repeated surveys and flow field interpolation has the potential to simplify computation of flow and sediment discharge through complex waterways.

Relationship of Delta Cross Channel Gate Operations to Loss of Juvenile Winter-Run Chinook Salmon at the CVP/SWP Delta Facilities
A. F. Low and J. White, DFG, and E. Chappell, DWR
November 2006

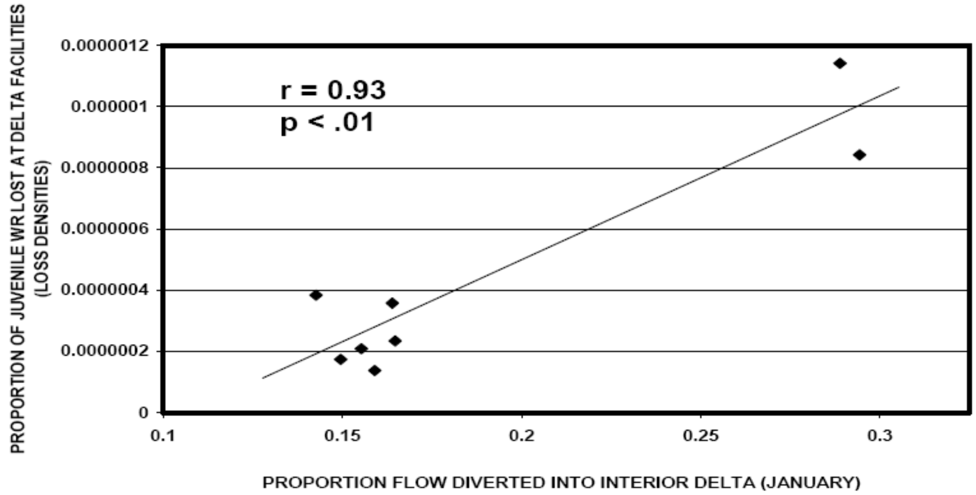
Key Findings

Comparison of the timing of winter-run–size juvenile chinook salmon passage at Knights Landing and the timing of losses at the Delta facilities indicates that winter-run–size juveniles rear in the Delta for significant time periods (1–4 months) before entrainment at the project facilities (Exhibit 4-4). Data analysis indicates that the proportion of the juvenile winter-run population lost at the Delta facilities each year is correlated to the proportion of acramento River flow diverted into the interior Delta via the DCC and Georgiana Slough in late December and early January (Exhibit 4-5). Gate closures during this period of migration could, therefore, significantly decrease losses of winter-run chinook salmon at the export facilities.



Source: Data provided by DFG in 2002

Timing of Juvenile Winter-Run Passage at Knights Landing, Rotary Screw Trap Sampling **Exhibit 4-4**



Relationship between the mean proportion of flow diverted into the interior Delta (through the DCC) in January and the proportion of juvenile winter-run chinook salmon lost at SWP/CVP Delta export facilities (loss densities divided by the Juvenile Production Index), October 1–May 31, 1996–2004

Source: Data provided by DFG in 2004

Flow Diversion and Salmon Loss **Exhibit 4-5**

Background

Winter-run chinook salmon are listed as endangered under both the California and federal Endangered Species Acts. One of the many factors contributing to their decline is the operation of the federal and state water projects in the south Delta. There is particular concern that entrainment losses of juvenile winter-run chinook at the project export facilities in the Delta are significant. These losses vary in their extent annually, but they seem to be correlated with water diversions from the Sacramento River into the interior Delta. The biggest of these diversions is through the DCC (up to 6,000 cfs and 40–50% of the Sacramento River flow, depending on its operation); however, varying percentages of flow are also diverted through Georgiana Slough year-round (no gates). This study reviewed data from multiple juvenile salmon monitoring programs in the Sacramento River, DWR data of juvenile losses at the export facilities, and Dayflow hydrologic data.

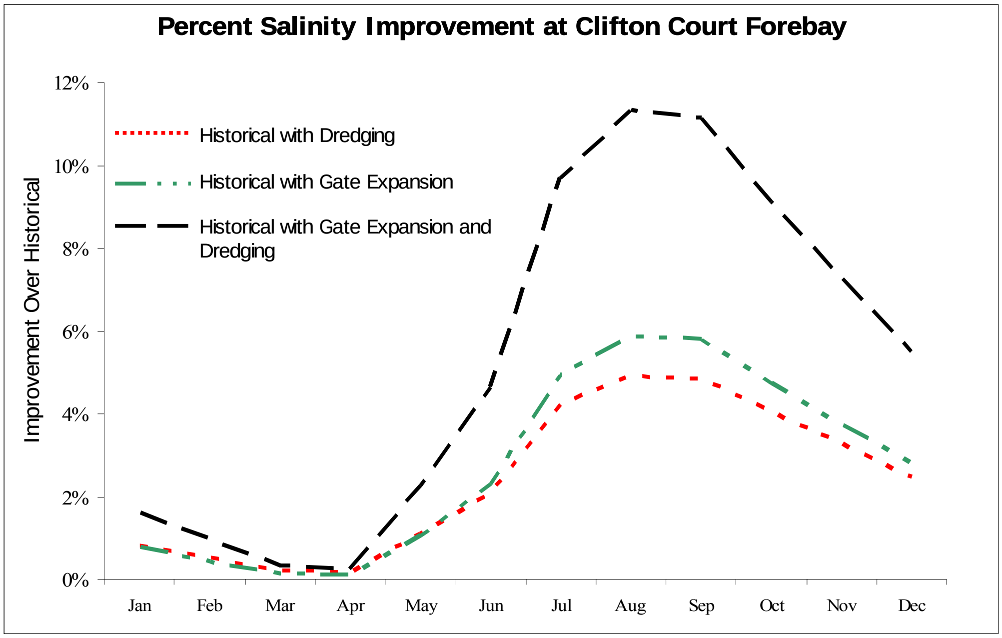
Technical Memorandum: Modeling of a Delta Cross Channel Gate Extension
J. Wilde, DWR
September 24, 2007

