The Delta Corridors Plan and Its Potential Benefits

Prepared for:

South Delta Water Agency
4255 Pacific Avenue, Suite 2
Stockton, CA 95207
Contact: John Herrick
209/956-0150

Prepared by:

ICF Jones & Stokes
630 K Street, Suite 400
Sacramento, CA 95814
Contact: Russ Brown
916/737-3000

November 2009

Preface: This description of the Delta Corridors Plan and its potential benefits was prepared by ICF Jones & Stokes staff under contract to South Delta Water Agency (SDWA). A previous tidal hydraulic evaluation of the Delta Corridors Plan was prepared by ICF Jones & Stokes staff under contract to SDWA and Central Delta Water Agency (CDWA) in 2007. ICF Jones & Stokes has used the best available modeling information and field data to evaluate the potential tidal flow and salinity effects of the Delta Corridors Plan. Although ICF Jones & Stokes has performed this technical analysis under the direction of SDWA, it does not endorse the Delta Corridors Plan or any other specific future Delta configuration or operations for water supply, water quality, and fish habitat protection and improvement. ICF Jones & Stokes supports the full evaluation and comparison of alternative future Delta configurations and operations.

ICF Jones & Stokes. 2009. T*he Delta Corridors Plan and Its Potential Benefits*. November. (ICF J&S 00086.09) Sacramento, CA. Prepared for: South Delta Water Agency.

Contents

Tables

Follows Page

Maps

Figures

Follows Page

Acronyms and Abbreviations

BDCP	Bay Delta Conservation Plan
CCF	Clifton Court Forebay
CCWD	Contra Costa Water District
CDWA	Central Delta Water Agency
cfs	cubic feet per second
CVP	Central Valley Project
DC Plan	Delta Corridors Plan
DCC	Delta Cross Channel
Delta	Sacramento–San Joaquin River Delta
DICU	Delta Islands Consumptive Use
DMC	Delta-Mendota Canal
DO	dissolved oxygen
DSM2	Delta Simulation Model II
DWR	Department of Water Resources
DWSC	Deep Water Ship Channel
EC	electrical conductivity
EIR/EIS	Environmental Impact Report/Environmental Impact Statement
ft/sec	foot per second
LV	Los Vaqueros
mg/l	milligrams per liter
msl	mean sea level
MWD	Metropolitan Water District
OMR	Old and Middle River
PC	Peripheral Canal
ppt	parts per thousand
RWCF	Regional Wastewater Control Facility
SDIP	South Delta Improvements Program
SDWA	South Delta Water Agency
SJR	San Joaquin River
SR	State Route
SWP	State Water Project
TDS	total dissolved solids
VAMP	Vernalis Adaptive Management Plan

The Delta Corridors Plan and Its Potential Benefits

Background

Delta Issues

Current Sacramento–San Joaquin River Delta (Delta) management issues have prompted great interest and as many solutions as there are observers. Recent Delta Vision Panel and Stakeholder Group investigations, Public Policy Institute of California reports on future Delta options and consequences, Delta Risk Management Strategy reports, ongoing State Water Board Bay-Delta Water Quality Control Plan review, Bay-Delta Conservation Strategy planning efforts (Bay Delta Conservation Plan 2009)—each has provided information and opinions about current Delta conditions and changes that should be considered for the Delta of the future. Previous changes in the Bay-Delta ecosystem and watershed have contributed to the current conditions, and continuing changes are likely to influence the physical configuration, hydrologic conditions, biological processes, and species habitat in the Bay-Delta system. Solving all the Delta issues will require a mosaic of approaches, but to get started, a relatively simple and effective plan could be implemented.

The Delta Corridors Plan (DC Plan) by itself cannot solve all the Delta management issues, but it would result in considerable improvements in export salinity and fish protection, while requiring only moderate changes in the Delta channel configuration. The DC Plan would separate the San Joaquin River (SJR) flows (that now flow through the south Delta channels to the existing Central Valley Project [CVP] and State Water Project [SWP] export pumps) from the Sacramento River diversions at the Delta Cross Channel (DCC) and Georgiana Slough. Separation of the Old and Middle River channels would eliminate the recycle of SJR salts at the CVP and SWP pumps, reducing the salt load in the exports by more than 25% and protecting all of the SJR migrating fish and many estuarine fish from the risk of entrainment in south Delta exports. These channel changes, although relatively easy to make, would have substantial benefits—reducing salinity and improving fish habitat conditions. This report evaluates the changes in Delta salinity conditions that the DC Plan would provide. Potential fish benefits that may result from the DC Plan are discussed briefly, but additional investigations are needed to substantiate the extent of those benefits.

This report describes the existing salinity conditions in the Delta as simulated by the Department of Water Resources (DWR) Delta Simulation Model II (DSM2) model for the 1976–1991 study period assuming D-1641 objectives. This model often is used for simulating Delta tidal hydraulics and salinity conditions. The calibration with measured tidal flows and salinity (electrical conductivity [EC]) are generally good. Model assumptions about agricultural drainage EC are discussed later in this report. More information about the DSM2 model can be found at the DWR Delta Modeling Section website (DWR 2009a).

The salinity conditions that would result from modifying the Delta channels according to the DC Plan are compared to the existing salinity conditions in the south and central Delta and in the CVP and SWP exports. The Delta inflows, exports, and outflows were not changed for this modeling comparison of the DC Plan with existing conditions. The DC Plan is briefly described at the beginning of the report, and potential fish benefits that might be achieved with the DC Plan are summarized at the end of the report. The purpose of this report is to encourage the evaluation of potential benefits from alternative future Delta configurations and operations (Public Policy Institute of California 2008). The DC Plan could provide considerable improvements for export salinity and fish protection, while requiring only moderate changes in the Delta channel configuration. Delta operational changes were not evaluated in this report; possible changes with the DC Plan would require additional investigations.

Sources of Delta Salinity

This salinity evaluation is focused on the sources of salt in the central and south Delta, and the salinity benefits that could be achieved by separating the SJR flow and salt load from the exports. The Sacramento River diversions at the DCC and Georgiana Slough would still provide most of the exported water. However, agricultural drainage and seawater intrusion would still contribute higher salinity water to the central and south Delta channels and to the exports. Agricultural drainage salinity is relatively high because it must carry the salt load from the applied water in order for farmers to maintain constant soil salinity. This report does not investigate the changes in SJR salinity resulting from the combination of seawater intrusion and CVP exports for irrigation from the Delta-Mendota Canal (DMC).

The DC Plan would eliminate the recycling of SJR salt and may allow seawater intrusion at the CVP and SWP exports to be controlled more easily. Because the DC Plan would reduce the CVP export salinity, the drainage from the applied water along the DMC would decline with time. The sources of salinity in the Delta were tracked with the DSM2 model for existing conditions and with the DC Plan configuration. Comparison of the salinity in the central and south Delta and in the exports allows the salinity effects from the DC Plan to be described accurately.

Salinity is an important issue in the south and central Delta because existing conditions often approach or exceed the established D-1641 salinity (EC) objectives. The south Delta EC objectives (at Vernalis, Brandt Bridge, Old River at Middle River, and Tracy Boulevard Bridge) are 700 microSiemens per centimeter (µS/cm) for the irrigation months of April–August and 1,000 µS/cm for the other months, when water is applied for some crops. The central Delta EC objectives (specified at Jersey Point, San Andreas, and Terminous) are 450 µS/cm from April through August 15, with relaxations (higher EC objectives) allowed at each location in low-runoff years. The EC objectives for water supply intakes and exports are 1,000 µS/cm year-round, and the Contra Costa Water District (CCWD) Rock Slough intake has chloride objectives of 150 milligrams per liter (mg/l) for 155 to 240 days (depending on runoff conditions) and 250 mg/l for the remaining days.

This report describes the seasonal variation in the simulated EC at these locations for the existing conditions and with the DC Plan configuration. The DC Plan would reduce the EC at the exports by about 25%, from an average of 460 µS/cm to an average of 350 µS/cm, for the 16-year study period. The salinity with the DC Plan would comply with the central and south Delta EC objectives, but the monthly EC would rise toward the objectives at some central and south Delta locations in some months because water in the Old River corridor would be predominantly SJR water and because seawater intrusion would have a greater effect on the Middle River corridor with the DC Plan. These EC changes are fully described and evaluated in this report.

Future changes in D-1641 minimum Delta outflow objectives that could reduce seawater intrusion for the existing conditions or the DC Plan configuration are described at the end of the report. However, these increased Delta outflows are not assumed for the DC Plan salinity evaluation. Other measures to avoid degradation of central and south Delta water quality (such as increased dilution flows through DC Plan facilities) or operation of other facilities (such as the two-gate project) are discussed but not assumed for this evaluation.

Introduction to the Delta Corridors Plan

The DC Plan has been suggested to the Bay Delta Conservation Plan (BDCP) and Delta Vision stakeholder groups as an interim solution and perhaps a permanent alternative to constructing a Peripheral Canal (PC) to protect Delta fish and improve Delta and export water quality. The DC Plan would allow water to be conveyed from the Sacramento River to the south Delta pumps using the existing Delta channel network. The entire SJR would be diverted into the head of Old River and be separated from the export pumping via a “river bridge” over a large Victoria Canal box culvert to allow the SJR water to flow down the Old River channel to Franks Tract. The locations of the major components of the DC Plan are shown in Map 1. The DC Plan components in the vicinity of the south Delta export facilities are shown in Map 2. The DC Plan components in the vicinity of Walnut Grove and the DCC are shown in Map 3.

ICF Jones & Stokes has modified the DSM2 model geometry and other input data files to allow the DC Plan to be simulated accurately. The major changes in the modeled Delta channels and gate operations for the DC Plan are:

1. A barrier across the SJR just downstream of the head of Old River is simulated with a floodgate that would be opened when the Vernalis flow exceeds about 10,000 cubic feet per second (cfs). Hydraulic studies are needed to establish the proper SJR flow for safe operation (i.e., opening) of this floodgate. This would create an SJR–estuary corridor along Old River to eliminate entrainment of migrating SJR fish and to separate about 25% of the Delta channel habitat area from entrainment risk at the SWP and CVP pumps.

2. A fish-friendly pump with a capacity of 250 cfs is simulated to provide a dilution flow from the Stockton Deep Water Ship Channel (DWSC) into the head of Old River near Lathrop.

3. The South Delta Improvements Program (SDIP)–planned tidal gates on Old River upstream of the DMC and on Middle River upstream of Victoria Canal would be operated for upstream dilution flow unless the Vernalis flow is greater than 10,000 cfs. A fish-friendly, low-head pump (250 cfs) would be required to increase the upstream flow at the Middle River gate near Victoria Canal.

4. The Tracy fish facility would be modified to divert the primary fish louver bypass flow of 250 cfs to Old River upstream of the tidal gate with another fish-friendly pump. The Skinner fish facility would be modified to divert the primary fish louver bypass flow of 250 cfs to Italian Slough and the Old River–estuary corridor. This would improve the survival of fish separated with the primary louvers at each fish facility, avoiding fish losses at the secondary louvers and from holding, handling, trucking, and release operations.

5. Old River would be divided at two locations with a wall structure (between Fabian Tract and Coney Island and between Victoria Canal and West Canal) to allow the SJR water to flow down Old River around the east side of Coney Island and to allow the water supply corridor water to flow from Victoria Canal to West Canal and upstream in West Canal to the Clifton Court Forebay (CCF) gates and the DMC intake.

6. A river bridge and box culvert would be constructed on Old River at the north end of Coney Island to allow the SJR water to flow across the river bridge (over the box culvert from Victoria Canal to West Canal) and continue down Old River to Franks Tract and the estuary. The water supply would flow under the river bridge in the box culvert from Victoria Canal to West Canal.

7. Rock barriers or walls with boat locks would be constructed on Woodward Canal, Santa Fe Canal, and Connection Slough. These barriers would separate the water supply corridor along Middle River from the SJR–estuary corridor along Old River. The barriers could be located at the east end to increase fish habitat or at the west end to supply more agricultural diversions from the Middle River corridor.

Delta Corridors Plan

Major Components

1. **Floodgate** – A floodgate across the San Joaquin River (SJR) would direct all SJR flow down Old River, unless the flow was greater than 10,000 cfs.

2. **Pump** – A fish-friendly pump would move 250 cfs upstream into Old River to maintain flow (upstream) from the Stockton Deep Water Ship Channel and provide dilution flow.

3. **Tidal Gates** – Gates would be operated for upstream flow along Old and Middle Rivers. A 250-cfs fish-friendly pump would augment flow over the Middle River gate.

4. **Fish Flushing Flows** – The Tracy fish facility would be modified to pump the primary fish louver bypass flow of 250 cfs to Old River upstream of the gate. The Skinner fish facility primary fish louver bypass flow of 250 cfs would be pumped to Italian Slough.

5. **Divided Channel** – Old River channel would be divided to keep the SJR-estuary corridor separate from the water supply corridor between Grant Line Canal and Coney Island and between Victoria Canal and West Canal.

6. **Old River Bridge/Culvert** – A water bridge over a Victoria Canal culvert would allow the SJR-estuary corridor to cross over the water supply corridor.

7. **Barriers with Boat Locks** – Barriers with boat locks would be constructed across Woodward Canal, Santa Fe Cut, and Connection Slough to separate the SJR-estuary corridor from the water supply corridor.

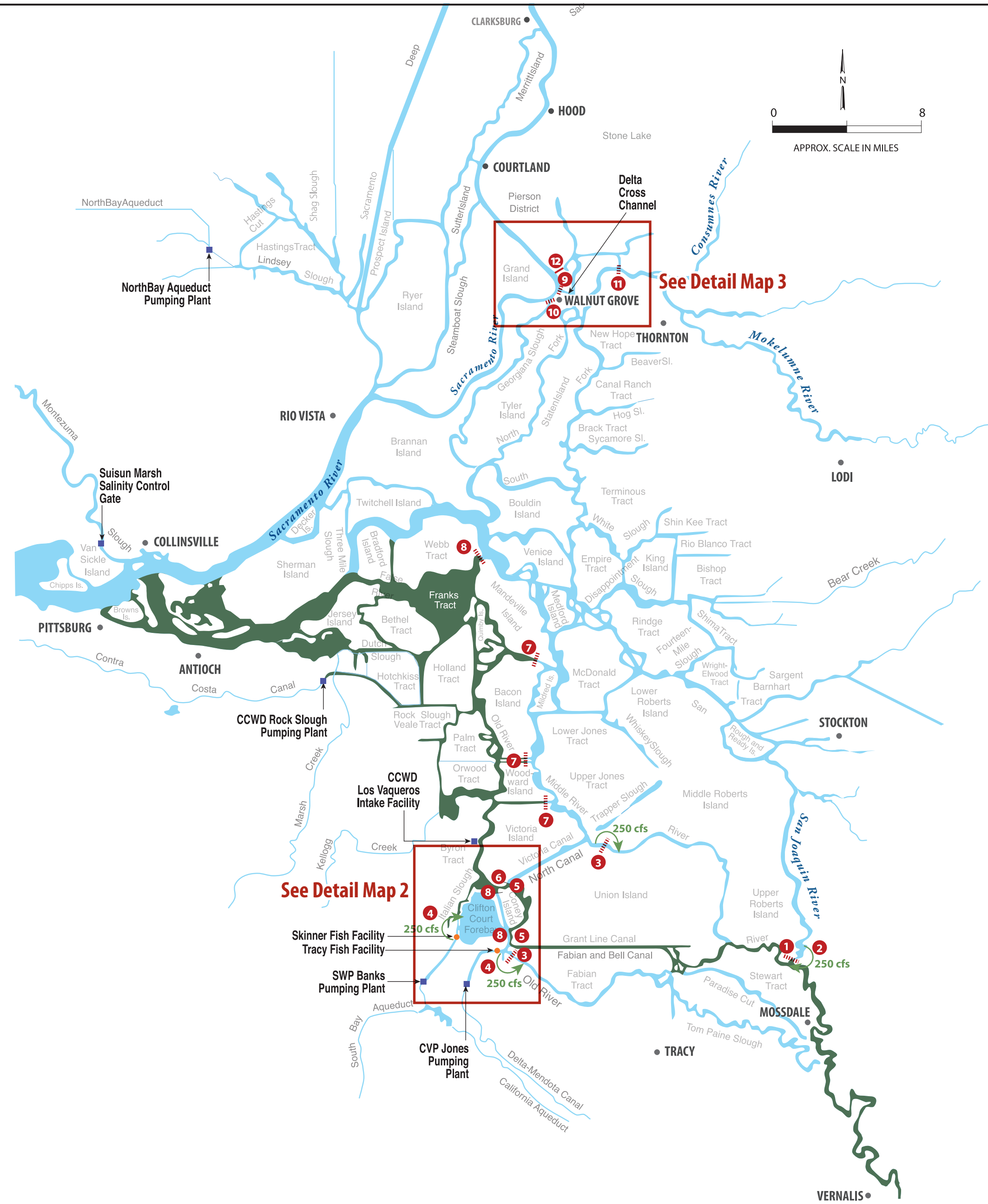
8. **Floodgates** – A barrier with a floodgate and a boat lock at the mouth of Old River would separate Franks Tract from the San Joaquin River channel. Floodgates and boat locks at the mouth of Grant Line Canal and at the north end of the West Canal would separate the SJR-estuary corridor from the water supply corridor. The floodgates would be opened when the SJR flow exceeded 10,000 cfs.

9. **Delta Cross Channel Fish Screen** – The Delta Cross Channel (DCC) would be screened to protect migrating fish in the Sacramento River. The DCC gates would be opened all the time unless the Mokelumne River flow exceeded 5,000 cfs.

10. **Georgiana Slough Fish Screen** – Georgiana Slough would be screened to protect migrating fish in the Sacramento River.

11. **Mokelumne River Gate** – A gate across the Mokelumne River at Thornton would direct all flow and fish into Middle Slough and the The Meadows Slough. The gate would open when the Mokelumne River flow exceeded 5,000 cfs.

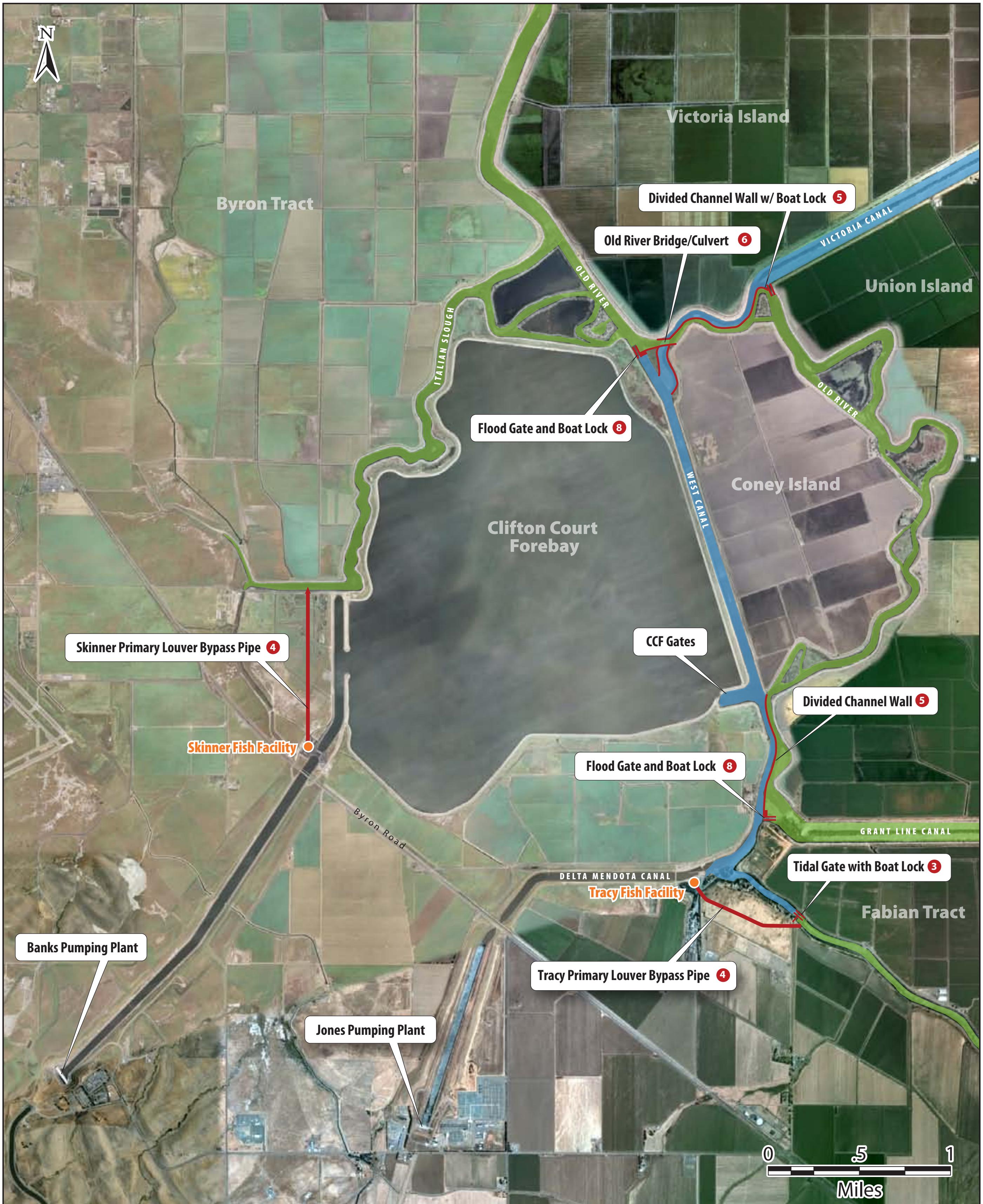
12. **Sacramento River Flood Gate** – A short channel and floodgate would connect the Mokelumne River flow and fish to the Sacramento River above Walnut Grove. The gate would close when the Mokelumne River flow exceeded 5,000 cfs.



Map 1
Major Components of the Delta Corridors Plan

Graphics\Projects\ 00086.09 Delta Corridors/(08-09) SS

ICF Jones & Stokes
an ICF International Company



Graphics\Projects\ 00086.09 SS (08-09)

Source: Google Inc. 2009. Google Earth, Version 4.3.7 Mountain View, CA. Accessed: August 14, 2009.

ICF Jones & Stokes
an ICF International Company

Map 2
Delta Corridors Plan Components in the Vicinity of the South Delta Exports Facilities

Source: Google Inc. 2009. Google Earth, Version 4.3.7 Mountain View, CA. Accessed: August 14, 2009.

Graphics\Projects\00086.09 Delta Corridors\(08-09) SS

ICF Jones & Stokes
an ICF International Company

Map 3
Delta Corridors Plan Components in the Vicinity of Walnut Grove

8. A rock barrier or wall with a boat lock and floodgate would be placed across the mouth of Old River, separating Franks Tract from the SJR channel. This would fully isolate the Franks Tract aquatic habitat from CVP and SWP pumping entrainment risk. Smaller rock barriers or walls with a boat lock and floodgate would be placed across the north end of West Canal and at the mouth of Grant Line Canal to separate the water supply corridor from Old River. The floodgates would be opened when the SJR flow at Vernalis was greater than about 10,000 cfs.

9. The DCC would be screened to protect migrating Sacramento River fish. The DCC gates would be opened unless the Mokelumne River inflows were greater than about 5,000 cfs. Greater diversions from the Sacramento River would be needed to supply the export pumping without increased flows from the Sacramento River around Sherman Island (i.e., reverse QWEST flows), which may cause increased salinity intrusion and fish entrainment impacts. Hydraulic investigations of scour and flood control issues are needed to determine if gate or channel modifications are necessary to allow the DCC to remain open at Sacramento River flows greater than 25,000 cfs.

10. Georgiana Slough also would be screened to separate the migrating Sacramento River fish from the water supply diversions. The DCC and Georgiana Slough in-river fish screens would be about 2,000 feet long (extending upstream and downstream of the channel entrance) and 15 feet high. A bottom wall and surface wall would reduce the number of fish encountering the screens and limit the sediment and floating debris at the screens. The surface wall also would protect boaters from any surface currents caused by the diversions. Boat locks would be provided at both screens. These fish screens would be designed with baffles to maintain uniform approach velocities and be operated with tidal gates to limit the DCC or Georgiana Slough diversion to less than 7,500 cfs to maintain an approach velocity of less than 0.25 foot per second (ft/sec) to reduce fish impingement. The screens would protect migrating Chinook salmon and other fish from higher predation in the central Delta. Upstream migration of adult fish would be achieved with an open panel or open gate in the screens.

11. A river gate with a boat lock would be constructed near Thornton to divert the Mokelumne–Cosumnes River flow into Middle Slough, Snodgrass Slough, and The Meadows Slough, unless the river flow was greater than about 5,000 cfs.

12. The Mokelumne–Cosumnes River flow (and migrating fish) would be connected to the Sacramento River with a short channel from The Meadows Slough and a flood gate upstream of Locke (similar to the DCC gates) to protect the Mokelumne fish from higher predation in the central Delta.

The simulated tidal hydraulics (i.e., tidal elevations and flows) were described and evaluated in a previous report (Jones & Stokes 2007) prepared for the South Delta Water Agency (SDWA) and Central Delta Water Agency (CDWA). These results demonstrated that full permitted exports (i.e., 4,600 cfs CVP and 6,680 cfs SWP) could be conveyed through the Middle River water supply corridor, after dredging about 7.5 million yards of sediment from shallow areas in Middle River and Victoria Canal. The dredging would maintain 3:1 (horizontal to vertical) slopes for channel stability to a depth of -25 feet mean sea level (msl). The simulated DC Plan tidal hydraulic conditions were most different from existing conditions along Middle River and Old River in the south Delta. This previous evaluation of tidal hydraulics demonstrated that the DC Plan was feasible but did not describe the salinity benefits of the DC Plan for drinking water and agricultural diversions. The tidal hydraulics report and other information about the DC Plan are available from www.DeltaCorridors.com.

Salinity Evaluation Topics

Results from DSM2 salinity (EC) simulations for the 1976–1991 study period were used to evaluate the salinity effects of the DC Plan, as calculated with EC values in the Delta channels and at the CVP and SWP exports. The major salinity evaluation issues for the DC Plan are:

Agricultural Diversion EC. The maximum summer agricultural diversions of about 1,250 cfs in the south Delta (representing about 25% of the total Delta agricultural diversions), must be satisfied by water from the SJR–estuary corridor along Old River and Grant Line Canal with salinity less than 700 µS/cm in the south Delta and less than 450 µS/cm in the central Delta. The salinity effects of the four DC Plan dilution flows (1,000 cfs total) simulated at the head of Old River, at the Middle River tidal gate, and at the Tracy and Skinner fish facilities were evaluated with maximum summer agricultural diversions along the Old River corridor.

Export EC. The benefits of separating the SJR from the CVP and SWP exports were evaluated with DSM2 salinity (EC) modeling by comparing the export EC for existing conditions and with the simulated DC Plan. The SJR flows are normally less than the exports, so under existing conditions most of the SJR flows and the SJR salt loads are exported. Eliminating the export of SJR flow and salt may substantially reduce the CVP and SWP salinity and allow most of the SJR salt load to flow into the estuary.

Seawater Intrusion EC. Increased salinity at the exports originates from seawater intrusion during periods of low Delta outflows. The DC Plan may eliminate some of this seawater intrusion by limiting the connections to the water supply corridor. However, the DC Plan would allow some seawater intrusion that has entered the SJR to move into Middle River and would also allow some flow from False River to “recycle” upstream into the Middle River water supply corridor. This recycle of SJR flow from False River may be increased when exports are greater than the DCC and Georgiana Slough and Threemile Slough flows, causing the SJR flow at Bradford Island to reverse direction (i.e., move upstream). The ability of the DC Plan to reduce seawater intrusion was evaluated with the DSM2 EC source tracking.

Some changes in Delta operations or other tidal gates might be useful for further reducing salinity intrusion or fish entrainment. However, these additional facilities or changes in future Delta operations were not evaluated in this report. For example, increased Delta outflow in some low-flow months may reduce seawater intrusion into the water supply corridor. It may be possible to shift export pumping to other months to compensate for increased Delta outflow for salinity control in these low-flow months.

A tidal gate on Threemile Slough is being investigated by California Department of Water Resources (DWR) to increase the net flow in Threemile Slough from the Sacramento River to reduce seawater intrusion at Jersey Point. This gate also might be effective in controlling salinity intrusion into the DC Plan water supply corridor. The two-gate project recently proposed by BDCP as an interim measure to separate Franks Tract from the water supply corridor with tidal gates on Old River (downstream of Rock Slough) and Connection Slough, or with additional tidal gates at Santa Fe Cut and Woodward Canal (four-gate project), could provide the desired water quality. However, these tidal gates are not part of the DC Plan and are not simulated in this report. The DSM2 model has some recognized limitations regarding agricultural drainage assumptions that affect salinity predictions. The limited scope of this evaluation did not allow salinity refinements to the DSM2 model.

The direct effects of the DC Plan on reducing CVP and SWP export EC values and providing adequate EC values for agricultural diversions along the Old River corridor were explored in this initial salinity evaluation report. This evaluation used the simulated monthly sequence of inflows, exports, and outflow to compare the simulated EC for existing Delta conditions with the simulated EC for DC Plan configuration. No changes in monthly inflows, outflows, or exports were evaluated in this comparison.

Simulated Delta Salinity Conditions with Existing Channels and Exports

The effects of the DC Plan configuration on Delta EC values were evaluated in comparison with existing conditions. Existing conditions were represented by the flows and EC conditions simulated for the SDIP Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) (DWR 2005). These simulated south Delta conditions included tidal gates in the south Delta (in Middle River upstream of Victoria Canal, in Old River upstream of the DMC intake, and in Grant Line Canal at the mouth) to regulate minimum tidal elevations for agricultural diversions. The SDIP included another gate at the head of Old River would protect juvenile SJR Chinook salmon from diversion into Old River and subsequent entrainment at the CVP and SWP pumps. The DC Plan would eliminate the Grant Line Canal gate, and would move the head of Old River gate to divert all of the SJR flow into Old River.

The monthly reservoir and Delta operations model (CALSIM) was used for the SDIP evaluation to estimate baseline Delta flows and exports. The baseline simulated inflows and exports were somewhat different from historical inflows and exports because the CALSIM simulations reflect current reservoir operations and Delta objectives (D-1641). The 16-year period of 1976–1991 generally is used by DWR in DSM2 modeling to represent the full range of Delta hydrology (inflows and exports) and EC conditions. Table 1 provides the monthly average inflows, exports, outflow, and SJR EC values used in the DSM2 modeling for three representative years: 1977 (critically dry), 1978 (above normal for the Sacramento River, wet for the SJR), and 1979 (below normal for the Sacramento River, above normal for the SJR). The inflows and exports and Delta outflows were the same for the existing conditions and the DC Plan EC simulations. The average flows for the 1977–1979 years, the 1976–1991 study period, and the full SDIP simulation (1922–1994) are given. Map 4 shows the 16-year average flows in several Delta channels for the DSM2 simulations of the existing conditions and of the DC Plan channel configuration.

Table 2 provides a summary of the DSM2-simulated average monthly flows at several Delta locations for the existing conditions and for the DC Plan during 1977–1979. The averages for the three years and the averages for the 16-year study period are given. The flow changes between the existing conditions and the DC Plan are given as the average change and as a percentage. For Old River at Bacon Island and the Los Vaqueros (LV) intake, the direction of the net flow would reverse (to flow downstream) with the DC Plan. The net flow also would reverse (to flow upstream) in the SJR at the Stockton DWSC with the DC Plan. The combined DCC and Georgiana Slough flows would be higher for the DC Plan in the winter and spring months because the DCC was closed for existing conditions but would be open with the DC Plan. Flows in Old River and Middle River would change substantially with the DC Plan.

The next section discusses the simulated baseline Delta EC conditions for this 16-year period. These baseline EC conditions then are compared to DSM2-simulated EC with the proposed DC Plan changes in the Delta channels. Delta EC conditions are described for Suisun Bay and for the south and central Delta. Suisun Bay EC values are controlled by Delta outflow, while south Delta EC values are controlled by the combination of SJR EC and seawater intrusion from Suisun Bay, which is controlled by Delta outflow. Map 5 shows the Delta locations that were used to evaluate changes in salinity (EC) with the DC Plan.

Suisun Bay Salinity

Figure 1a shows the simulated monthly average EC in Suisun Bay for 1976–1991. Martinez, at the downstream end of Suisun Bay, is the downstream DSM2 model boundary. Martinez is located about 56 km upstream from the Golden Gate Bridge. The Martinez EC values are estimated as model inputs from the historical EC data and the simulated Delta outflow values. The highest monthly average EC at Martinez was about 23,500 µS/cm in several years during the low-outflow fall months. An EC of 23,500 µS/cm is equivalent to about 15,000 mg/l (15 parts per thousand [ppt]) salinity, using the assumed ratio of 1.55 EC (µS/cm) to total dissolved solids (TDS) (mg/l).

The simulated EC at Chipps Island was a little more than half the EC at Martinez. Chipps Island, across from Mallard Slough, is located about 75 km upstream from the Golden Gate Bridge (19 km upstream from Martinez). The highest

Table 1. Simulated Delta Inflows, Exports, and Outflow (cfs) and Boundary Conditions EC (uS/cm) for Water Years 1977, 1978, and 1979 for Existing Conditions and the Delta Corridors Plan

Calendar		Sacramento Inflow (cfs)	San Joaquin Inflow (cfs)	Mokelumne-Cosumnes Inflow (cfs)	Total Inflow (cfs)	CVP Exports (cfs)	SWP Exports (cfs)	Outflow (cfs)	San Joaquin EC (uS/cm)	Martinez EC (uS/cm)	San Joaquin Salt Load (tons/day)
Year	Month										
1976	Oct	7,785	3,176	23	11,097	2,588	3,272	4,088	504	23,301	2,750
1976	Nov	8,486	2,092	104	10,749	1,728	3,229	4,616	559	22,926	2,059
1976	Dec	9,408	1,684	78	11,228	800	2,643	6,826	590	22,561	1,739
1977	Jan	8,523	1,306	75	9,963	800	1,718	8,172	722	21,732	1,655
1977	Feb	7,619	1,381	94	9,211	800	1,063	6,566	907	20,634	2,171
1977	Mar	7,742	1,271	81	9,277	800	1,158	5,626	1,000	20,255	2,163
1977	Apr	9,034	1,699	37	10,983	800	700	5,629	702	19,871	1,974
1977	May	6,478	1,577	36	8,205	800	700	4,343	630	20,497	1,690
1977	Jun	11,005	1,219	5	12,359	1,476	1,426	4,712	666	21,700	1,276
1977	Jul	15,772	884	0	16,762	3,214	4,854	5,940	843	21,950	1,143
1977	Aug	11,310	673	0	12,094	2,988	1,639	5,692	1,000	22,371	1,055
1977	Sep	7,101	974	7	8,929	2,810	1,526	3,907	1,000	23,388	1,642
1977	Oct	7,761	1,458	11	9,340	3,052	848	4,428	762	23,368	1,905
1977	Nov	7,208	1,340	104	8,716	1,251	994	5,351	785	22,856	1,836
1977	Dec	15,118	1,512	320	17,014	2,989	4,230	7,905	648	20,739	1,709
1978	Jan	63,491	3,728	1,813	69,911	2,991	4,593	64,940	338	3,643	2,187
1978	Feb	48,085	7,851	1,199	58,681	4,218	8,500	47,631	234	1,550	3,177
1978	Mar	61,742	9,079	1,787	74,733	4,305	7,561	63,210	291	867	4,614
1978	Apr	30,538	12,876	1,933	46,363	800	700	44,002	214	1,891	4,765
1978	May	20,539	10,948	1,262	32,894	800	3,274	25,855	223	5,221	4,246

Calendar Year	Month	Sacramento Inflow (cfs)	San Joaquin Inflow (cfs)	Mokelumne-Cosumnes Inflow (cfs)	Total Inflow (cfs)	CVP Exports (cfs)	SWP Exports (cfs)	Outflow (cfs)	San Joaquin EC (uS/cm)	Martinez EC (uS/cm)	San Joaquin Salt Load (tons/day)
1978	Jun	16,792	11,270	793	29,024	2,942	6,539	14,756	230	10,194	4,445
1978	Jul	17,830	2,532	34	20,553	4,600	3,083	7,962	606	15,435	2,720
1978	Aug	16,412	1,875	3	18,452	4,557	6,680	5,008	704	19,760	2,225
1978	Sep	16,135	2,604	32	18,948	4,483	7,180	6,510	725	21,650	3,227
1978	Oct	10,804	4,600	1,164	16,687	4,369	6,537	5,633	376	22,240	2,974
1978	Nov	10,054	1,543	321	11,983	4,258	2,418	5,352	751	22,284	2,098
1978	Dec	9,980	1,720	278	12,101	3,893	1,605	5,860	617	21,651	1,844
1979	Jan	23,120	4,973	639	29,873	4,229	8,338	17,670	277	16,825	2,381
1979	Feb	40,769	9,354	1,581	53,485	4,250	6,313	43,830	211	5,239	3,412
1979	Mar	29,463	8,715	2,212	41,128	4,255	7,561	29,578	285	4,699	4,325
1979	Apr	16,288	6,322	1,372	24,142	1,500	1,500	19,578	307	8,929	3,380
1979	May	16,697	5,575	1,496	23,931	2,274	2,887	15,709	337	10,608	3,257
1979	Jun	19,677	2,154	660	22,672	3,000	4,482	11,222	641	13,832	2,310
1979	Jul	18,925	1,841	0	20,938	4,590	5,100	5,749	706	17,654	2,144
1979	Aug	16,274	1,751	0	18,202	4,544	6,680	3,260	702	20,643	2,062
1979	Sep	14,291	1,837	76	16,397	4,476	6,231	3,390	901	22,158	2,815
WY 77-79 Average		**18,285**	**3,761**	**545**	**22,973**	**2,840**	**3,827**	**14,736**	**583**	**16,531**	**2,538**
WY 76-91 Average		**21,550**	**4,656**	**999**	**30,678**	**2,969**	**4,108**	**22,049**	**587**	**15,629**	**2,654**
WY 22-94 Average		**22,293**	**3,692**	**895**	**29,182**	**3,178**	**4,584**	**19,892**			

Note: Daily flows can differ considerably from the monthly average flow

Table 2. DSM2-Simulated Monthly Channel Flows for Water Years 1977, 1978, and 1979 for Existing Conditions and the Delta Corridors Plan

Calendar Year	Month	Existing Delta Cross Channel & Georgiana (cfs)	DC Plan Delta Cross Channel & Georgiana (cfs)	Existing Threemile Slough from Sac (cfs)	DC Plan Threemile Slough from Sac (cfs)	Existing SJR at Bradford (cfs)	DC Plan SJR at Bradford (cfs)	Existing False River (cfs)	DC Plan False River (cfs)	Existing Antioch (cfs)	DC Plan Antioch (cfs)
1976	Oct	4,320	4,306	1,024	1,121	480	-1,298	2,169	3,722	2,378	2,398
1976	Nov	3,856	4,539	1,171	1,071	145	-526	2,093	3,141	1,960	2,494
1976	Dec	3,781	4,850	1,025	809	683	825	2,499	3,077	2,986	3,792
1977	Jan	3,191	4,458	913	641	961	1,531	2,640	2,976	3,491	4,444
1977	Feb	2,281	4,039	1,133	743	382	1,295	2,284	2,635	2,454	3,766
1977	Mar	2,306	4,129	1,210	798	307	1,359	2,086	2,367	2,167	3,534
1977	Apr	2,523	4,706	1,364	868	301	1,614	2,001	2,288	1,962	3,599
1977	May	2,088	3,510	1,166	848	293	968	2,189	2,531	2,226	3,285
1977	Jun	5,181	5,462	1,266	1,184	33	666	2,036	1,643	1,728	1,882
1977	Jul	7,393	7,354	1,913	1,930	-1,305	-1,406	1,180	1,269	-516	-552
1977	Aug	5,859	5,776	1,378	1,392	-359	-55	1,862	1,515	1,205	1,081
1977	Sep	4,090	3,989	1,254	1,296	-447	-689	1,949	2,070	1,221	1,097
1977	Oct	4,312	4,219	1,071	1,118	233	-217	2,113	2,424	2,083	1,979
1977	Nov	3,353	3,837	958	858	707	829	2,401	2,589	2,898	3,227
1977	Dec	5,004	6,766	1,697	1,360	-501	-231	1,653	2,605	774	2,142
1978	Jan	9,308	19,491	1,793	-342	6,565	12,225	4,314	6,251	11,046	19,006
1978	Feb	7,324	15,349	1,910	427	3,521	4,516	3,296	7,856	6,779	13,186
1978	Mar	9,071	18,986	1,794	-135	6,527	8,747	4,023	8,799	10,634	18,520
1978	Apr	4,957	10,198	-690	-1,563	10,284	8,776	6,402	11,268	17,069	21,341
1978	May	3,734	7,861	143	-535	6,067	3,958	4,481	9,208	10,612	14,076
1978	Jun	6,615	7,201	558	662	3,601	-1,483	3,082	7,981	6,536	7,181
1978	Jul	7,853	7,834	1,564	1,592	-81	-897	1,728	2,551	1,218	1,343

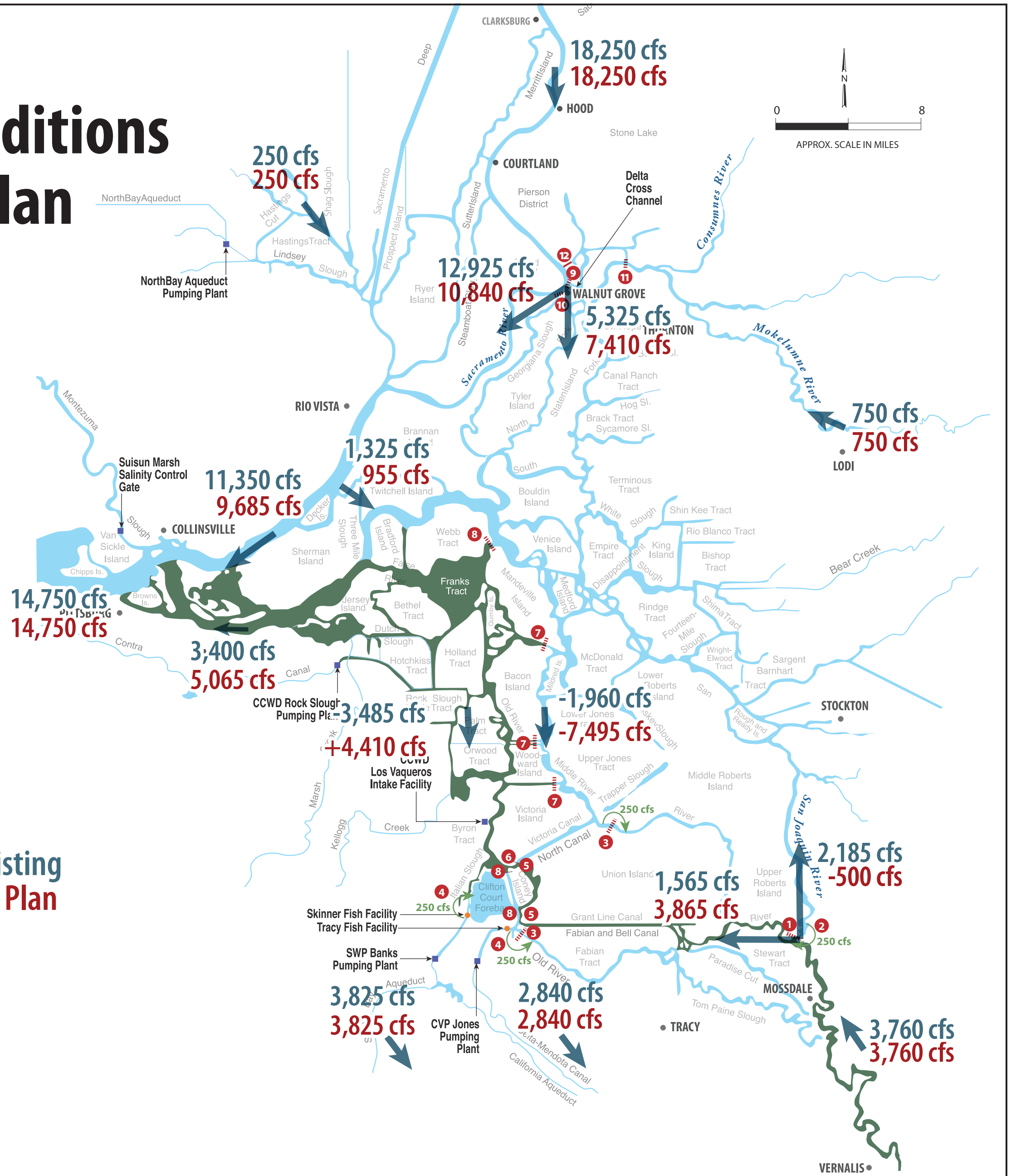
Calendar Year	Month	Existing Delta Cross Channel & Georgiana (cfs)	DC Plan Delta Cross Channel & Georgiana (cfs)	Existing Threemile Slough from Sac (cfs)	DC Plan Threemile Slough from Sac (cfs)	Existing SJR at Bradford (cfs)	DC Plan SJR at Bradford (cfs)	Existing False River (cfs)	DC Plan False River (cfs)	Existing Antioch (cfs)	DC Plan Antioch (cfs)
1978	Aug	7,615	7,609	2,045	2,110	-1,601	-2,960	891	2,096	-1,182	-1,167
1978	Sep	7,507	7,511	1,868	1,959	-959	-2,998	1,155	2,947	-202	-170
1978	Oct	5,411	5,452	1,382	1,522	-62	-3,176	1,571	4,315	1,206	1,284
1978	Nov	4,458	5,252	1,470	1,339	-529	-1,054	1,657	2,670	853	1,493
1978	Dec	3,954	5,112	1,464	1,241	-438	-540	1,765	2,625	1,021	1,902
1979	Jan	5,901	9,096	1,925	1,423	384	-884	1,827	5,104	1,882	4,455
1979	Feb	6,390	13,166	1,098	-100	5,902	5,701	3,974	8,751	9,976	15,419
1979	Mar	4,932	10,131	1,399	542	3,379	1,953	2,914	7,768	6,118	10,407
1979	Apr	3,321	6,795	554	-87	4,243	3,908	3,533	6,214	7,713	10,525
1979	May	3,388	6,929	1,130	473	2,240	2,032	2,575	5,218	4,571	7,454
1979	Jun	7,568	8,122	1,586	1,499	289	203	1,661	2,154	1,596	2,059
1979	Jul	8,252	8,231	2,067	2,106	-1,412	-2,132	885	1,536	-1,110	-1,100
1979	Aug	7,572	7,565	2,158	2,222	-2,013	-3,325	641	1,801	-1,959	-1,949
1979	Sep	6,964	6,961	1,936	2,010	-1,469	-3,018	962	2,320	-1,018	-1,005
WY 77-79 Average		5,323	7,411	1,325	956	1,288	950	2,347	4,063	3,399	5,067
WY 76-91 Average		5,702	8,279	1,392	912	2,310	1,919	2,730	4,806	4,873	6,923
WY 76–91 Change			2,577		-480		-391		2,076		2,050
Percent of Existing			145%		65%		83%		176%		142%