Key Findings

An expanded intake at the DCC junction with the Sacramento River would improve water quality at the south Delta export facilities. An expanded gate structure alone provides minimal improvement, but when it is combined with dredging of constricted conveyance pathways in the lower Mokelumne River region, salinity in the central Delta could be reduced substantially (11% on average in late summer at Clifton Court Forebay). This option provides a fairly simple yet efficient alternative for water quality improvements in the south Delta.

Background

Preliminary modeling results for expanding the DCC gates showing water quality benefits were marginal; therefore, DWR directed RMA to explore possible channel constraints downstream of the DCC. RMA proceeded to include the dredging of the mouth of Snodgrass Slough and the adjacent reach of the Mokelumne River at the North and South Fork split, thereby increasing conveyance capacity across the Delta by more than 1,000 cfs in late summer. Modeling results are summarized in Exhibit 4-6.



Source: Data provided by RMA in 2007

Average Monthly Percent Salinity Improvement at Clifton Court Forebay **Exhibit 4-6**

5 OTHER RELEVANT STUDIES

This section identifies other studies that have been conducted that may have relevance to the projects included in this summary report. Some of the studies under this heading were completed with CALFED Program funding that do not fall under a specific project heading. These studies generally have Delta-wide implications and provide useful information for all potential Delta projects, including the Franks Tract, TDF, and DCC Reoperation projects. The studies may address topics and issues such as dissolved organic carbon, mercury, flood hydrology/levee stability, subsidence, navigation and access, recreation, and climate change.

Estimating the Abundance of Sacramento River Juvenile Winter-Run Chinook Salmon with Comparisons to Adult Escapement
C. D. Martin, P. D. Gaines, and R. R. Johnson
USFWS, Red Bluff
July 2001

Key Findings

This study provides information for estimating juvenile chinook salmon escapement, which is critical to water management in the Delta. Escapement estimates from carcass surveys were found to be a satisfactory replacement for Red Bluff Diversion Dam ladder counts.

Background

USFWS developed in-river quantitative methodologies to provide a juvenile chinook salmon production index (JPI) in the Sacramento River using data collected from rotary screw traps at the Red Bluff Diversion Dam. The juvenile indices were used in conjunction with and in support of estimates of adult escapement and were used to evaluate year-class strengths in winter-run abundance. Estimates of juvenile winter-run chinook production derived from escapement estimates based on ladder counts at Red Bluff Diversion Dam, winter-run chinook carcass surveys, and the National Marine Fisheries Service's juvenile production estimates (JPEs) were compared to the JPI to identify possible sources of bias and determine whether these surveys were correlated in magnitude and trend. In addition, the JPE model was evaluated for its accuracy in estimating escapement. Five complete brood-year periods—each July through June of the following year—were monitored to index winter-run production for 1995, 1996, 1997, 1998, and 1999. Emergence and dispersal of winter-run fry (≤45 mm FL) started in July for all brood years evaluated, with peak dispersal occurring in September. Presmolt/smolt (>45 mm FL) emigration started in September, with 100% of production passing Red Bluff Diversion Dam 2–3 months before the onset of the next brood year.

Summary of Delta Hydrology Data, Water Years 1985–2004
USGS
2004

Key Findings

The Sacramento River contributed 84.5% of the fresh water to the Delta during the period examined; this contribution increased to 91.8% between 2000 and 2004. Conversely, flow contributions from the San Joaquin River decreased from 11.2% to 6.2% from 2000 to 2004. Flows in Old River and Middle River are inversely correlated with pumping in the south Delta. Only once during the study period, in 1998, was the net annual flow on Old River and Middle River northward, away from the export facilities.

Background

Hydrologic data for the Delta from 1985 through 2004 were gathered and analyzed. The three main forces driving circulation, transport, and mixing in the Delta are riverine input from the north, south, and east; tides propagating from the Pacific Ocean through San Francisco Bay from the west; and state and federal export facilities operating to the south. The study compiled yearly mean flow values for the entire period of record (since 1955), monthly mean values for data collected between 1985 and 2004, and deviations of monthly values from monthly means for the period between 1985 and 2004.