Calendar Year	Month	Existing Old River at Bacon (cfs)	DC Plan Old River at Bacon (cfs)	Existing Old at LV Intake (cfs)	DC Plan Old at LV Intake (cfs)	Existing Middle R at Santa Fe (cfs)	DC Plan Middle R at Santa Fe (cfs)	Existing Old River at Head (cfs)	DC Plan Old River at Head (cfs)	Existing SJR at Stockton DWSC (cfs)	DC Plan SJR at Stockton DWSC (cfs)
1976	Oct	-2,544	3,542	-3,515	3,960	-2,027	-6,613	426	3,353	2,669	-268
1976	Nov	-2,185	2,707	-3,026	3,004	-1,764	-5,753	316	2,380	1,800	-270
1976	Dec	-1,096	2,330	-1,620	2,558	-1,005	-4,254	972	1,946	713	-267
1977	Jan	-701	2,105	-1,077	2,306	-696	-3,261	707	1,577	612	-253
1977	Feb	-588	1,951	-727	2,264	-531	-2,642	704	1,624	651	-275
1977	Mar	-772	1,667	-940	1,977	-636	-2,750	638	1,477	557	-295
1977	Apr	-1,112	1,659	-1,197	2,134	-818	-2,401	32	1,812	1,472	-331
1977	May	-923	1,867	-1,059	2,284	-733	-2,357	14	1,776	1,480	-294
1977	Jun	-1,842	799	-2,007	1,278	-1,314	-3,867	544	1,284	418	-361
1977	Jul	-4,420	522	-5,363	977	-3,082	-8,973	545	966	99	-359
1977	Aug	-2,557	682	-3,009	1,088	-1,828	-5,583	438	812	72	-329
1977	Sep	-2,033	1,357	-2,520	1,692	-1,526	-5,142	516	1,172	380	-288
1977	Oct	-1,930	1,834	-2,419	2,215	-1,461	-4,710	239	1,670	1,157	-284
1977	Nov	-1,021	1,904	-1,304	2,216	-855	-3,036	212	1,594	1,117	-272
1977	Dec	-3,042	2,088	-4,035	2,383	-2,273	-7,953	992	1,762	515	-266
1978	Jan	-2,283	4,391	-3,472	4,803	-1,848	-8,268	2,033	3,940	1,685	-231
1978	Feb	-3,923	7,740	-5,562	8,766	-2,833	-13,364	4,088	7,988	3,676	-235
1978	Mar	-3,510	8,483	-4,839	9,713	-2,465	-12,565	4,812	9,293	4,130	-424
1978	Apr	2,291	11,686	3,094	13,560	1,729	-2,441	6,585	11,078	6,145	-260
1978	May	478	9,936	783	11,586	415	-4,851	5,687	10,530	5,216	-319
1978	Jun	-2,736	9,390	-3,065	11,216	-1,631	-10,430	5,796	10,774	5,160	-367
1978	Jul	-3,849	2,182	-4,458	3,025	-2,547	-8,706	1,644	2,874	884	-360

Table 2. Continued

Calendar Year	Month	Existing Old River at Bacon (cfs)	DC Plan Old River at Bacon (cfs)	Existing Old at LV Intake (cfs)	DC Plan Old at LV Intake (cfs)	Existing Middle R at Santa Fe (cfs)	DC Plan Middle R at Santa Fe (cfs)	Existing Old River at Head (cfs)	DC Plan Old River at Head (cfs)	Existing SJR at Stockton DWSC (cfs)	DC Plan SJR at Stockton DWSC (cfs)
1978	Aug	-5,716	1,772	-7,227	2,303	-4,027	-12,070	529	2,033	1,202	-320
1978	Sep	-5,062	2,844	-6,760	3,267	-3,562	-12,476	1,618	2,778	893	-285
1978	Oct	-5,076	4,609	-6,798	5,246	-3,748	-11,736	623	4,757	3,852	-285
1978	Nov	-3,173	2,240	-4,184	2,570	-2,369	-7,530	275	1,899	1,360	-269
1978	Dec	-2,277	2,201	-2,980	2,546	-1,724	-6,332	1,003	1,961	693	-279
1979	Jan	-4,613	5,265	-6,389	5,904	-3,293	-13,204	2,670	5,145	2,242	-240
1979	Feb	-2,686	8,923	-3,761	10,173	-1,897	-11,304	4,851	9,474	4,403	-233
1979	Mar	-3,571	8,378	-4,823	9,612	-2,467	-12,566	4,613	8,984	4,107	-285
1979	Apr	-1,661	6,087	-2,030	7,133	-1,266	-3,941	25	6,573	6,229	-300
1979	May	-2,818	5,196	-3,575	6,114	-2,108	-6,009	24	5,794	5,467	-334
1979	Jun	-4,313	1,512	-5,034	2,257	-2,911	-8,424	542	2,284	1,415	-368
1979	Jul	-5,434	1,216	-6,447	1,959	-3,657	-10,662	544	1,939	1,067	-362
1979	Aug	-5,769	1,645	-7,237	2,185	-4,017	-12,108	529	1,899	1,069	-326
1979	Sep	-5,137	2,151	-6,795	2,479	-3,754	-11,555	518	2,022	1,226	-295
WY 77-79 Average		-2,711	3,746	-3,483	4,410	-1,959	-7,495	1,564	3,867	1,779	-300
WY 76-91 Average		-2,612	4,500	-3,382	5,314	-1,890	-7,906	1,885	4,188	2,429	-298
WY 76–91 Change			7,112		8,696		-6,016		2,303		-2,727
Percent of Existing		Reverse	-172%	Reverse	-157%		418%		222%	Reverse	-12%

Delta Channel Flows —Comparing Existing Conditions to the Delta Corridors Plan



Average Flows for 1976–1979—Existing

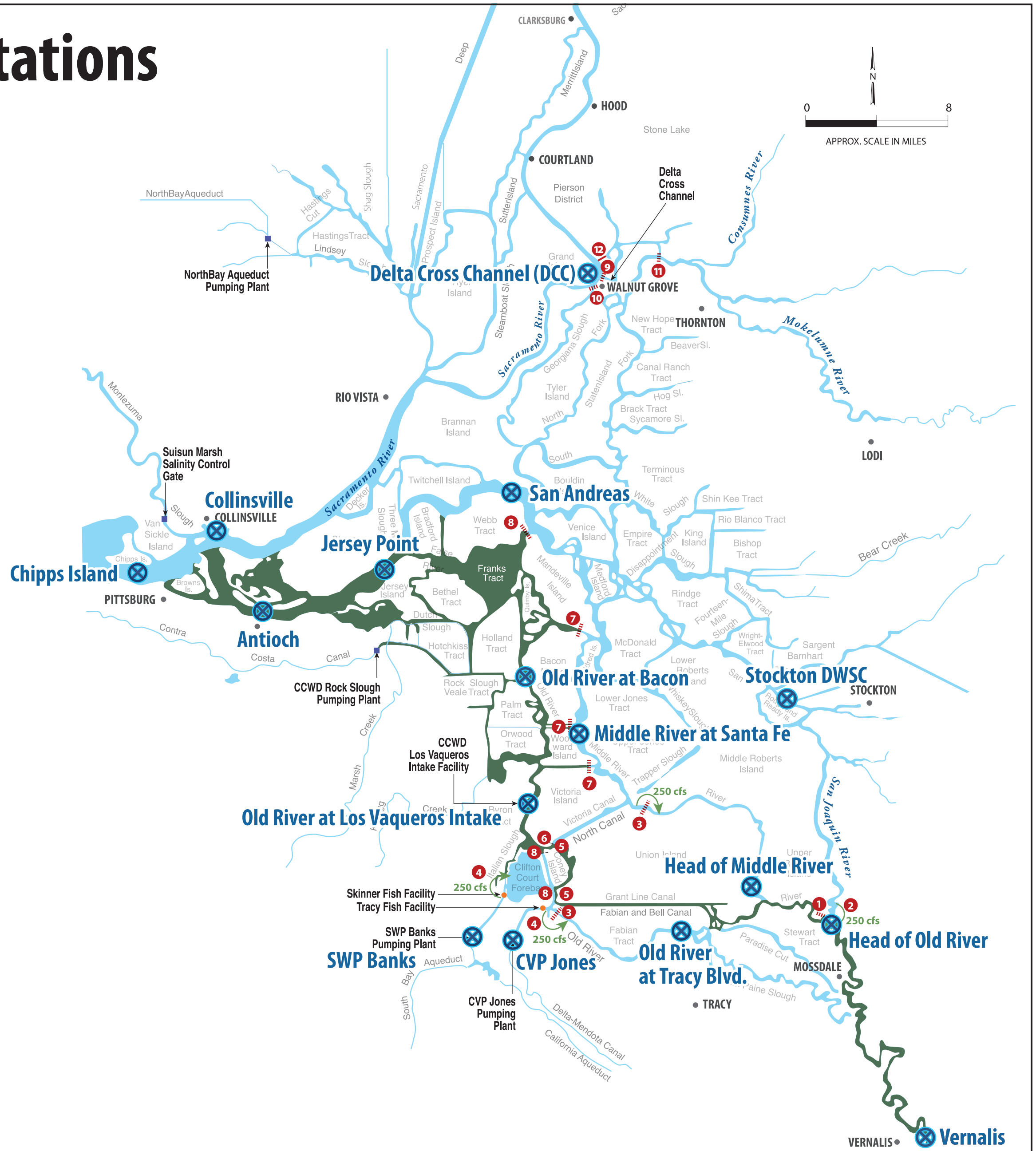
Average Flows for 1976–1979—DC Plan

Graphics\Projects\ 00086.09 Delta Corridors/(08-09) SS

ICF Jones & Stokes
an ICF International Company

Map 4
Changes in Delta Channel Flows with the Delta Corridors Plan

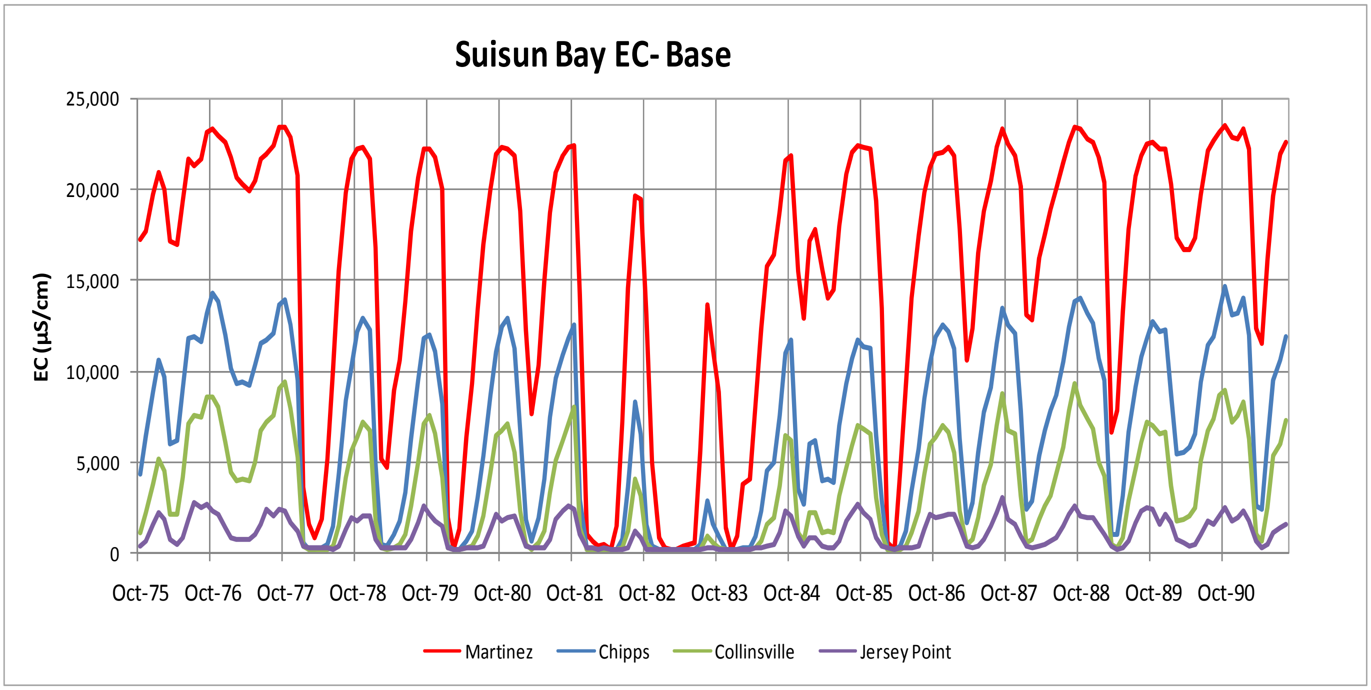
Electrical Conductivity Stations Used for Evaluating the Delta Corridors Plan



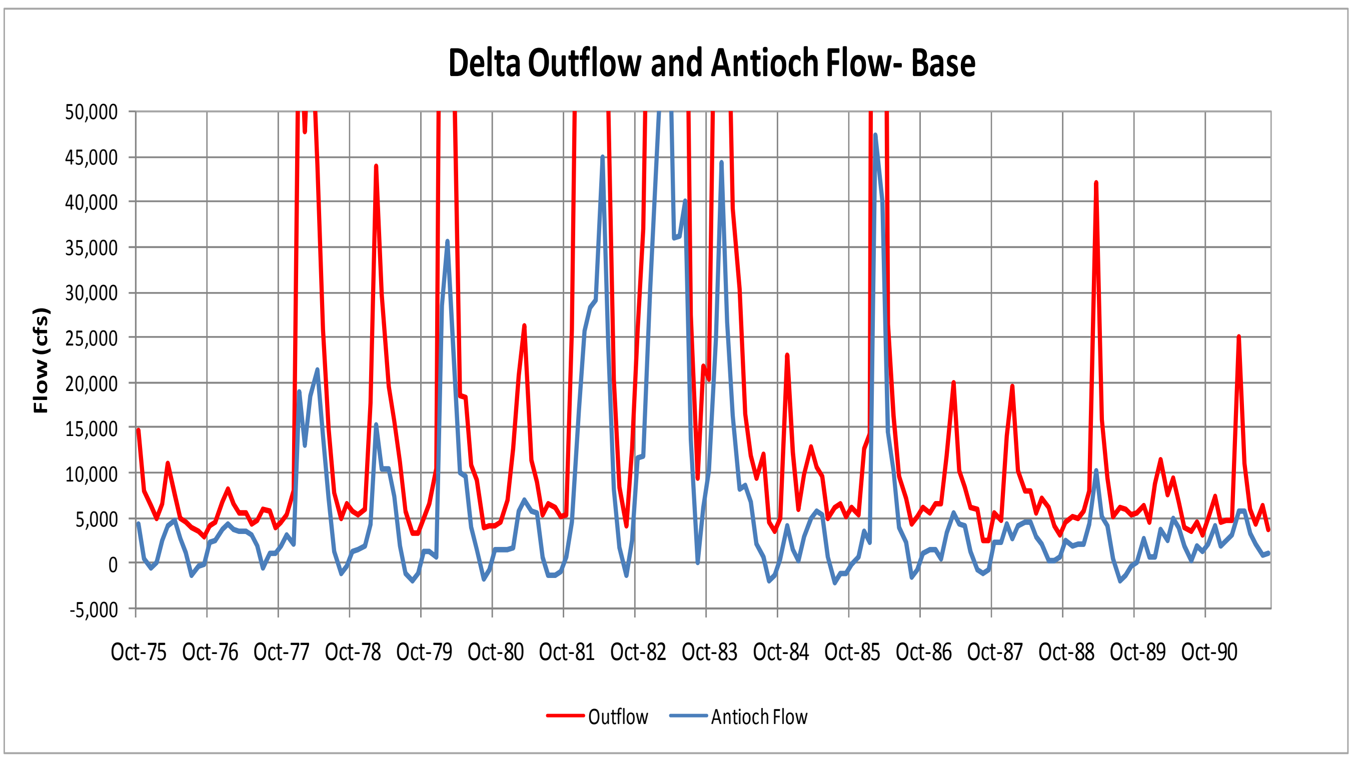
Graphics\Projects\ 00086.09 Delta Corridors/(08-09) SS

ICF Jones & Stokes
an ICF International Company

Map 5
Electrical Conductivity Stations Used for Evaluating the Delta Corridors Plan



1a. DSM2-Simulated Suisun Bay and Jersey Point EC for WY 1976–1991



1b. DSM2-Simulated Delta Outflow and San Joaquin River Flow at Antioch for WY 1976–1991

00086.09

ICF Jones & Stokes
an ICF International Company

Figure 1

monthly average EC at Chipps Island was about 14,000 µS/cm during months with the lowest Delta outflow. The simulated EC at Collinsville, which is near the confluence of the SJR and the Sacramento River about 81 km upstream of the Golden Gate (6 km upstream from Chipps Island), was about 9,000 µS/cm during the fall months with lowest Delta outflow. The simulated EC at Jersey Point, located on the SJR about 18 km upstream of Collinsville, was about 2,500 µS/cm during the fall months with lowest Delta outflow.

To illustrate the general relationships between outflow and Suisun Bay EC, Figure 1b shows the simulated monthly Delta outflow and the corresponding SJR flow at Antioch. The higher outflow periods correspond to lower Suisun Bay EC values. The fall months with Delta outflow of less than 5,000 cfs often have negative (i.e., upstream) flows at Antioch. Tidal movement and mixing of the Suisun Bay water causes the EC at Suisun Bay and western Delta locations to increase as the Delta outflow is reduced.

Figure 2a shows the relationship between Delta outflow and DSM2-simulated EC in Suisun Bay. The EC at each Suisun Bay station is higher when the outflow is lower. Figure 2b shows the relationship between the simulated EC in Suisun Bay and the “effective” Delta outflow. The effective Delta outflow is calculated as a running average of the monthly outflow values, using a procedure called the G-model introduced by CCWD staff (CCWD 2007). The very strong relationship between the effective Delta outflow and simulated EC at these locations demonstrates that the salinity in Suisun Bay and at Collinsville and Jersey Point is almost totally dependent on the Delta outflow sequence. This negative-exponential relationship allows the EC at a location to be estimated as a function of the effective outflow:

Estimated EC (µS/cm) = constant x exp [-coefficient x effective outflow (cfs)]

> where the constant and coefficient values can be calibrated for each Suisun Bay location from the measured EC data.

The simulated EC at Martinez decreases slowly (i.e., small coefficient) with increasing effective outflow, and the EC is greater than 15,000 µS/cm when the effective outflow is 10,000 cfs. The simulated EC at Chipps Island decreases more rapidly with outflow (i.e., larger coefficient) and the EC is about 5,000 µS/cm when the effective outflow is 10,000 cfs. The simulated Collinsville EC is about 5,000 µS/cm when the effective outflow is 6,000 cfs. The simulated Jersey Point EC is about 2,500 µS/cm when the effective outflow is 4,000 cfs, which was the minimum effective outflow simulated for the 1976–1991 period with the CALSIM model.

The Delta outflow is regulated under D-1641 during the months of February–June by the location of the 2 ppt bottom salinity (X2). The 2 ppt salinity is equivalent to a surface EC of about 2,640 µS/cm. Figure 2b shows that an effective outflow of about 7,500 cfs is required to maintain X2 at Collinsville. An effective outflow of about 12,500 cfs is required to maintain X2 at Chipps Island. Delta outflow is the only effective control for managing Suisun Bay or western Delta salinity.

CCWD uses the Mallard Slough intake only when the chloride concentration is less than about 100 mg/l, in order to deliver their target chloride concentration of 65 mg/l. The corresponding EC values at Mallard Slough (assuming a typical chloride/EC ratio of about 0.2) is about 500 μS/cm, which occurs when Delta outflow is greater than about 25,000 cfs. The City of Antioch intake is used when the chloride concentration is less than about 200 mg/l, equivalent to an EC of 1,000 μS/cm, which corresponds to an outflow of about 7,000 cfs.

The DC Plan would not change the salinity in Suisun Bay or the western Delta because the DC Plan would not change the Delta outflow. The DC Plan would not change the salinity at the Antioch and Mallard Slough intakes substantially during the periods that these intakes are used. Table 1 gives the monthly Antioch EC values for three years of the simulation (1977, 1978, and 1979) and indicates the small changes when the existing conditions EC values were less than 1,000 μS/cm (i.e., suitable for Antioch intake). The average Antioch EC was 350 μS/cm for the existing conditions in the months with high outflow and was increased slightly to 390 μS/cm in these same months with the DC Plan.

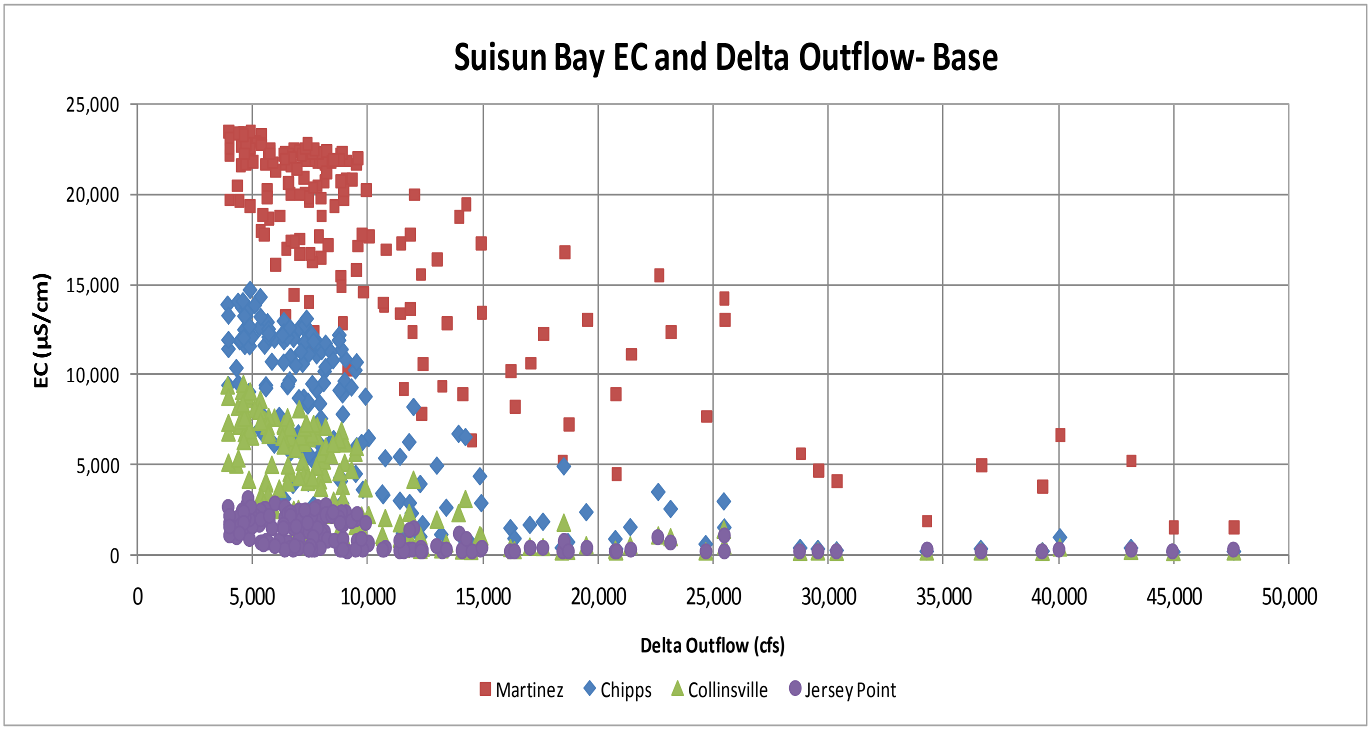
Sacramento River Salinity

The Sacramento River EC ranges from about 125 μS/cm at high flows to about 225 μS/cm at low flows, with an average EC of about 175 μS/cm. The DSM2 model assumes that the Sacramento River and Yolo Bypass EC values are 175 μS/cm all the time. The Mokelumne River and Cosumnes River EC values are assumed to be 150 μS/cm, but this inflow is generally much less than the Sacramento River diversions to the central Delta. The SJR and agricultural drainage EC values are usually higher than the Sacramento River EC. Therefore, the lowest possible EC in the central Delta and at the exports is the Sacramento River EC of 175 μS/cm.

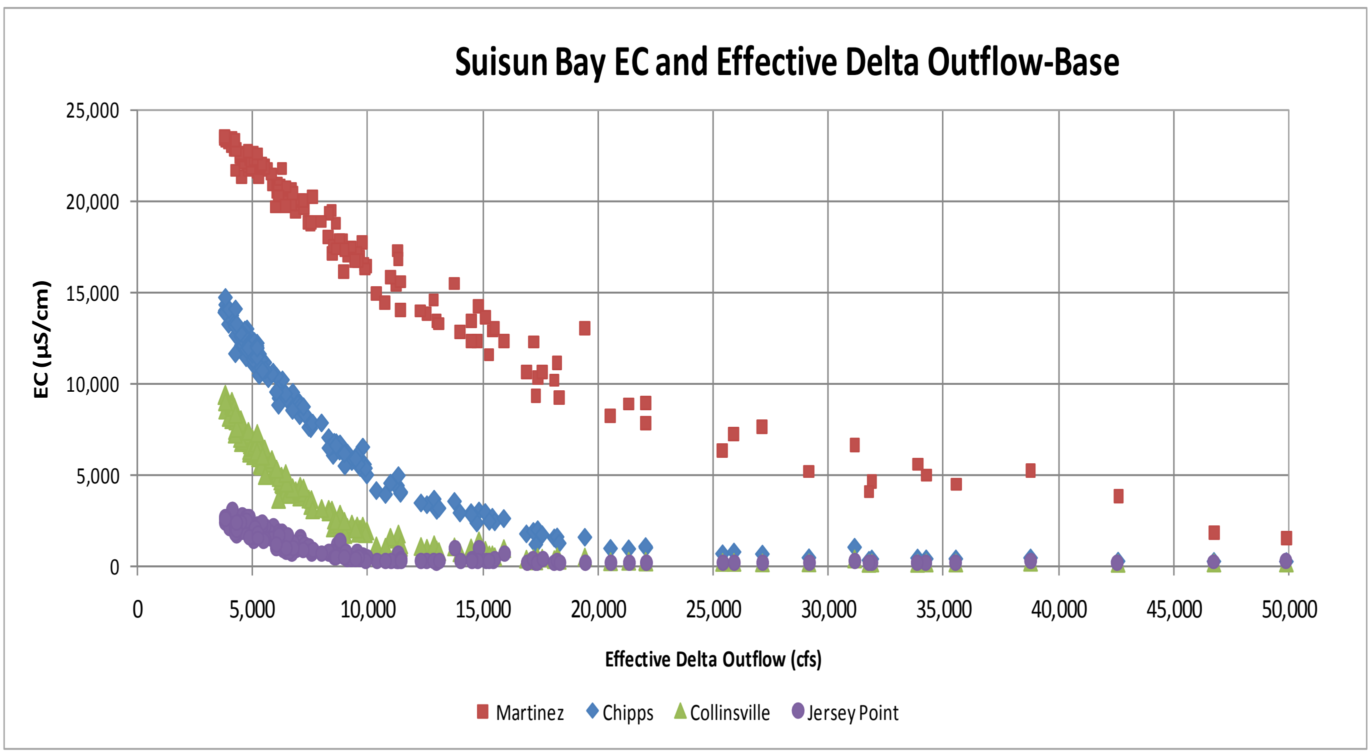
The EC of the CVP and SWP exports will be greater than the assumed Sacramento River EC of 175 μS/cm if some of the source water reaching the exports has an EC value greater than 175 μS/cm. The salinity evaluation of the DC Plan was based on the EC at the exports above the simulated Sacramento River EC of 175 μS/cm. The excess EC at a Delta location or at the exports is defined as:

$$\text{Excess EC } (\mu S/cm) = \text{Simulated EC } (\mu S/cm) - 175\ (\mu S/cm)$$

The three possible sources of excess EC at the exports (i.e., higher EC than the Sacramento River EC) are the SJR, agricultural drainage from the Delta islands, and seawater intrusion from Martinez (i.e., Suisun Bay). Only the excess EC at the exports or other Delta locations can be reduced by the DC Plan or other Delta conveyance alternatives. The reduction of the excess EC at the CVP and SWP exports (from the existing conditions excess EC) provides a salinity reduction performance measure for the DC Plan or other Delta alternatives.



2a. Relationship between DSM2-Simulated Suisun Bay EC and Delta Outflow



2b. Relationship between DSM2-Simulated Suisun Bay EC and Effective Delta Outflow (G-model)

00086.09

ICF Jones & Stokes
an ICF International Company

Figure 2

The DCC is closed about half the time in December and January and all the time from February to June under D-1641 objectives to provide protection for Sacramento River migrating fish. The DC Plan would open the DCC all of the time (with fish screens on DCC and Georgiana Slough) and allow more of the low-EC Sacramento River water to be diverted into the central Delta and the Middle River water supply corridor to the exports. The DC Plan also would separate the SJR from the exports and reduce the contribution of agricultural drainage to the exports. The salinity evaluation of the DC Plan is described as the reduction in the excess EC at various Delta locations and at the exports.

San Joaquin River Salinity and Salt Load

The SJR EC generally varies with flow and is highest at low flows. The SJR EC ranges from less than 250 µS/cm during high flows (above 10,000 cfs) to about 1,000 µS/cm at low flows of about 1,000 cfs. The SJR flow and EC values are calculated in the CALSIM monthly operations model, based on historical salt loads from runoff and upstream agricultural drainage. Releases from New Melones Reservoir on the Stanislaus River are assumed in the CALSIM model to provide necessary dilution (i.e., low-EC water) to satisfy the EC objective at Vernalis. More releases for dilution are needed in years with low SJR flows. The Vernalis EC objective in D-1641 is a monthly average EC of less than 700 µS/cm during the irrigation season of April through August, and a monthly average EC of less than 1,000 µS/cm for the other months. For the 16-year study period, the average CALSIM-estimated SJR EC was about 587 µS/cm, so the average SJR excess EC was about 412 µS/cm (i.e., 587 – 175).

Figure 3a shows the historical measured monthly SJR flows and EC values for the 1976–1991 period. The CALSIM-estimated SJR flows and EC values for the existing conditions were generally similar to the historical values, although New Melones Reservoir was not yet filled in the first part of the period and the Vernalis salinity objective was different. The simulated months of high flows in wet years were similar, as were periods of low flows (less than 2,500 cfs) during the 5-year (1987–1991) drought period.

Figure 3b shows the historical and CALSIM-simulated dilution relationships for the SJR flow and EC values. The SJR EC was almost always above 175 µS/cm; only when flows were greater than 20,000 cfs was the measured or estimated SJR EC less than 175 µS/cm. Although there are differences in the historical and existing conditions monthly flows and EC values, the general magnitude of the CALSIM-estimated flow and EC values is similar to the historical measurements. Therefore, the CALSIM-estimated monthly SJR flows, EC values, and salt loads are a reliable representation of the existing conditions. The similarity of the CALSIM-simulated flows and the historical flows does not imply that these low SJR flows are sufficient for downstream uses. The salinity evaluation of the DC Plan used these simulated monthly SJR flows and EC values without assuming any changes in SJR flow or salinity. Potential flow and salt management opportunities on the SJR (such as DMC recirculation or selenium total maximum daily load [TMDL] implementation actions) could be evaluated in subsequent studies.

The salt load of the SJR can be estimated from the flow and the EC value with the following relationship:

Salt load (tons/day) = 5.4/1.55/2000 x EC (µS/cm) x flow (cfs)

= 0.00175 x EC (µS/cm) x flow (cfs)

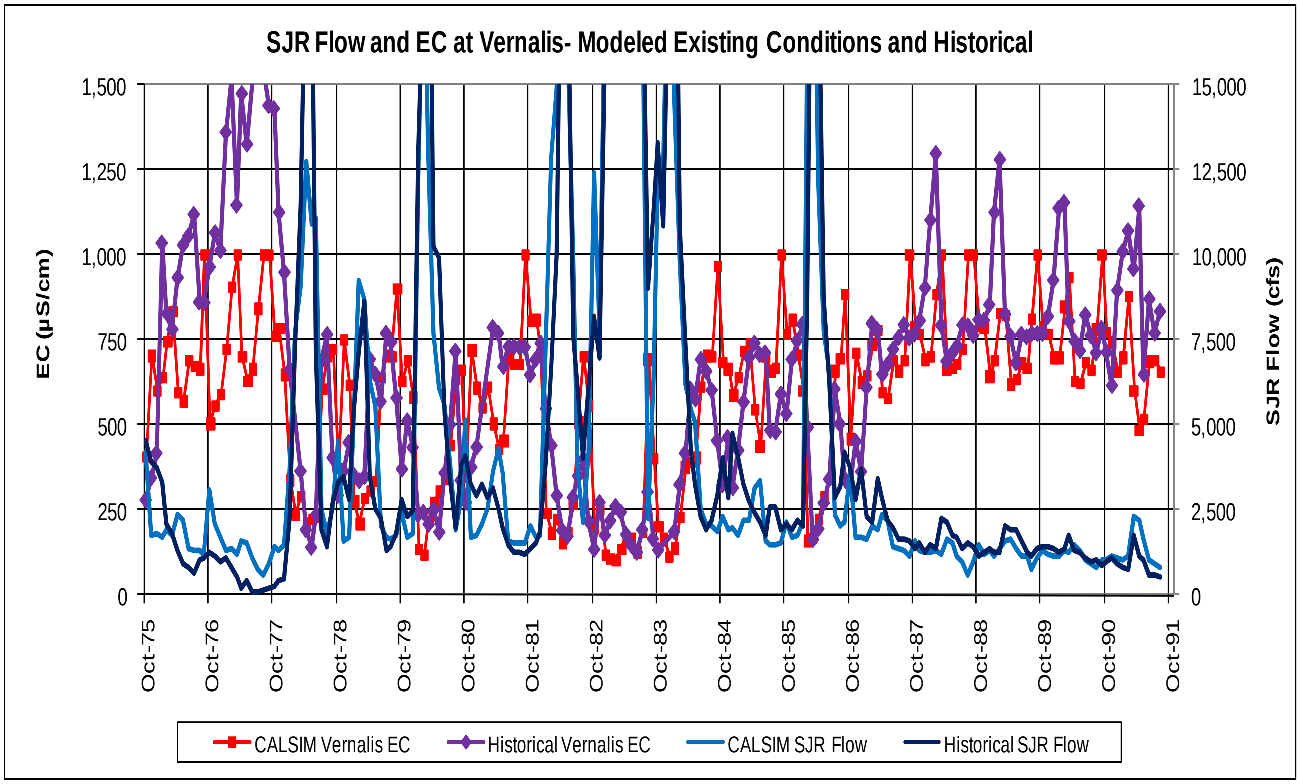
where 5.4 is the conversion from mg/l and cfs to lb/day, 1.55 is the assumed ratio of EC (µS/cm) to dissolved salt (mg/l), and a ton equaling 2,000 pounds.

For example, an SJR flow of 1,000 cfs with an EC of 1,000 µS/cm carries a total salt load of about 1,750 tons/day. The excess salt load can be calculated from the flow and the excess EC value. The excess salt load in an SJR flow of 1,000 cfs and a measured EC of 1,000 µS/cm (excess EC of 825 µS/cm) would be about 1,450 tons/day. The non-excess SJR salt load for 1,000 cfs (with an EC of 175 µS/cm) would be about 300 tons/day. Because the SJR EC is a maximum of 1,000 µS/cm, the maximum fraction of excess salt load for the SJR is 82.5%.

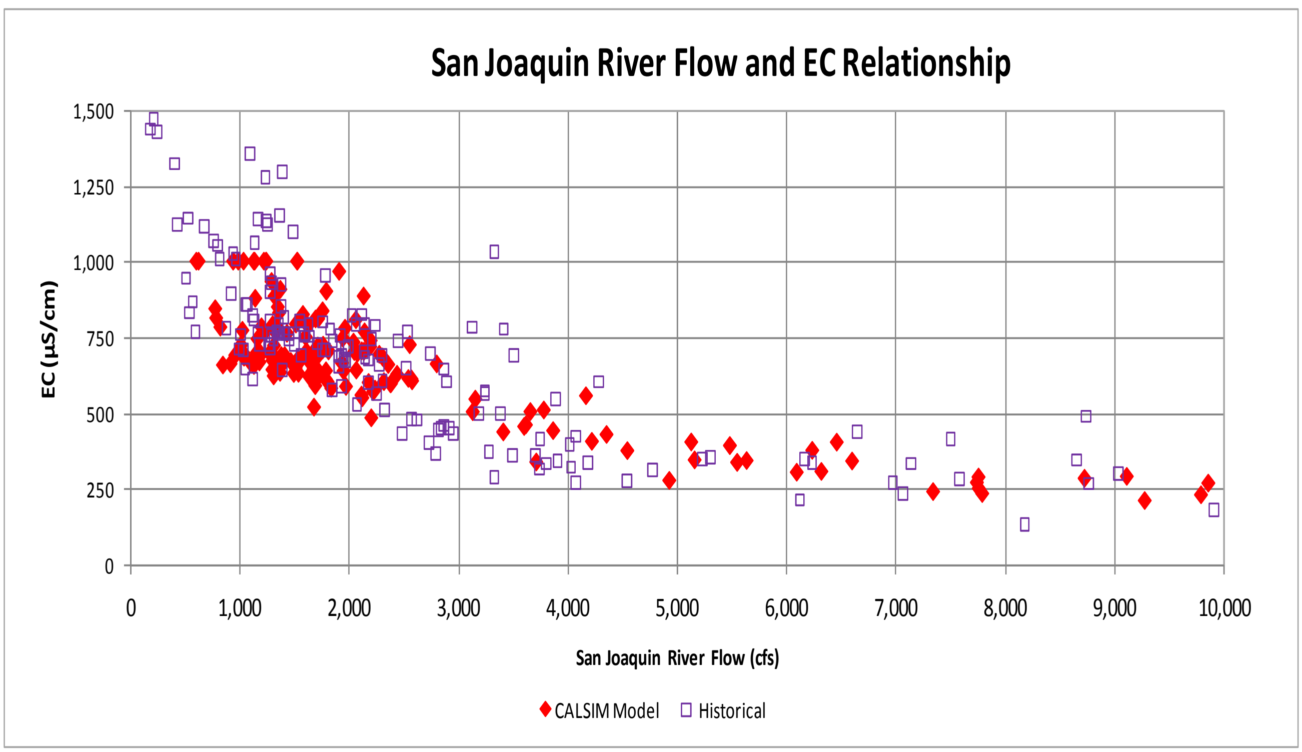
An EC/TDS ratio of 1.55 was estimated from measured EC and TDS on the SJR. This corresponds to a TDS/EC ratio of about 0.65. The TDS/EC ratio is less (about 0.55) for seawater. The estimates of excess salt load for the SJR are accurate using this ratio, while the estimates of excess salt load from seawater intrusion may be about 15% high. The simulated changes in seawater salt load as a percentage of the existing conditions seawater salt load will be accurate for either assumed ratio.

Figure 4a shows the monthly estimated SJR flow and EC values for the 1976–1991 DSM2 modeling period, along with the monthly excess salt load (tons/day). The monthly excess EC values range from about 0 when SJR flows are greater than about 20,000 cfs to 825 µS/cm when the estimated EC is 1,000 µS/cm at low SJR flows of about 1,000 cfs. Figure 4b shows that the monthly average excess salt load generally ranges from about 1,000 tons/day to about 2,500 tons/day. The highest excess salt loads of 1,500 to 2,500 tons/day are estimated for SJR flows of about 2,000 cfs to 10,000 cfs.

The average SJR flow for the 1976–1991 study period was 4,650 cfs, and the average excess EC was 412 µS/cm. Because the EC is reduced at higher flows, the average excess salt load must be calculated for each month’s flow and EC values. The average excess salt load for the SJR was calculated to be about 1,360 tons/day. The average excess salt load was about 50% of the total average SJR salt load of about 2,654 tons/day. The DC Plan would reduce or eliminate the excess salt load at the CVP and SWP export pumps originating from the SJR, because very little of the SJR water would be exported when the SJR EC was greater than 175 µS/cm.



3a. Comparison of Historical and CALSIM-Estimated San Joaquin River Flow and EC for WY 1976–1991

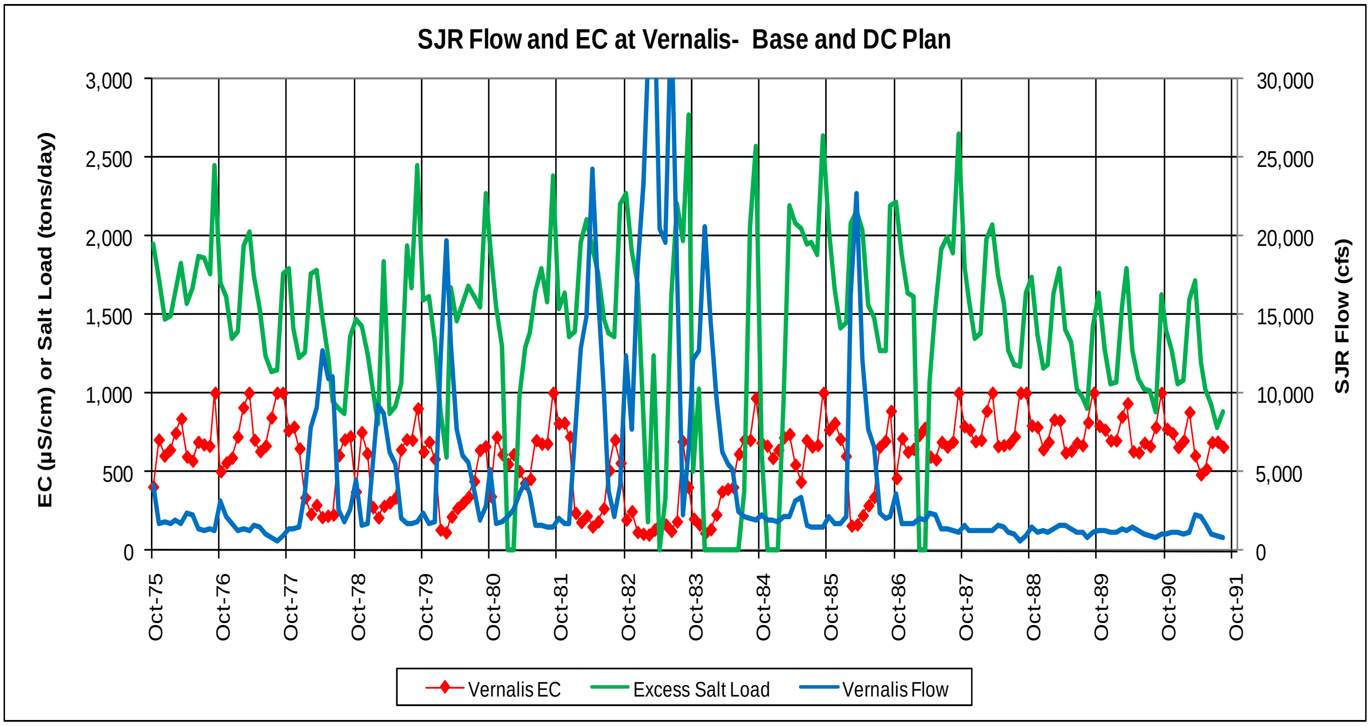


3b. Relationship between SJR Monthly Flow (cfs) and EC (µS/cm) for Historical and CALSIM-Simulated Condition

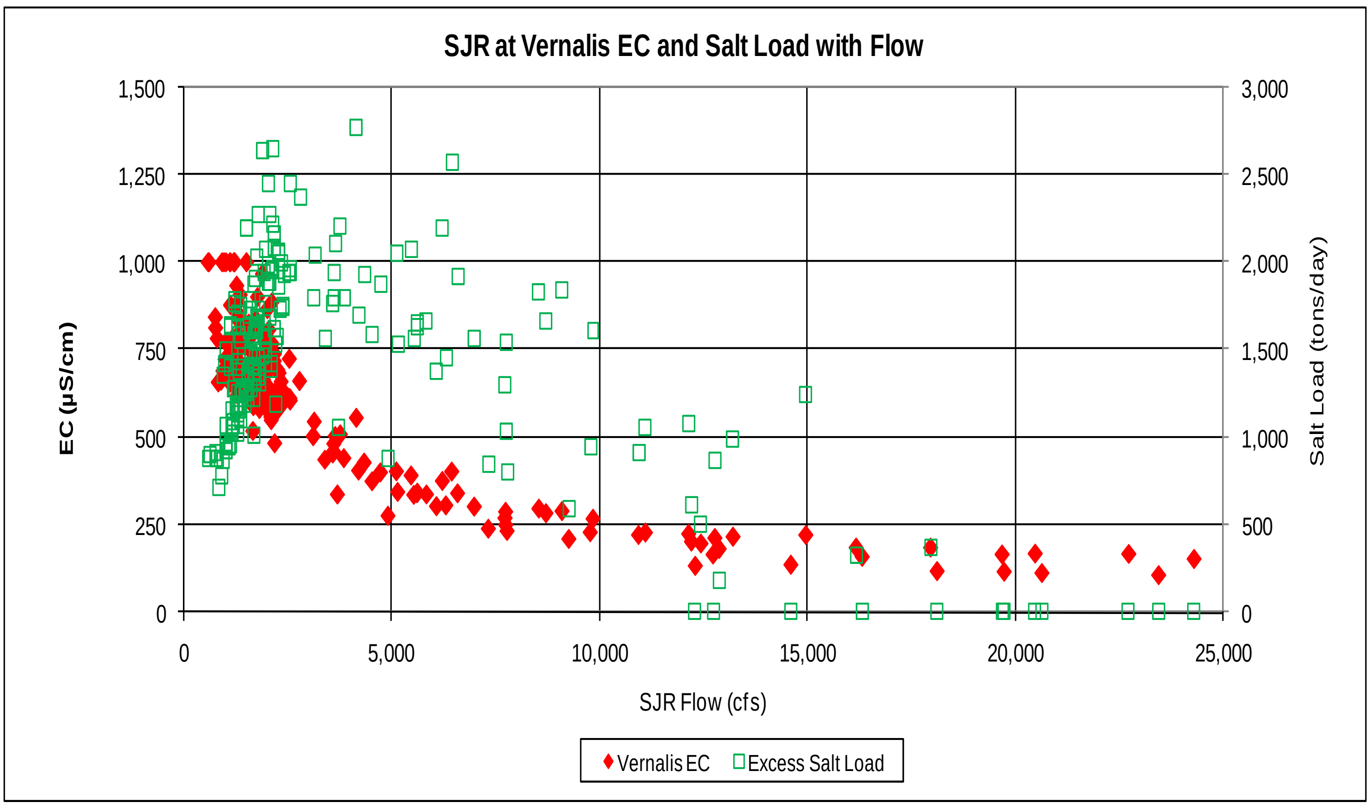
00086.09

ICF Jones & Stokes
an ICF International Company

Figure 3



4a. San Joaquin River Flow and EC and Excess Salt Load (for EC >175) for WY 1976–1991



4b. Relationship between CALSIM-Estimated SJR monthly Flow (cfs) and EC (µS/cm) and Excess Salt Load (tons/day)

00086.09

ICF Jones & Stokes
an ICF International Company

Figure 4

When the SJR flow was greater than 10,000 cfs, and the DC Plan gates would be opened for flood control (at the Head of Old River, at the mouth of Grant Line Canal, at the north end of West Canal, and at the mouth of Old River) allowing SJR water to be exported, the SJR EC value would be less than 250 µS/cm, and the SJR excess EC and excess salt load would be small. The next section will describe how much of the SJR excess EC and excess salt load is exported under existing conditions.