6 CONTINUING AND PLANNED ACTIONS

This section provides summary information for continuing and planned actions (i.e., studies) in support of Delta conveyance improvement studies. These summaries (including key findings as available) will be provided in the updated report in fall 2008.

Clarksburg Bend – Fish Study Results
DWR, USGS, Reclamation, and NRS
Ongoing

This research was done as a "trial run" for a larger regional fish study to be performed in 2008 and 2009. The experiment conducted in Clarskburg Bend in winter 2006–2007 provided significant support for the proposed study's underlying conceptual model of juvenile salmon outmigration dynamics (e.g., fish are aggregated on the outside of bends because of behavioral responses to secondary circulation) and demonstrated the value of using acoustic tag tracking technology for studying juvenile salmon outmigration.

Particle Tracking Modeling Results for Movement of Fish through the Delta
RMA and USGS
Ongoing

Particle-tracking modeling studies are being conducted in support of Franks Tract, TDF, and DCC Reoperation projects to evaluate impacts on Delta fisheries, analyze and design support for tagged fish release studies, and develop and provide a graphic user interface–based postprocessing tool for CALFED to run particle-tracking simulations from precomputed flow and salinity results.

Currently, the RMA particle-tracking model is being used to guide release and monitoring strategies on north Delta salmon outmigration studies. The goal of the particle tracking is to determine fish behavior by modeling and analyzing transport particles in conjunction with salmon movement within channel bends and confluences. This model will also be employed in a larger tagged-fish release study proposed to start late in 2008.

A particle-tracking model in support of Franks Tract is already underway. The project alternatives will be evaluated to determine the impacts on delta smelt, outmigrating juvenile salmon, and other fish species of concern.

Regional Hydrodynamics and Salmon Outmigration Study in the Delta
DWR, USGS, Reclamation, USFWS and DFG
Proposed for 2008/2009

With multibillion-dollar modifications to the Delta being seriously considered, a process-level understanding is needed to predict impacts on the Bay-Delta ecosystem. For this to be achieved, a combination of field investigations and numerical modeling studies of the winter-run of Chinook salmon is proposed. A team of multidisciplinary scientists, led by Jon Burau of USGS, will be conducting a series of studies and monitoring exercises focused on critical confluences in the Sacramento River.

The operation of the DCC strongly influences water movement, salinity, and juvenile salmon distribution throughout the Delta, thus affecting water deliveries south of the Delta. Furthermore, operation of the DCC affects route selection and survival of juvenile salmon outmigrants and adult migrants. This large research effort will include a regional examination addressing the impacts of Sacramento River flow rate and DCC gate operations on juvenile salmon outmigration pathways through the north, west, and central Delta regions.

Crucial to predicting juvenile salmon behavior at confluences is an understanding of the impact of existing structures, their operations, as well as junction specific hydrodynamics. Route selection at confluences may depend minimally on behavioral responses that occur within the confluence, depending to a greater degree on subtle behavioral responses/interactions to geometry-mediated current profiles that occur upstream of a given confluence. Therefore, to study route selection, it is proposed to simultaneously measure the current hydrodynamics and the positions of acoustically tagged fish in three dimensions within the confluences of the Sacramento River with the DCC and Georgiana Slough. An array of listening stations will be deployed to track the movement of tagged salmon. Data from previous fisheries and flow tracking studies will be used in the experiment design. Ultimately, the results from field data and numerical modeling analysis will be developed into tools that would allow managers to quantify the effects from various day-to-day management actions, such as DCC and/or TDF operations.

Franks Tract NEPA/CEQA Documentation
DWR, Reclamation
Ongoing

DWR is initiating preparation of an environmental impact statement/environmental impact report (EIS/EIR) for the Franks Tract project. The combined environmental document will be prepared pursuant to NEPA and CEQA requirements. Reclamation will be the lead federal agency, and DWR will be the lead state agency. The environmental compliance document will evaluate, at a minimum, two Franks Tract project alternatives:

- Alternative 1: West False River Barrier and
- Alternative 2: Threemile Slough Barrier.

The public draft of the EIS/EIR is expected to be released in summer 2009.

7 RESOURCES

7.1 WEB LINKS TO PROJECT STUDIES

CALFED Bay-Delta Program: <http://www.calwater.ca.gov/>

DCC and TDF: <http://baydeltaoffice.water.ca.gov/ndelta/TDF/index.cfm>

Franks Tract Project: <http://baydeltaoffice.water.ca.gov/ndelta/frankstract/index.cfm>

Franks Tract State Recreation Area: <http://www.parks.ca.gov/?page_id=490>

Interagency Ecological Program: <http://www.iep.ca.gov/>

State Water Project: <http://www.publicaffairs.water.ca.gov/swp/swptoday.cfm>

The Delta: <http://www.publicaffairs.water.ca.gov/swp/delta.cfm>

USFWS Juvenile Fish Monitoring Program for the DCC: <http://www.delta.dfg.ca.gov/jfmp/dcc.asp>

USGS San Francisco Bay Hydrodynamics: <http://ca.water.usgs.gov/projects/sf_hydrodynamics.html>