Exported San Joaquin River Salt Load

One of the major objectives of the DC Plan is to eliminate the export of the SJR flow and excess salt load (and reduce the entrainment of SJR fish). Most of the SJR excess salt load currently is exported at the CVP and SWP pumps.

Figure 5a shows the monthly SJR flows and the monthly combined export flows for the 1976–1991 study period. The SJR flow is normally less than the combined export flow, so most of the SJR flow is exported under the existing conditions. The maximum SJR flow that can be exported each month is the combined export flow. Comparing the SJR flow and the combined export flow each month, the SJR flow that could have been exported averaged about 3,000 cfs, which would have been about 65% of the total SJR flow of 4,650 cfs during this study period.

About 95% of the SJR excess salt load could have been exported, based on the SJR flow and excess salt load, when the exports were higher than the SJR flow. Only during high SJR flows (SJR > exports), when the SJR EC and excess salt load are relatively small, is some of the SJR flow not exported. Figure 5b shows the excess SJR salt load that could have been exported and the DSM2-simulated excess salt load reaching the exports. The SJR excess salt load was generally less than 2,500 tons/day. During periods when the SJR flow was greater than 20,000 cfs, the excess salt load in the SJR and at the exports declined and approached 0.

The fraction of the SJR flow and excess salt load that could be exported was generally confirmed by the DSM2 modeling. The average SJR flow that was simulated with the DSM2 model to reach the exports was about 2,500 cfs, which is 500 cfs less than expected by comparing the SJR and export flows. The DSM2 model simulated most of the SJR flow not reaching the exports to be diverted at south and central Delta agricultural diversions. DSM2-simulated SJR excess salt load that was exported with the existing conditions was about 975 tons/day, representing about 75% of the SJR excess salt load (1,360 tons/day), and about 30% of the total excess salt load (3,365 tons/day) at the combined exports.

Salinity in the Central Valley Project and State Water Project Exports

Figure 6a shows the monthly simulated CVP and SWP pumping flows compared to the SJR inflows. About half of the SJR flow is transported to the CVP pumps in Old River and Grant Line Canal, while the other half is transported more uniformly to the CVP and SWP pumps. Because more than half of the SJR flow is transported to the CVP pumps, the SJR EC has a greater influence on the CVP pumps. Because the CVP and SWP combined pumping is usually greater than the SJR flow, Sacramento River water and other sources of water also are transported to the exports. Agricultural drainage is usually a small fraction (5–10%) of export pumping but can contribute a larger portion of the excess EC at the CVP and SWP exports, because the simulated drainage EC is higher than the diverted water EC. The major source of excess EC at the exports (55%) is salinity intrusion from Martinez. Seawater intrusion contributes a larger fraction of the excess EC at the exports when the Delta outflow is lowest.

Figure 6b shows the DSM2-simulated EC at the CVP and SWP exports for 1976–1991 with existing conditions of Delta inflows and exports with the existing channel configuration. The SJR at Vernalis EC values and the SJR at San Andreas Landing (located just downstream of the Mokelumne River mouth) EC values are shown for reference. The SWP EC is often similar to the CVP EC, but there are times when the CVP EC is higher because of the stronger influence of the SJR EC on the CVP EC.

Seawater intrusion moves upstream in the SJR past Jersey Point and into Franks Tract. The EC at San Andreas Landing indicates the magnitude of the seawater intrusion in the central Delta. The EC in Old River at Bacon Island is usually similar to the San Andreas EC. During many fall months, when Delta outflow is lowest and seawater intrusion is strongest, the SWP and CVP EC values approach the San Andreas EC values.

Table 3 gives the simulated EC values at the CVP and SWP exports for existing conditions for the three representative years 1977–1979. The averages for the three years and for the 16-year study period are given at the bottom of each column. The averages for the April–August irrigation season EC values are also given at the bottom of each column. The simulated average CVP EC value for 1977–1979 was 501 µS/cm, and the average CVP EC value for 1976–1991 was 478 µS/cm. The 16-year average CVP excess EC value was therefore 303 µS/cm (i.e., 478 – 175). The simulated average SWP EC value for 1977–1979 was 485 µS/cm and the average SWP EC value for 1976–1991 was 450 µS/cm. The 16-year average SWP excess EC value therefore was 275 µS/cm (i.e., 450 – 175). The average EC values at the exports are generally higher in dry years and lower in wet years.

Because the SJR at Vernalis EC and the San Andreas EC often increase in the low-flow fall months, both water sources (SJR and seawater intrusion) contribute to the higher EC at the exports in the fall. The next section describes the

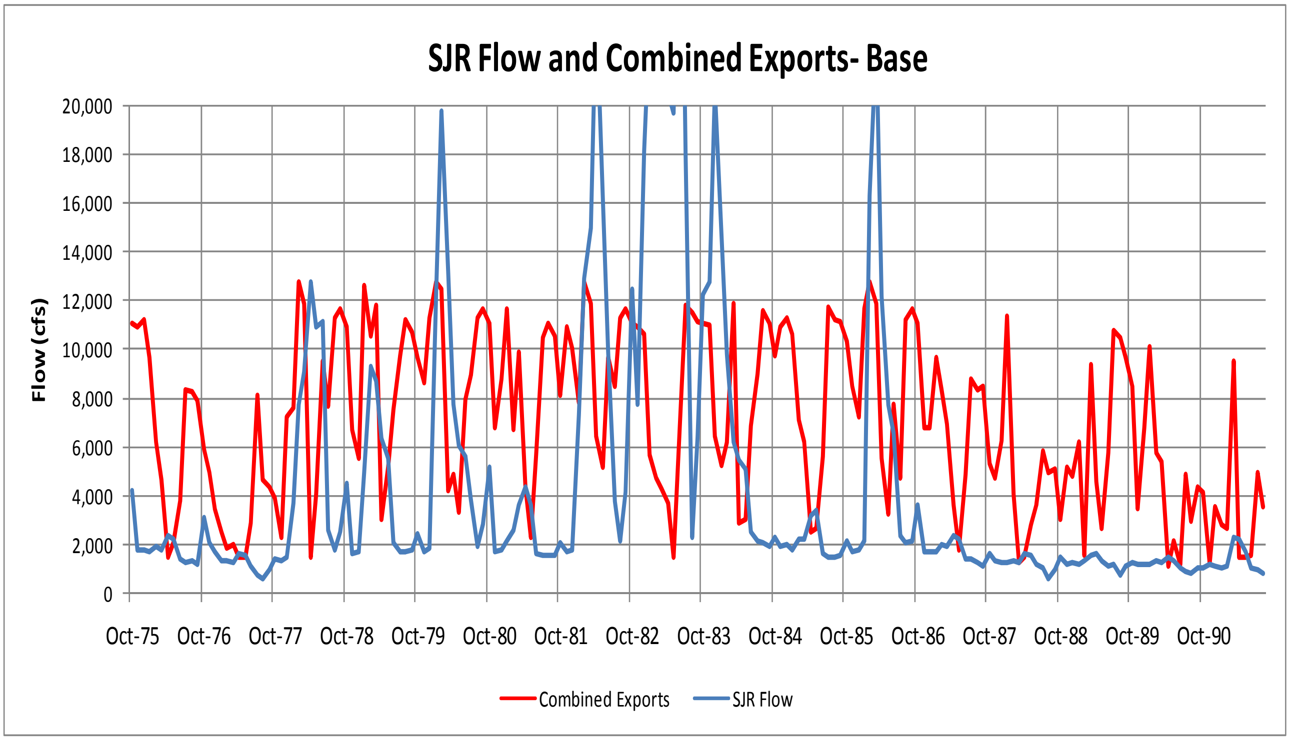
Table 3. DSM2-Simulated Monthly Channel EC (µS/cm) for Water Years 1977, 1978, and 1979 for Existing Conditions and the Delta Corridors Plan

Calendar Year	Month	Existing Antioch EC	DC Plan Antioch EC	Existing Jersey Point EC	DC Plan Jersey Point EC	Existing San Andreas EC	DC Plan San Andreas EC	Existing Stockton DWSC EC	DC Plan Stockton DWSC EC	Existing Head of Middle EC	DC Plan Head of Middle EC	Existing Old at Tracy Blvd EC	DC Plan Old at Tracy Blvd EC
1976	Oct	4,847	5,002	2,368	2,447	867	1,299	540	418	571	778	737	772
1976	Nov	4,454	4,325	2,107	2,023	780	985	557	511	516	666	633	681
1976	Dec	3,111	2,871	1,406	1,342	601	613	592	462	564	493	607	488
1977	Jan	1,938	1,786	834	847	417	373	720	464	664	420	685	354
1977	Feb	1,664	1,517	704	763	393	329	888	432	758	367	823	329
1977	Mar	1,802	1,635	751	817	400	335	992	369	849	344	937	424
1977	Apr	1,861	1,637	773	802	405	315	738	342	671	333	709	446
1977	May	2,299	2,144	984	1,010	470	392	631	308	626	284	614	337
1977	Jun	3,386	3,487	1,565	1,636	566	532	679	320	648	484	622	461
1977	Jul	4,470	4,564	2,434	2,525	743	853	734	369	638	578	616	533
1977	Aug	4,204	4,432	2,089	2,324	737	872	808	443	684	576	671	588
1977	Sep	4,864	5,211	2,393	2,676	886	1,095	965	397	550	516	628	518
1977	Oct	4,722	5,080	2,362	2,626	929	1,209	801	425	630	682	757	682
1977	Nov	3,390	3,577	1,656	1,841	688	808	784	479	654	568	729	574
1977	Dec	2,528	2,426	1,215	1,165	479	532	683	480	591	427	613	412
1978	Jan	427	354	332	319	262	211	382	726	356	460	602	463
1978	Feb	238	282	235	276	221	201	247	708	240	351	279	396
1978	Mar	227	263	225	257	219	193	300	497	294	393	329	609
1978	Apr	233	225	234	219	233	186	219	313	217	310	223	341
1978	May	212	213	210	212	208	187	225	302	224	273	231	344
1978	Jun	224	250	205	234	200	217	233	309	232	275	242	387
1978	Jul	636	660	306	348	204	235	597	305	601	427	376	385

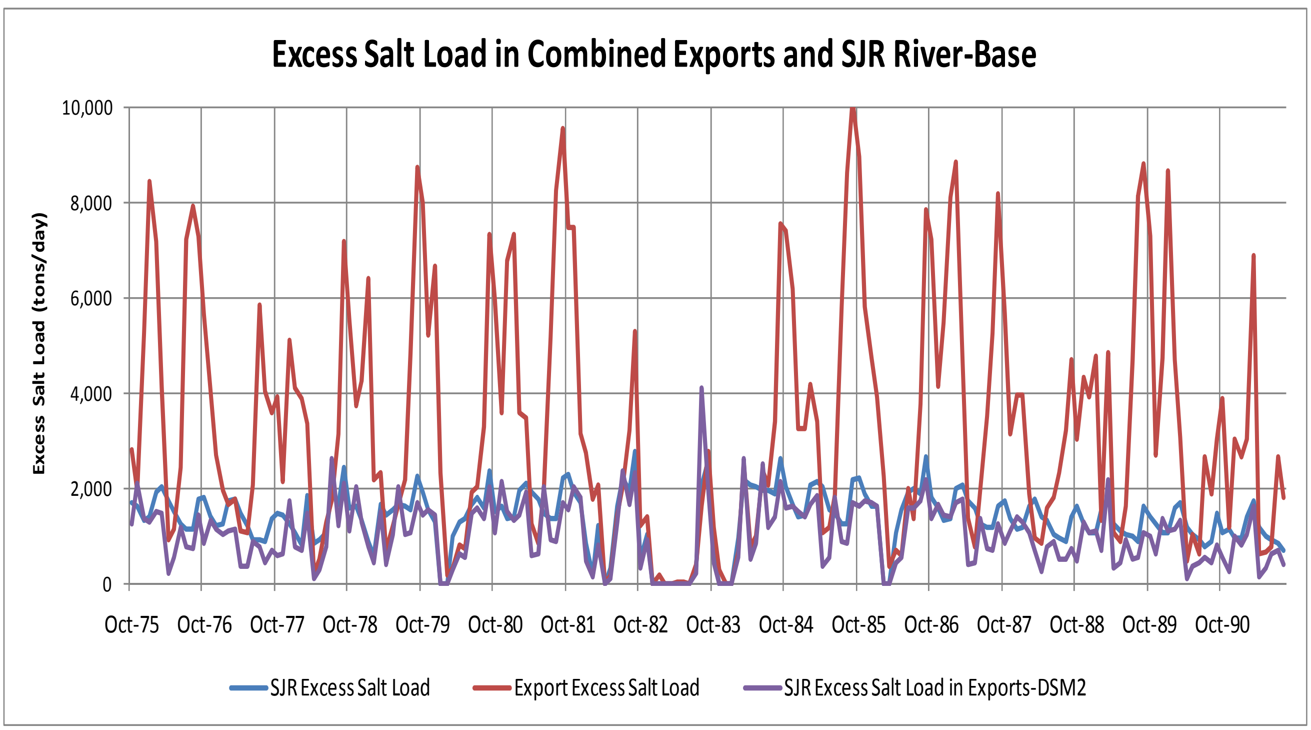
Calendar Year	Month	Existing Antioch EC	DC Plan Antioch EC	Existing Jersey Point EC	DC Plan Jersey Point EC	Existing San Andreas EC	DC Plan San Andreas EC	Existing Stockton DWSC EC	DC Plan Stockton DWSC EC	Existing Head of Middle EC	DC Plan Head of Middle EC	Existing Old at Tracy Blvd EC	DC Plan Old at Tracy Blvd EC
1978	Aug	2,455	2,523	1,255	1,328	370	490	697	297	409	406	389	384
1978	Sep	3,569	3,672	1,914	2,003	567	780	723	311	724	531	545	534
1978	Oct	3,875	3,942	1,779	1,781	511	757	392	334	428	539	505	544
1978	Nov	4,445	4,276	2,066	1,896	646	731	732	367	433	466	490	463
1978	Dec	4,108	3,839	2,032	1,811	738	756	636	357	573	481	620	459
1979	Jan	1,305	1,150	712	628	377	414	311	467	294	493	343	464
1979	Feb	272	266	262	257	249	213	222	452	215	348	243	322
1979	Mar	220	250	217	252	213	204	287	298	286	289	296	271
1979	Apr	223	258	222	253	236	192	310	221	369	253	344	274
1979	May	273	279	229	253	224	197	337	264	369	255	382	336
1979	Jun	458	477	255	307	196	224	631	300	579	480	402	420
1979	Jul	1,426	1,458	697	743	258	322	702	302	517	477	405	401
1979	Aug	3,154	3,233	1,717	1,801	503	663	703	303	438	468	452	448
1979	Sep	4,741	4,860	2,654	2,755	801	1,060	883	328	541	650	646	640
WY 77–79 Average		2,285	2,290	1,150	1,188	467	527	580	388	499	448	520	458
WY 76-91 Average		2,049	2,040	1,077	1,088	438	483	588	371	484	428	493	434
WY 76–91 Change			-8		11		45		-216		-56		-59
Percent Existing			100%		101%		110%		63%		88%		88%
WY 77-79 Apr–Aug		1,701	1,723	878	933	370	392	550	313	481	392	445	406
WY 76–91 Apr-Aug		1,635	1,666	852	908	358	388	552	312	471	392	449	409
WY 76–91 Change			30		55		30		-240		-79		-40
Percent Existing			102%		106%		108%		57%		83%		91%

Calendar Year	Month	Existing Grant Line Mouth EC	DC Plan Grant Line Mouth EC	Existing Old at LV Intake EC	DC Plan Old at LV Intake EC	Existing Old at Bacon EC	DC Plan Old at Bacon EC	Existing Middle at Santa Fe EC	DC Plan Middle at Santa Fe EC	Existing SWP Banks EC	DC Plan SWP Banks EC	Existing CVP Jones EC	DC Plan CVP Jones EC
1976	Oct	704	560	828	581	942	602	548	785	740	771	718	783
1976	Nov	620	571	716	581	816	582	484	638	647	676	625	651
1976	Dec	604	564	678	559	725	566	504	445	630	487	609	463
1977	Jan	675	623	575	603	513	603	502	316	598	344	660	328
1977	Feb	800	732	560	694	447	691	531	290	611	318	779	299
1977	Mar	834	804	540	744	440	744	574	271	605	298	801	281
1977	Apr	616	654	543	624	455	650	603	264	593	292	612	273
1977	May	588	541	546	516	484	525	592	253	586	281	585	258
1977	Jun	592	597	577	550	601	564	512	307	577	301	587	306
1977	Jul	648	688	661	627	771	652	441	463	580	441	607	453
1977	Aug	696	754	728	702	838	732	474	523	659	553	677	531
1977	Sep	674	782	681	739	832	727	442	519	595	489	652	509
1977	Oct	765	730	852	732	993	750	585	670	713	643	761	673
1977	Nov	719	704	751	692	799	698	596	533	734	606	719	551
1977	Dec	613	601	559	587	556	602	493	371	570	393	595	374
1978	Jan	441	406	488	423	390	448	488	302	508	320	454	312
1978	Feb	273	271	347	277	275	292	377	234	372	244	305	240
1978	Mar	310	309	322	310	264	317	352	233	340	236	332	239
1978	Apr	219	227	230	228	251	232	258	252	299	256	234	256
1978	May	225	228	238	228	233	230	239	214	251	240	248	224
1978	Jun	236	236	254	236	226	240	256	207	255	210	251	208
1978	Jul	443	561	243	534	215	514	265	216	257	221	338	217
1978	Aug	467	623	338	592	360	587	314	315	320	303	360	310
1978	Sep	667	671	557	660	628	656	401	519	500	515	574	516

Calendar Year	Month	Existing Grant Line Mouth EC	DC Plan Grant Line Mouth EC	Existing Old at LV Intake EC	DC Plan Old at LV Intake EC	Existing Old at Bacon EC	DC Plan Old at Bacon EC	Existing Middle at Santa Fe EC	DC Plan Middle at Santa Fe EC	Existing SWP Banks EC	DC Plan SWP Banks EC	Existing CVP Jones EC	DC Plan CVP Jones EC
1978	Oct	455	402	509	413	560	427	374	526	469	525	464	525
1978	Nov	518	639	556	615	638	594	397	448	479	460	503	448
1978	Dec	622	577	684	571	773	579	504	452	612	456	623	453
1979	Jan	357	332	509	340	500	362	419	360	497	374	407	366
1979	Feb	236	233	328	237	293	246	310	252	317	260	257	255
1979	Mar	286	289	272	288	243	290	286	212	287	217	289	215
1979	Apr	316	307	297	304	265	309	314	210	304	220	314	214
1979	May	316	332	290	326	258	327	315	198	314	211	310	202
1979	Jun	371	589	261	549	213	527	329	209	292	212	317	210
1979	Jul	422	641	282	598	264	596	309	247	291	244	317	246
1979	Aug	534	629	452	607	507	607	355	411	409	397	441	405
1979	Sep	714	791	724	772	841	753	488	648	630	634	660	643
WY 77–79 Average		516	533	499	518	511	523	423	370	485	379	500	373
WY 76-91 Average		496	533	469	515	479	519	408	346	450	353	477	348
WY 76–91 Change			37		46		40		-62		-97		-129
Percent Existing			108%		110%		108%		85%		78%		73%
WY 77-79 Apr–Aug		446	507	396	482	396	486	372	286	399	292	413	288
WY 76–91 Apr-Aug		433	506	389	482	382	486	371	284	387	288	412	285
WY 76–91 Change			74		93		104		-88		-99		-127
Percent Existing			117%		124%		127%		76%		74%		69%



5a. Comparison of CALSIM-Simulated Combined Exports (cfs) and San Joaquin River Flow (cfs) for WY 1976–1991

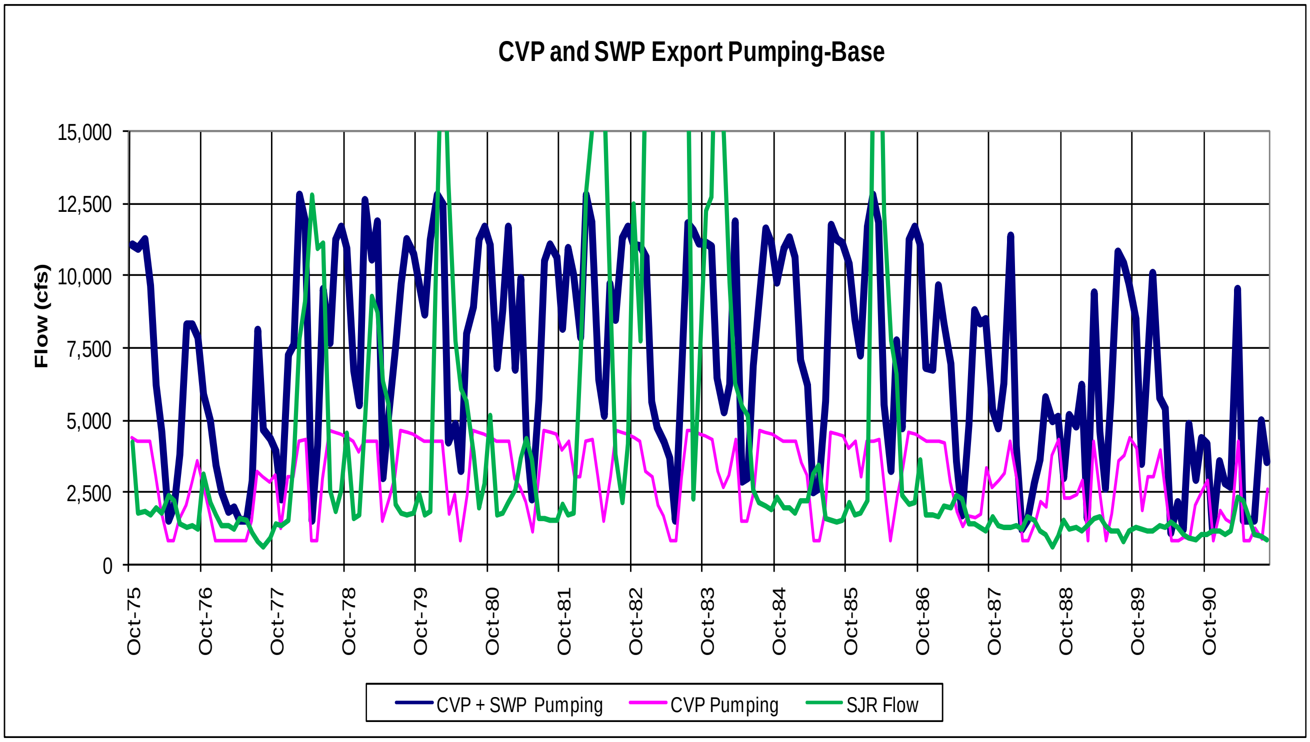


5b. DSM2-Simulated San Joaquin River Excess Salt Load (tons/day) compared to the Combined Exports Excess Salt Load (tons/day) and the SJR Excess Salt Load in the Combined Exports for Existing Conditions for WY 1976–1991

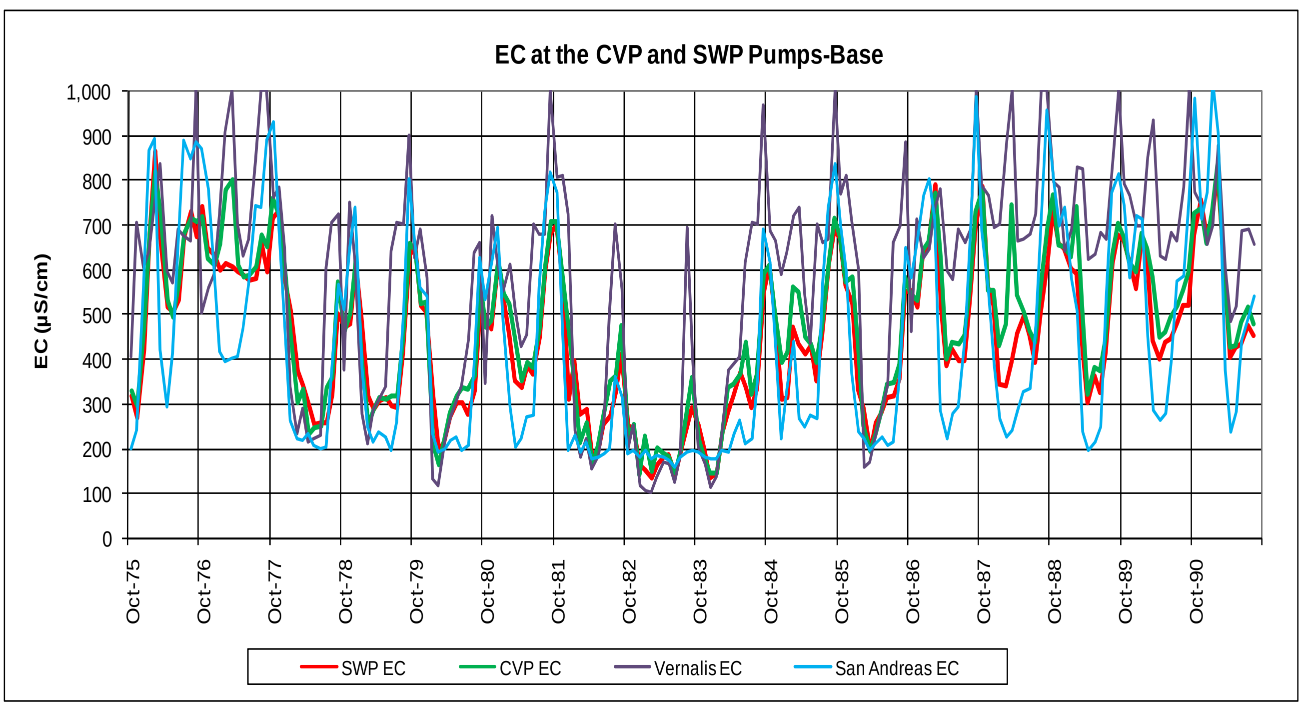
00086.09

ICF Jones & Stokes
an ICF International Company

Figure 5



6a. CALSIM-Simulated CVP and SWP Monthly Export Pumping Compared to SJR Flows for Existing Conditions for WY 1976–1991



6b. DSM2-Simulated EC in the CVP and SWP Export Pumping for Existing Conditions for WY 1976–1991

00086.09

ICF Jones & Stokes
an ICF International Company

Figure 6

methods used in DSM2 to identify the fraction of the water and excess EC from the various Delta water sources at the CVP and SWP export pumps.

Tracking the Sources of Water and Electrical Conductivity

The DSM2 model was used to separately track the water and EC from the three potential sources of excess EC and excess salt load: the SJR water and EC, the agricultural drainage water and EC, and the seawater intrusion water and EC from Martinez. The freshwater sources of water and EC (i.e., Sacramento, Yolo Bypass, Mokelumne, Cosumnes, and Calaveras Rivers) also were tracked. This was accomplished by separately calculating two model concentration variables for each of these water sources. One tracking variable for each inflow is given a constant concentration value of 100 units. There are no other sources for this model variable. As this concentration changes in the Delta channels, it represents the percentage of the water in the channel that originated from the tracking source. This is called *volumetric tracking*.

For example, the SJR flow was tracked with one of these model concentration variables. The SJR inflow was given a value of 100 every month. If the model variable had a simulated value of 35 units in the CVP export flow for a particular month, this would indicate that 35% of the CVP export flow originated from the SJR. If the CVP export flow was 3,000 cfs, about 1,050 cfs (i.e., 0.35 x 3,000 cfs) from the SJR would have been transported to the CVP pumps this month. This SJR flow that was "tracked" to the CVP export (i.e., flow tracking) also can be compared to the monthly SJR flow to determine the fraction of the SJR flow that was transported to the CVP exports. This fraction would depend on the SJR and the CVP and SWP export flows, the operation of the south Delta gates, and possibly on other Delta inflows. For example, if the SJR inflow was 2,000 cfs, about 52.5% (i.e., 1,050/2,000) of the SJR flow would have been transported to the CVP exports for this example.

A second tracking variable for each inflow was given the monthly EC value for the water source to separately track each source of EC. For example, if the SJR EC tracking value was 150 µS/cm at the CVP export, and the total CVP EC value was 450 µS/cm, about a third of the CVP export EC would have originated from the SJR inflow. This is called *EC source tracking*.

The volumetric and EC source contributions are consistent. The EC source contribution can be calculated as the volumetric source contribution times the source EC. The excess EC contribution was calculated as the EC source contribution times the ratio of the excess EC to total EC of the source. For example, if the SJR EC tracking value was 150 µS/cm at the CVP export, and the SJR EC was 750 µS/cm, then the excess San Joaquin EC value at the CVP export would be about 115 µS/cm (i.e., 150 x [750 – 175]/750). This excess EC tracking was calculated in a spreadsheet based on the DSM2 results for the volumetric and EC source tracking.

Figure 7 shows the DSM2-simulated water contributions and EC contributions at the CVP export pumps for the 1976–1991 period. The water tracking is shown as the percentage of the water originating from each possible source. Each month has different water-tracking percentages, depending on the Delta inflows and exports, as well as Delta gate operations that modify the water transport pathways.

Table 4 summarizes these simulated contributions of water and EC at the CVP exports for existing conditions. An average of about 8% of the CVP export water came from agricultural drainage, about 47% of the CVP export water came from freshwater sources, about 1% of the CVP export water came from Martinez (seawater intrusion), and about 44% of the CVP export water came from the SJR. The monthly variations of the SJR and freshwater source contributions were sometimes large. The maximum percentage of CVP export water from agricultural drainage was about 18%, and the maximum percentage of water from Martinez was just 2.3%. Because the Martinez EC is high, even a 1% water contribution will contribute a large percentage of the EC at the exports.

The average simulated (total) EC at the CVP export pumps was 478 µS/cm for existing conditions. The average contribution of EC at the CVP export pumps was about 70 µS/cm from agricultural drainage, about 82 µS/cm from freshwater sources, about 125 µS/cm from Martinez, and about 200 µS/cm from the SJR. The average excess EC of the CVP exports was about 308 µS/cm, and the SJR excess EC contributed about 127 µS/cm (41%), the Martinez excess EC contributed about 124 µS/cm (40%), and agricultural drainage excess EC contributed about 57 µS/cm (19%).

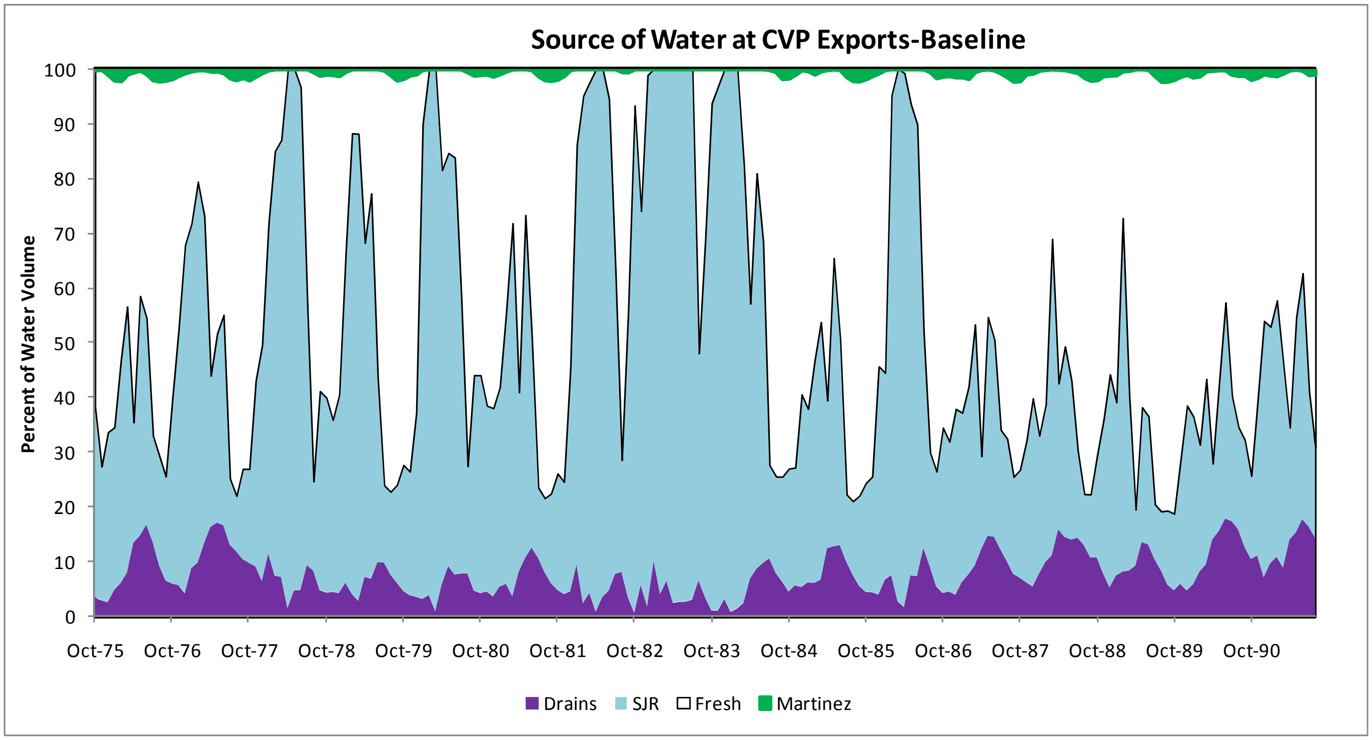
Figure 8 shows the DSM2-simulated water contributions and EC contributions at the SWP export pumps for the 1976–1991 period. Table 4 summarizes these simulated contributions of water and EC at the SWP exports for existing conditions. An average of about 8% of the SWP export water came from agricultural drainage, about 60% of the SWP export water came from freshwater sources, about 1% of the SWP export water came from Martinez (seawater intrusion), and about 30% came for the SJR. The maximum percentage of water from Martinez was about 3.5%. The SWP export water had a smaller contribution from the SJR, with a slightly larger freshwater contribution.

The average simulated EC at the SWP export pumps was 450 µS/cm for existing conditions. The contribution of EC at the SWP export pumps was about 78 µS/cm from agricultural drainage, about 105 µS/cm from freshwater sources, about 156 µS/cm from Martinez, and about 112 µS/cm from the SJR. The average SWP export excess EC was about 280 µS/cm, and the SJR excess EC contributed about 63 µS/cm (23%), the Martinez excess EC contributed about 154 µS/cm (55%), and agricultural drainage excess EC contributed about 63 µS/cm (22%).

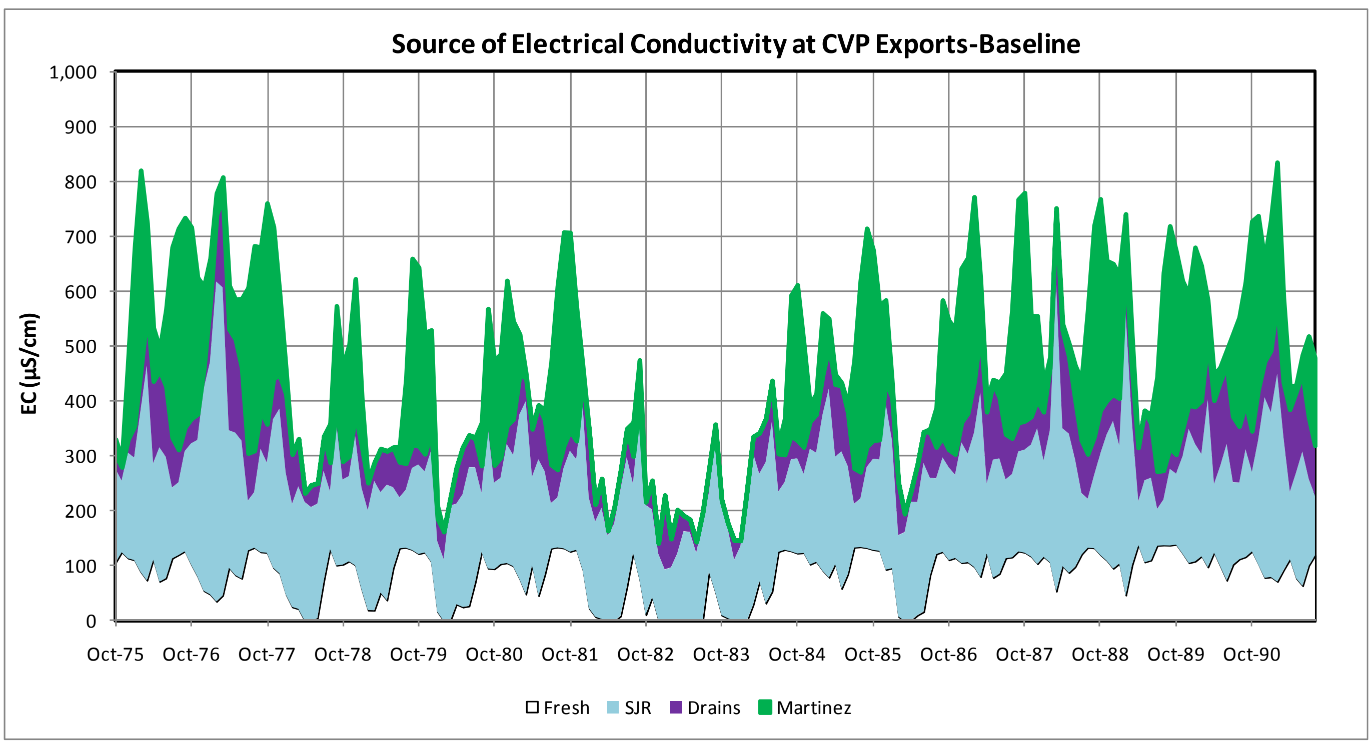
Figure 9 shows the DSM2-simulated water contributions and EC contributions at the combined CVP and SWP export pumps for the 1976–1991 period. Table 4 summarizes these simulated contributions of water and EC at the combined exports for existing conditions. An average of about 8% of the combined export

Table 4. DSM2-Simulated Water Contributions (%) and EC Contributions (µS/cm) at the CVP and SWP Export Pumps for 1976–1991 with the Baseline Conditions

		Ag Drains	Fresh Inflows	Martinez Boundary	San Joaquin River
Flow Contribution at CVP Exports (%)					
Water—minimum		0.7	0.0	0.0	9.3
Water—average	100	7.8	47.2	0.7	44.3
Water—maximum		17.8	80.6	2.3	99.1
EC Contribution at CVP Exports (µS/cm)					
EC—minimum	142.2	5.9	0.0	0.0	66.5
EC—average	477.9	70.3	81.8	125.0	200.7
EC—maximum	835.6	184.5	138.7	415.7	582.6
Excess EC—average	308	57	___	124	127
Flow Contribution at SWP Exports (%)					
Water—minimum		0.8	0.0	0.0	0.8
Water—average	100	8.4	60.6	0.9	30.2
Water—maximum		17.7	88.5	3.4	99.2
EC Contribution at SWP Exports (µS/cm)					
EC—minimum	132.1	11.3	0.0	0.0	5.3
EC—average	449.9	77.6	105.0	155.7	111.7
EC—maximum	863.8	216.4	154.7	580.9	249.4
Excess EC—average	280	63	___	154	63
Flow Contribution at Combined Exports (%)					
Water—minimum		0.9	0.0	0.0	4.8
Water—average	100	8.1	54.7	0.8	36.4
Water—maximum		17.4	84.9	2.8	99.1
EC Contribution at Combined Exports (µS/cm)					
EC—minimum	139.9	11.4	0.0	0.0	36.2
EC—average	463.5	74.4	94.8	141.7	152.6
EC—maximum	842.3	191.9	148.4	472.5	382.4
Excess EC—average	293	60	___	140	93



7a. DSM2-Simulated Source Volume Tracking at CVP Export Pumps for Existing Conditions for WY 1976–1991

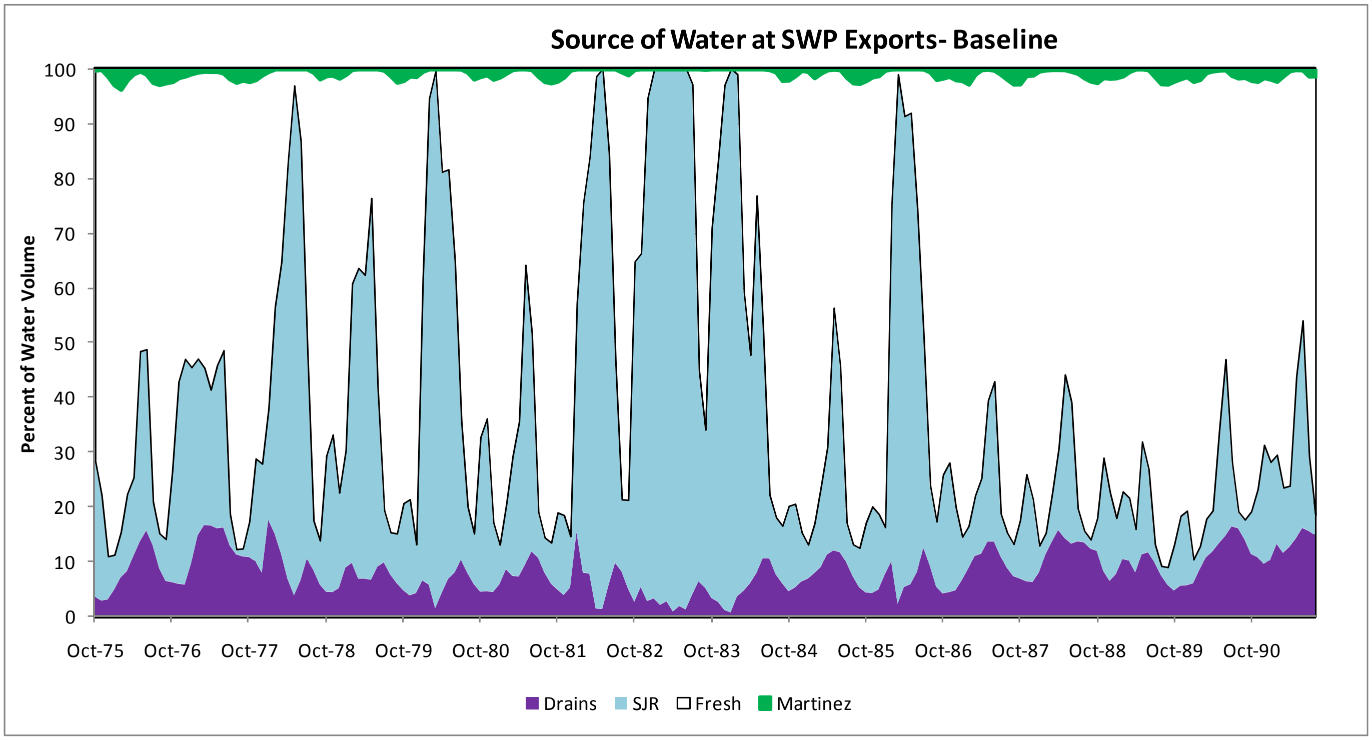


7b. DSM2-Simulated Source EC Tracking at CVP Export Pumps for Existing Conditions for WY 1976–1991

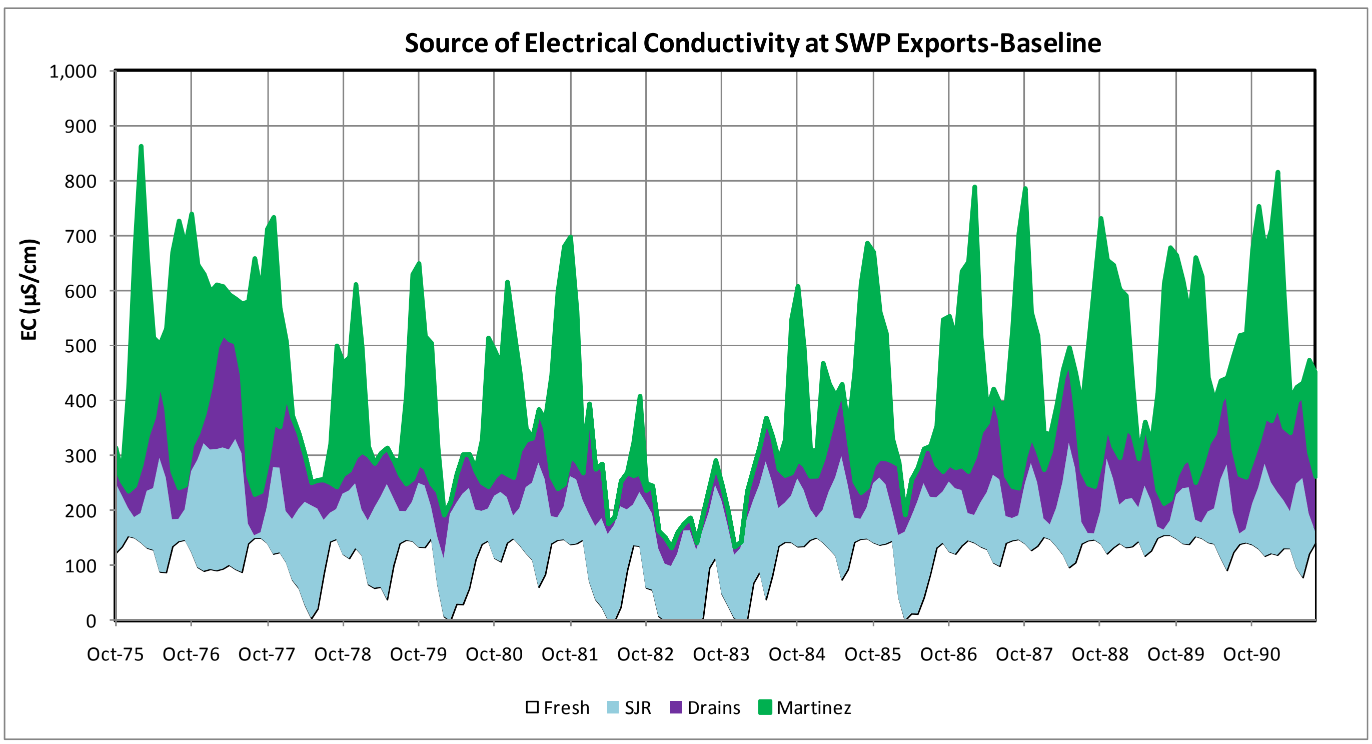
00086.09

ICF Jones & Stokes
an ICF International Company

Figure 7



8a. DSM2-Simulated Source Volume Tracking at SWP Export Pumps for Existing Conditions for WY 1976–1991

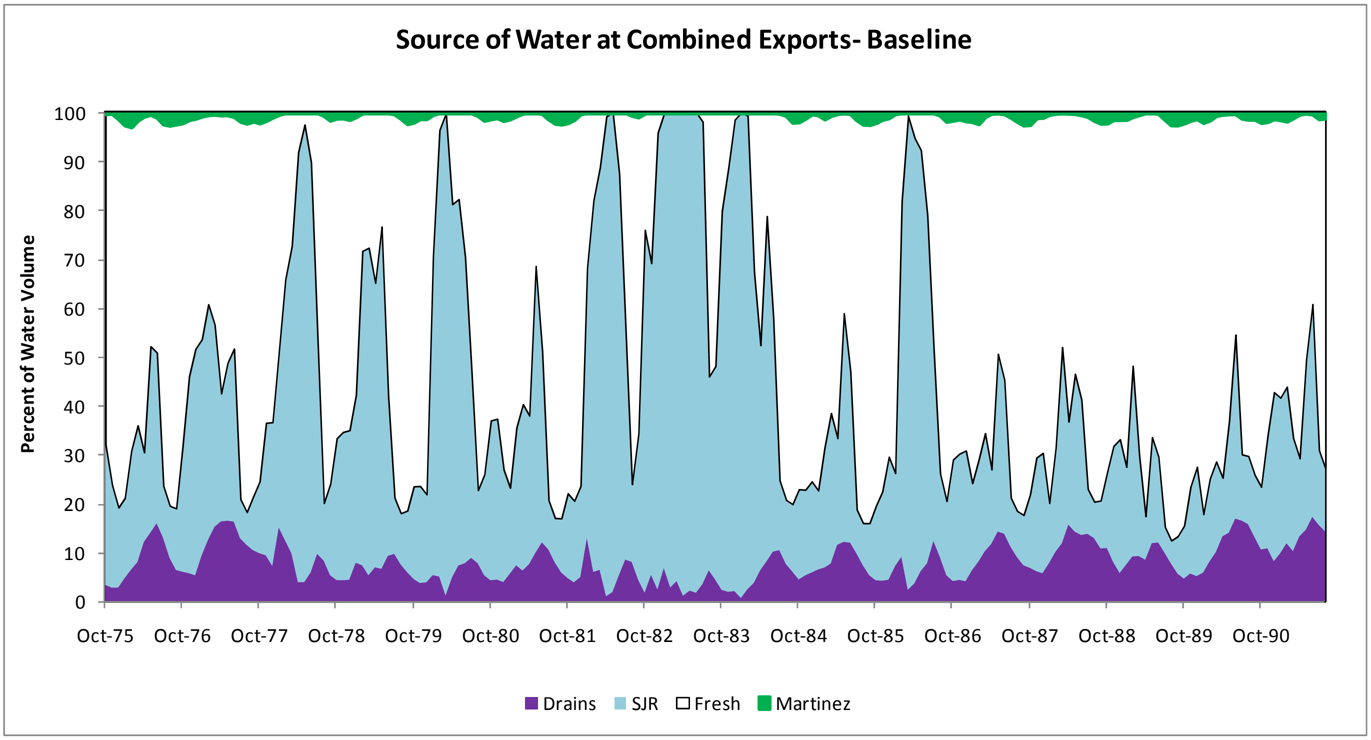


8b. DSM2-Simulated Source EC Tracking at SWP Export Pumps for Existing Conditions for WY 1976–1991

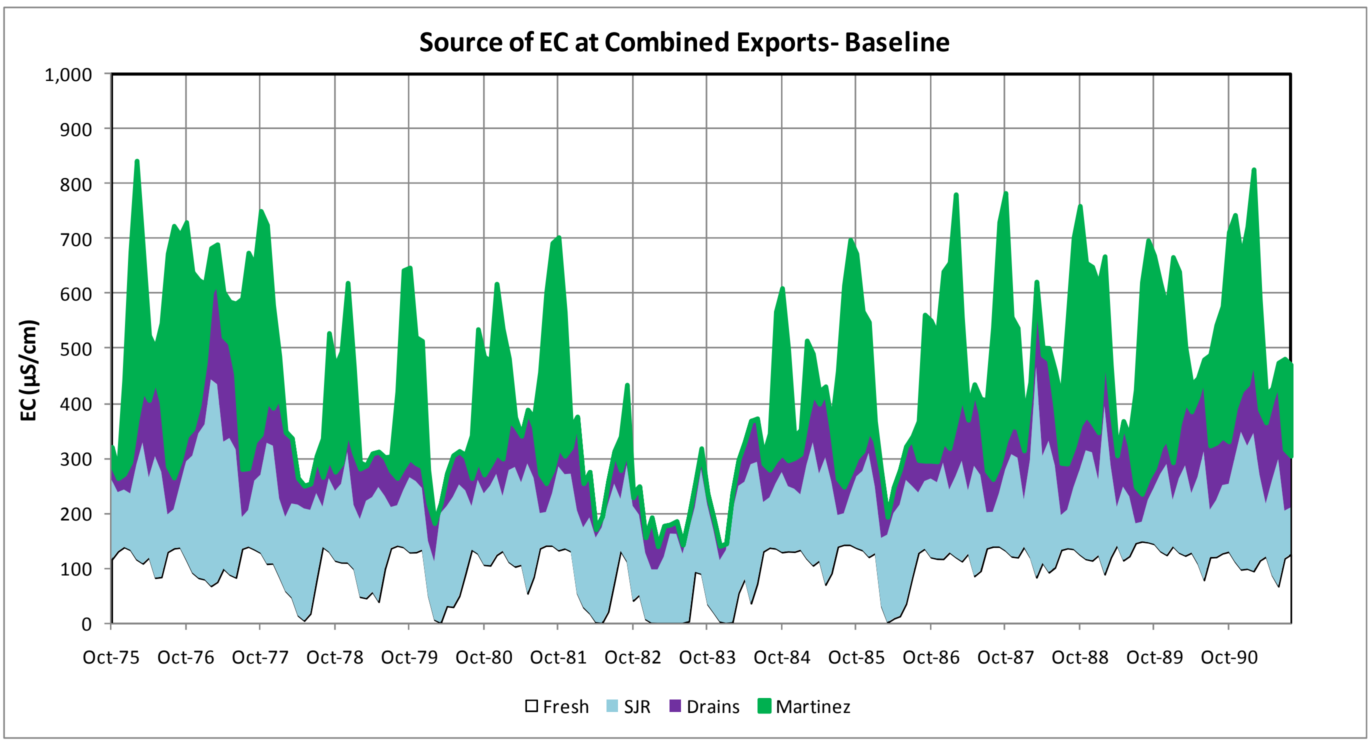
00086.09

ICF Jones & Stokes
an ICF International Company

Figure 8



9a. DSM2-Simulated Source Volume Tracking at the Combined CVP and SWP Export Pumps for Existing Conditions for WY 1976–1991



9b. DSM2-Simulated Source EC Tracking at the Combined CVP and SWP Export Pumps for Existing Conditions for WY 1976–1991

00086.09

ICF Jones & Stokes
an ICF International Company

Figure 9

water came from agricultural drainage, about 55% of the combined export water came from freshwater sources, about 1% of the combined export water came from Martinez (seawater intrusion), and about 36% of the combined export water came from the SJR.

The average simulated EC for the combined exports was 464 µS/cm for existing conditions. The EC in the combined exports was made up of about 74 µS/cm from agricultural drainage, about 95 µS/cm from freshwater sources, about 142 µS/cm from Martinez, and about 153 µS/cm from the SJR. The average combined export excess EC was about 293 µS/cm, and the SJR excess EC contributed about 93 µS/cm (32%), the Martinez excess EC contributed about 140 µS/cm (48%), and agricultural drainage excess EC contributed about 60 µS/cm (20%).

The source-tracking patterns for water and EC are helpful in understanding how water and salt move through the Delta with existing conditions, and how the water and salt transport patterns would change with the DC Plan. One of the major objectives of the DC Plan is to reduce or eliminate the SJR water and excess EC at the CVP and SWP exports, and to allow the majority of the SJR water to leave the Delta as outflow. This also would protect the SJR fish from entrainment at the CVP and SWP export pumps. The results of the water and EC source tracking for the DC Plan were compared to these source-tracking results for the existing conditions.

Agricultural Drainage Effects

The agricultural drainage flows and EC values generally are well represented in the DSM2 model. The Delta Islands Consumptive Use (DICU) model was developed by DWR to estimate the diversions, seepage, and drainage (of rainfall and applied water) from each of the Delta islands, based on land acreage and crop/soil water budgets. The DICU seepage, diversions, and drainage values are used in the DSM2 model, distributed along the channels according to the locations of diversions and drainage pumps.

Soil salinity increases during the irrigation season from evaporation and transpiration of the applied water, and is partially leached by drainage from the fields or is flushed from the soil during the winter. Mineral soils in the south Delta generally are flushed during irrigation, while central Delta peat soils require more winter leaching. Agricultural operations (i.e., fertilizers or soil amendments) do not increase the salt load from the applied water by much, but the drainage EC is higher than the applied water because the drainage volume is less than the applied water volume (unless the drainage is from rainfall), concentrating the salt content. The DSM2-simulated drainage flows are estimated with an assumed Delta Lowlands seepage of 1 inch per month (about 1 cfs per square mile) plus about 30% of the summer diversions, and include rainfall in the winter (varies each year). However, the DSM2 drainage EC values are specified as fixed monthly values for the entire central and south Delta region for every year. The simulated drainage flows and EC values for the SJR–estuary corridor were evaluated to determine the simulated agricultural (i.e., soil) salt budget in the south and central Delta.

The DC Plan SJR–estuary corridor would include the SJR from Vernalis to the head of Old River near Mossdale, Old River from the head to Franks Tract, Grant Line Canal, and Middle River upstream of Victoria Canal. The average DICU monthly diversion (with seepage) for the SJR–estuary corridor was about 700 cfs. The maximum diversion (with seepage) was 1,500 cfs. The average monthly DICU drainage flow was about 275 cfs, but this includes some months with high rainfall drainage in wet years. The maximum net diversion was about 1,250 cfs.

With the specified monthly diversion flows and the SJR EC values, the average salt load diverted from the SJR–estuary corridor was about 600 tons/day. With the DICU estimates of the drainage flow and monthly specified drainage EC values, the average salt load discharged to the channels was about 500 tons/day. Most of the drainage salt load was simulated by DSM2 in the winter months. Therefore, although the average drainage salt load is less than the applied salt load (i.e., some buildup of soil salt), the effects of agricultural drainage on channel or export EC during the irrigation season were small. The agricultural drainage flow and EC estimates in DSM2 are considered to be generally reasonable for maintaining a long-term soil salt balance.

The DC Plan would allow most of the agricultural drainage from the south and central Delta to be transported to the ocean in the SJR–estuary corridor. Therefore, less of the agricultural drainage would be exported at the CVP and SWP pumps. A few drainage pumps along Middle River might be moved to discharge into Old River. Most of the treated wastewater discharges (Manteca, Tracy, Mountain House, Discovery Bay, Ironhouse) are located on the DC Plan SJR–estuary corridor, and the Stockton wastewater discharge would be transported upstream to the head of Old River and the SJR–estuary corridor. The DC Plan therefore would remove the salinity load of these wastewater and agricultural drainage discharges from the water supply corridor.

Delta Salinity with the Delta Corridors Plan

The simulated monthly Delta inflows and exports and outflows for the DC Plan are the same as for the existing conditions (Table 1). Because Delta outflow was not changed, there were few simulated EC changes in Suisun Bay or the western Delta. The combined DCC and Georgiana Slough flows are higher for the DC Plan in the winter and spring months, when the DCC is closed with existing conditions, but would be open with the DC Plan. However, these north Delta flow changes would not change the EC in the north Delta channels. Because most of the DC Plan components are in the central and south Delta, the major flow and EC changes would be in the Old and Middle River corridors.

Table 3 gives the monthly EC values at several Delta locations for the 1977–1979 example period. The averages for the 3-year and the 16-year periods are given. The averages for the irrigation season of April–August also are given.

The major EC changes with the DC Plan would be in the Old River and Middle River channels, which would be separated from each other with the DC Plan. The CVP and SWP EC values would be reduced substantially from the existing conditions. These simulated EC changes are shown with comparative graphs of the monthly EC values at several Old River and Middle River locations and at the exports.

Old River and Middle River Flow and Electrical Conductivity with the Delta Corridors Plan

The DC Plan would route all of the SJR flow down the Old River corridor to Franks Tract and through Dutch Slough or False River toward Antioch and the estuary. The SJR flows would be augmented in the DC Plan with four supplemental dilution flows of about 250 cfs each. These dilution flows would be sufficient to maintain the monthly Vernalis EC values and often would reduce the EC along the Old River corridor to less than the monthly Vernalis EC. All of the water supply would flow upstream in Middle River and Victoria Canal to West Canal and the CCF and DMC intakes. The hydraulic modeling results (Jones & Stokes 2007) indicate that substantial dredging (5–10 million cubic yards) would be required in Middle River and Victoria Canal to allow full permitted pumping of about 11,280 cfs. Additional dredging may be needed for maximum capacity pumping of about 15,000 cfs.

Old River Flows and Dilution Flows

The SJR channel would have an operable flood gate, diverting all of the SJR flow (if less than 10,000 cfs) into the Old River channel. The first DC Plan dilution flow would be at the head of Old River near Mossdale. This 250 cfs dilution flow would be pumped with a fish-friendly, low-head pump to draw water upstream from the Stockton DWSC, including 50 cfs discharged from the Stockton Regional Wastewater Control Facility (RWCF). This dilution water would come from the water supply corridor, and because the RWCF discharge EC is about 1,200 µS/cm, the EC of the blended flow would be 100–200 µS/cm above the EC in the Stockton DWSC. The DSM2 results indicate that the Stockton DWSC EC would be lower than the SJR EC and would range from about 250 µS/cm to about 500 µS/cm (during the winter months with high agricultural drainage EC). This dilution flow of 250 cfs would augment the SJR inflow and would usually dilute (reduce) the SJR EC as the flow is diverted at the head of Old River.

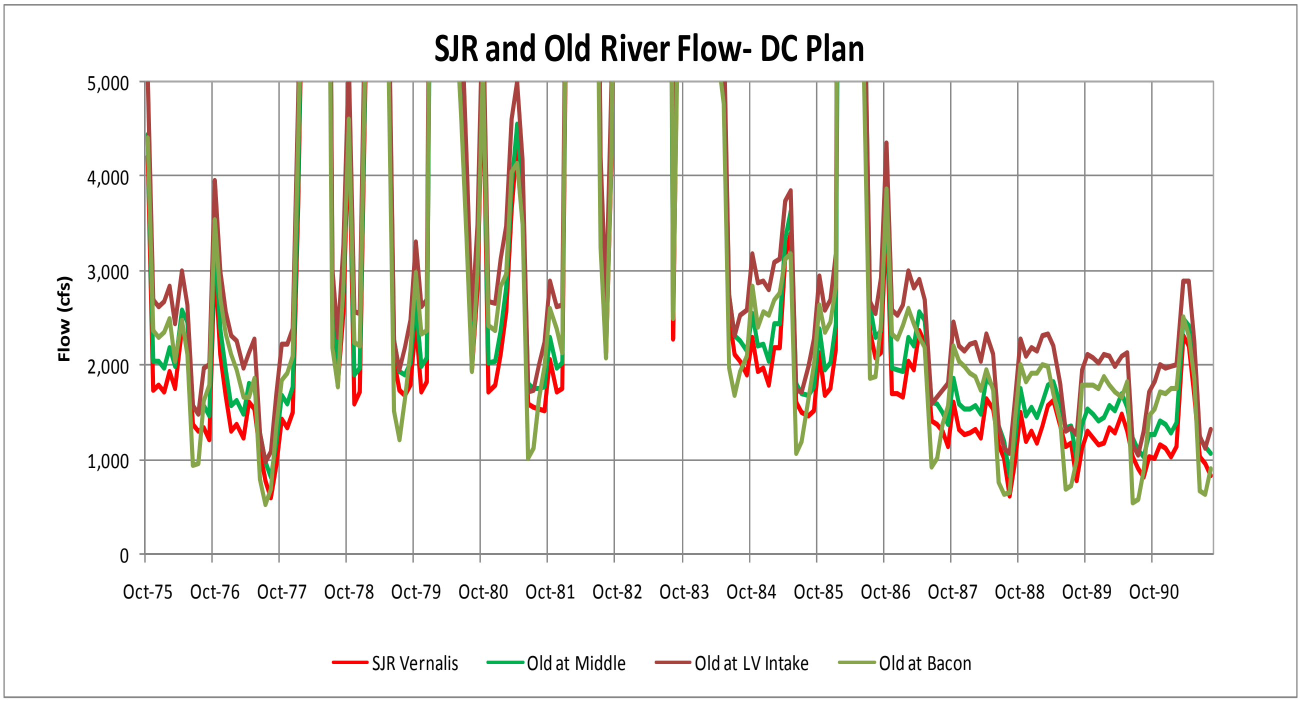
The second DC Plan dilution flow would be pumped with a fish-friendly, low-head pump from Victoria Canal into Middle River upstream of the simulated tidal gate. Some of this dilution flow would be diverted for agricultural uses from Middle River during the summer, but there always would be a small net upstream flow from the upstream end (head) of Middle River into Old River near Tracy. The DSM2 results indicate that the minimum net flow would be about 25 cfs in June and July of some years. The DSM2 results indicate that the head of Middle River EC would range from about 250 µS/cm to almost 750 µS/cm during the fall months with low Delta outflow (high seawater intrusion). The EC of this Middle River dilution flow also would be increased by the agricultural drainage discharged into Middle River. The Middle River dilution flow therefore was small during the summer, and the EC of the dilution water was relatively high during the fall months. Nevertheless, the Middle River dilution flow provides all of the agricultural diversions from this portion of Middle River, some augmentation of the SJR–estuary flow, and some dilution of the SJR EC.

The third DC Plan dilution flow was simulated from the Tracy fish facility, located at the DMC intake channel, to Old River upstream of the simulated tidal gate. This dilution flow would be pumped (fish-friendly) from the bypass channel of the Tracy fish facility primary louvers. Some of this dilution water would be diverted from Old River for agricultural uses during the summer. The DSM2 results indicate that the dilution flow upstream at the Tracy Boulevard Bridge would be reduced to about 100 cfs during June and July of some years. The EC of this dilution water would vary from about 250 µS/cm to almost 750 µS/cm during the fall months with low Delta outflow (high seawater intrusion). This Old River at DMC dilution flow would provide all of the agricultural diversions in this portion of Old River, provide at least 100 cfs augmentation of the SJR–estuary flow during the summer, and dilute the SJR EC.

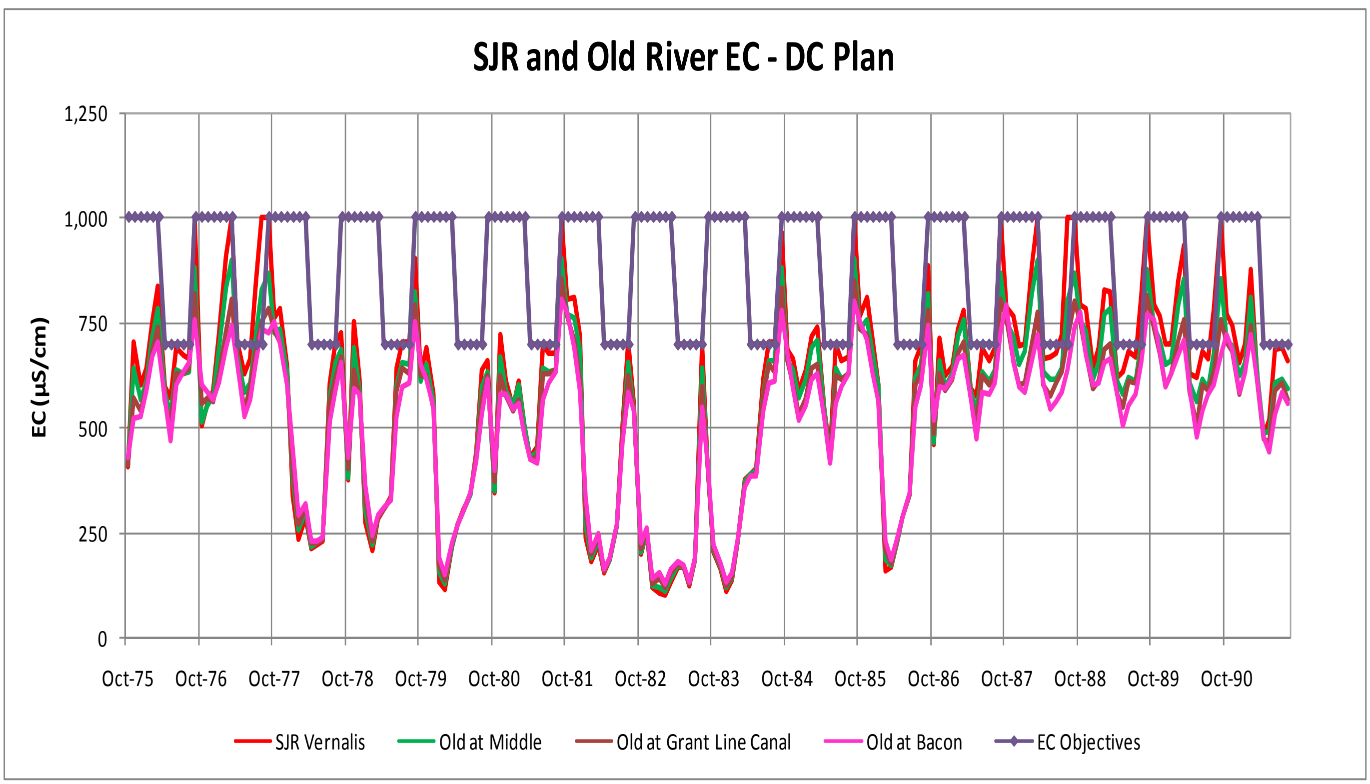
The fourth DC Plan dilution flow was simulated as the bypass flow from the primary louvers at the Skinner fish facility at the CCF. The dilution flow would be discharged to Italian Slough and would flow into Old River just upstream of the CCWD LV intake near the State Route (SR) 4 Bridge. The dilution flow would be about 250 cfs in most months because there are few agricultural diversions from Italian Slough. The EC of this dilution flow would be the same as the SWP EC and therefore would vary from about 250 µS/cm to about 750 µS/cm in fall months with low Delta outflow (high seawater intrusion).

Figure 10a shows the monthly SJR Vernalis flows and the simulated Old River flows between the head of Old River and Bacon Island, where the Old River flows enter Franks Tract, for the 1976–1991 study period with the DC Plan. The minimum Vernalis flow was estimated to be less than 1,000 cfs in the summer months of the dry years of 1977, and 1988–1991. The simulated flows at the head of Middle River (Old at Middle) were about 100 cfs to 250 cfs greater than Vernalis because agricultural diversions between Vernalis and the head of Middle River during the summer months reduce the additional 250-cfs flow pumped from the Stockton DWSC into Old River.

The other three DC Plan dilution flows were added to the Old River flow above the LV intake, so the flows there were about 1,000 cfs more than the Vernalis flow in the winter months, and about 250 cfs more than the Vernalis flow in the summer months with highest agricultural diversions. Because of additional agricultural diversions and the CCWD diversions at the LV intake and at Rock Slough, the Old River at Bacon Island flows were about 250 cfs less than at the LV intake. In the summer months, the Old River at Bacon Island flow was reduced to about the same as the original SJR flow at Vernalis. Therefore, the



10a. DSM2-Simulated Monthly Flows in the San Joaquin River–Old River–Estuary Corridor for WY 1976–1991



10b. DSM2-Simulated Monthly EC in the San Joaquin River–Old River–Estuary Corridor for WY 1976–1991

00086.09

ICF Jones & Stokes
an ICF International Company

Figure 10

simulated dilution flows of about 1,000 cfs total were necessary to satisfy all of the south Delta agricultural diversions and transport the SJR at Vernalis flow to the estuary at Franks Tract. Because the DSM2 simulation of the DC Plan did not move the CCWD LV diversions to the new Victoria Canal intake, the summer flows at Bacon Island likely would be about 250 cfs more than shown in Figure 10a. The actual dilution flows for the DC Plan likely would be seasonal, and likely would be higher in the summer irrigation season and lower in the winter months. Higher dilution flows might be needed when the Vernalis EC was close to the objectives.

Old River Electrical Conductivity

Figure 10b shows the Vernalis EC and the simulated Old River EC values at several locations with the DC Plan. The simulated EC values along Old River were always less than the estimated SJR EC at Vernalis because of the dilution flows. The simulated Old River EC values were not changed much during months when the SJR Vernalis EC was less than 500 µS/cm because the SJR flow was above 2,500 cfs in these months and the dilution flow EC from the water supply corridor was similar to the SJR EC. The greatest EC reductions from the Vernalis EC by the dilution flows along the Old River corridor were simulated in the summer and fall months of the driest years. The Old River at Bacon Island EC values were reduced to a maximum of about 800 µS/cm in the three driest years, when the estimated Vernalis EC was about 1,000 µS/cm. The average reduction in Old River at Bacon Island EC during the summer and fall months was about 50–150 µS/cm. The Old River at Bacon Island EC values remained less than 700 µS/cm during the irrigation season of April–August and less than 800 µS/cm in the fall months of all years.

Figure 11a compares the simulated EC at the mouth of Grant Line Canal for existing conditions and the EC with the DC Plan for the 1976–1991 period. The EC with the DC Plan often would be higher than for the existing conditions because the water in Grant Line Canal would contain a higher percent of SJR water. The 16-year average EC at the mouth of Grant Line Canal was 496 µS/cm for existing conditions and would be 533 µS/cm with the DC Plan. There is no EC objective for Grant Line Canal, but the south Delta EC objectives are shown for reference. The simulated EC at the mouth of Grant Line Canal was less than the 700 µS/cm south-Delta EC objective during the irrigation season of April–August and would be adequate for crops and soils in the south Delta. The 16-year average EC at the mouth of Grant Line Canal during the irrigation season was 433 µS/cm for existing conditions and would be 506 µS/cm with the DC Plan.

Figure 11b shows the simulated EC in Old River at Bacon Island and indicates that the EC would be higher with the DC Plan than for existing conditions. The 16-year average EC in Old River at Bacon Island was 479 µS/cm for existing conditions and would be 519 µS/cm with the DC Plan. The simulated EC in Old River at Bacon Island was less than the south-Delta objective of 700 µS/cm for the irrigation season of April–August but was higher than the 450 µS/cm central Delta objective in some years. Additional measures should be included to avoid degradation and provide adequate water quality. The average EC in Old River at Bacon Island would increase with the DC Plan because there would be more SJR water and less Sacramento River water in the Old River corridor. The average EC in Old River at Bacon Island during the irrigation season was 382 µS/cm for existing conditions and would be 486 µS/cm with the DC Plan. The average EC during the irrigation season would be less than the 450-µS/cm objective in many years and could be reduced if necessary with additional dilution flows released from the water supply corridor. The CCWD Rock Slough diversion EC would be similar to the Old River at Bacon Island EC.

The maximum chloride concentrations at the CCWD LV and Rock Slough intakes would be lower than the maximum EC values for the DC Plan would indicate, because the ratio of chloride concentration to EC for seawater is higher (Cl/EC = 0.3) than for SJR water (Cl/EC = 0.15). Because seawater intrusion in Old River will be greatly reduced with the DC Plan, the peak chloride concentrations will be reduced more than the simulated EC values were reduced in the fall months with the DC Plan.

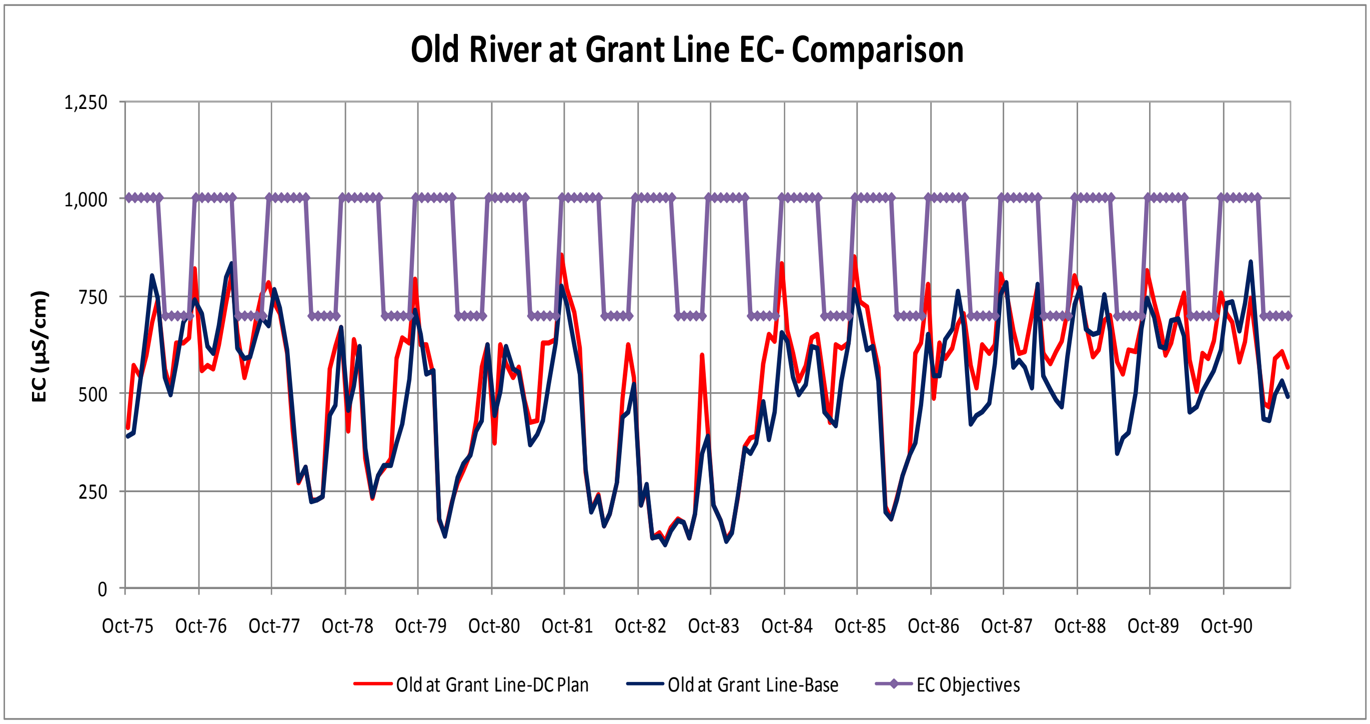
Middle River Flows

Table 2 indicates that the Middle River at Santa Fe Cut flows will change most dramatically with the DC Plan. The 16-year average flows in Middle River for the existing conditions were about -1,900 (upstream net flow). Under existing conditions, about half of the SJR flow moves downstream to the DWSC and some is diverted into Middle River through Turner Cut or Columbia Cut, or at the mouth of Middle River. Most of the Middle River (upstream) flow originates from the Sacramento River and is diverted at the DCC or Georgiana Slough to the Mokelumne River channels.

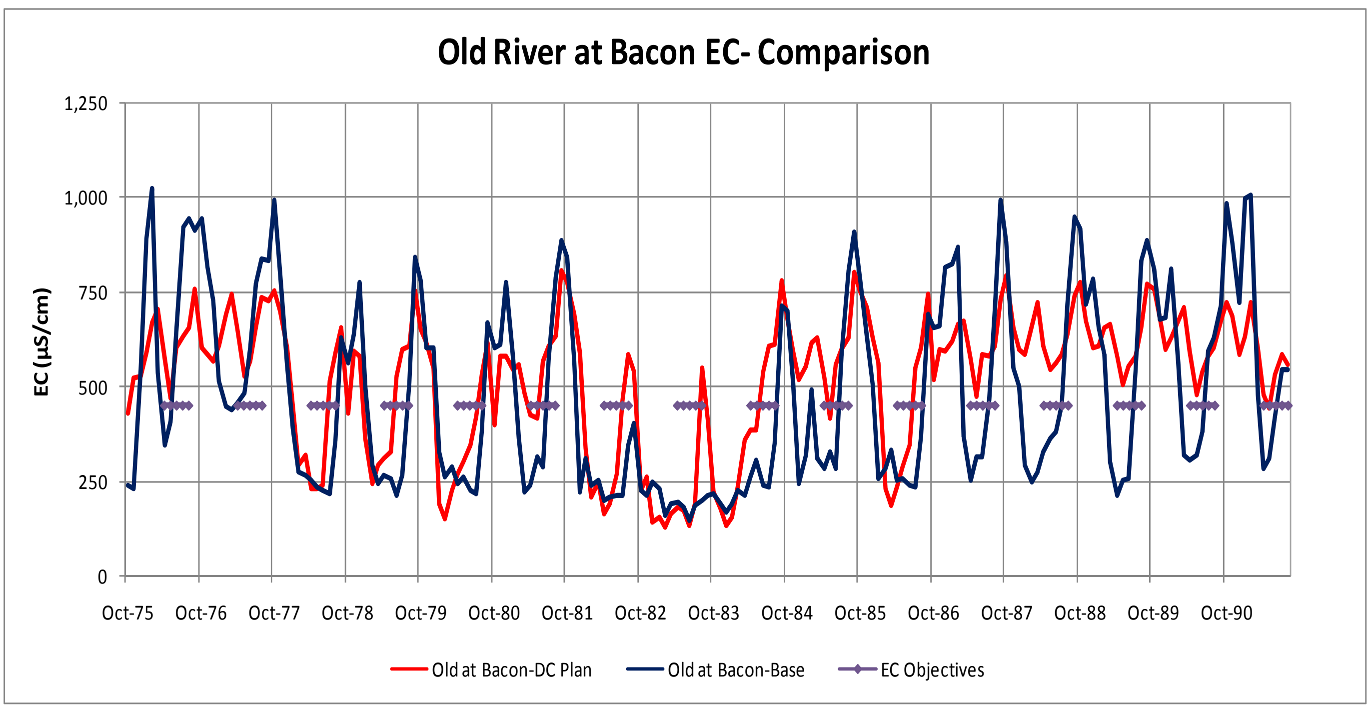
The DC Plan would increase the average reverse Middle River flow at Santa Fe Cut by about 6,000 cfs, from -1,900 cfs (upstream) to -7,900 cfs (upstream), because all of the CVP and SWP pumping would be transported upstream in Middle River to Victoria Canal and to West Canal. No SJR water would flow directly to the exports in Old River or Grant Line Canal. No flow would move upstream in Old River from Franks Tract to the exports. About 750 cfs of dilution flows (at Victoria Canal and at the Tracy and Skinner fish facilities) also would be transported in the Middle River corridor. The 250 cfs dilution flow from the DWSC would flow upstream in the SJR channel. The DC Plan would open the DCC gates all of the time, and most of the Middle River corridor flow would be diverted from the Sacramento River at the DCC and Georgiana Slough. Some would be transported from the Sacramento River through Threemile Slough, and some would move upstream from the SJR at Antioch.

Middle River Electrical Conductivity

Figure 12a shows the simulated changes in EC in Middle River at Santa Fe Cut for the existing conditions and with the DC Plan for the 1976–1991 period. The



11a. Comparison of DSM2-Simulated EC at the Grant Line Canal Mouth for the Existing Conditions and the DC Plan for WY 1976–1991

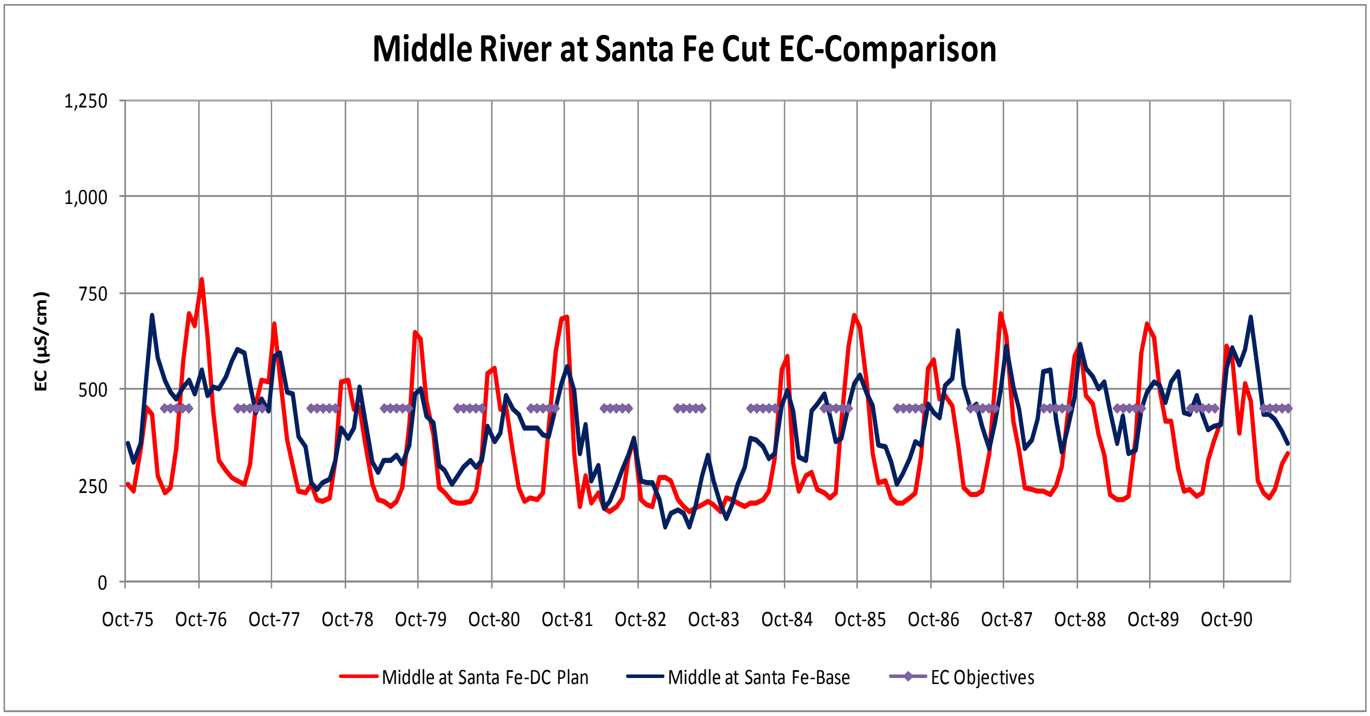


11b. Comparison of DSM2-Simulated EC in Old River at Bacon Island for the Existing Conditions and the DC Plan for 1976–1991

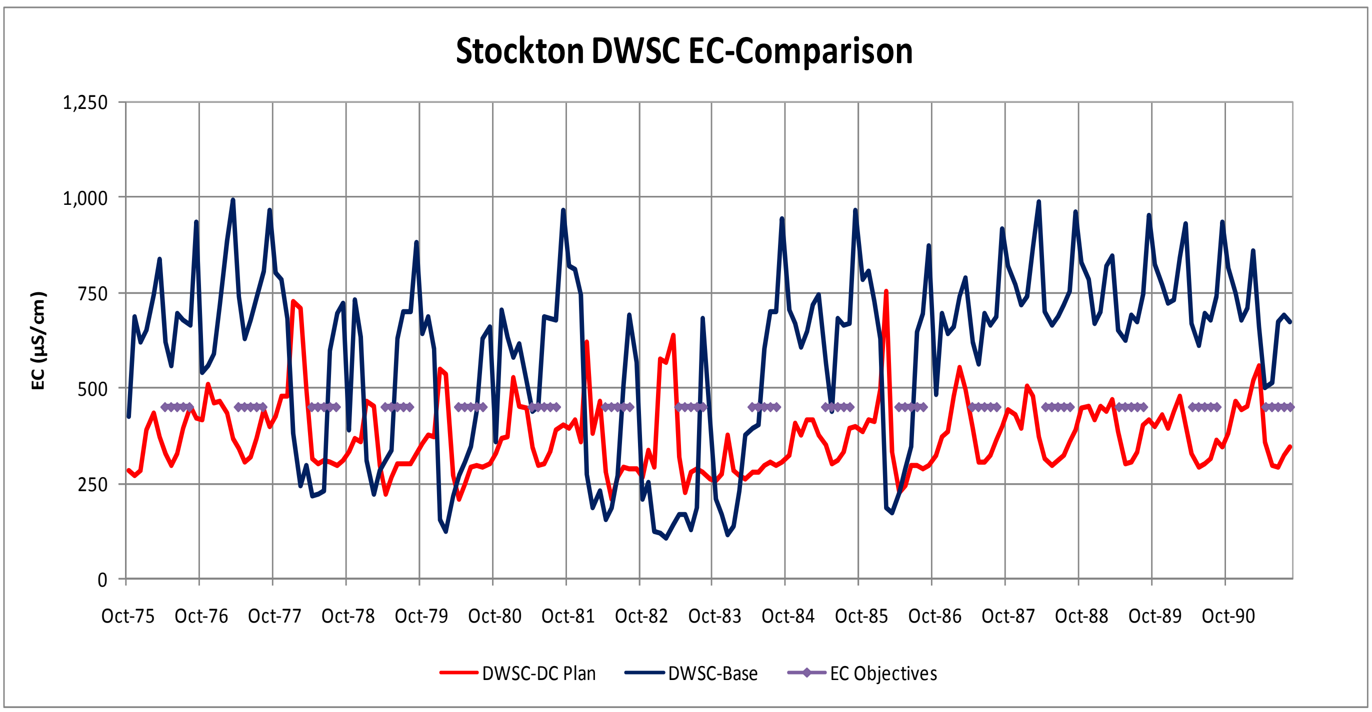
00086.09

ICF Jones & Stokes
an ICF International Company

Figure 11



12a. Comparison of DSM2-Simulated EC in Middle River at Santa Fe Cut for the Existing Conditions and the DC Plan for WY 1976–1991



12b. Comparison of DSM2-Simulated EC in the Stockton Deep Water Ship Channel for the Existing Conditions and the DC Plan for WY 1976–1991

00086.09

ICF Jones & Stokes
an ICF International Company

Figure 12

DC Plan would increase the EC from seawater intrusion in the fall months but would reduce the EC during the irrigation season of April to August. The 16-year average EC in Middle River at Santa Fe Cut was 408 µS/cm for existing conditions and would be reduced to 346 µS/cm with the DC Plan. The 16-year average EC in Middle River at Santa Fe Cut during the irrigation season was 371 µS/cm for existing conditions and would be reduced to 284 µS/cm with the DC Plan.

Figure 12b shows the simulated changes in EC in the Stockton DWSC for the existing conditions and with the DC Plan for the 1976–1991 study period. The DC Plan would reduce the EC most of the time compared to the existing conditions EC, which is dominated by the SJR EC. The DC Plan would reverse the net flow of the SJR from Turner Cut upstream through the DWSC with the pumped dilution flow of 250 cfs at the head of Old River. Only in a few winter months will the effects from agricultural drainage cause the EC in the DWSC to be higher than the existing conditions EC value. The 16-year average EC in the Stockton DWSC was 588 µS/cm for existing conditions and would be reduced to 371 µS/cm with the DC Plan. The 16-year average EC in the Stockton DWSC during the irrigation season was 552 µS/cm for existing conditions and would be reduced to 312 µS/cm with the DC Plan. There are no EC objectives for the DWSC, but the central Delta EC objective of 450 µS/cm is shown for reference.

Summary of EC Changes in Central and South Delta

The DC Plan would sometimes increase the EC along Old River because Old River currently is transporting low-EC water from the Sacramento River toward the exports. The Old River EC with the DC Plan would meet the south Delta EC objective of 700 µS/cm and usually would be less than the central Delta EC objective of 450 µS/cm during the irrigation season of April–August. Additional measures should be included to avoid degradation and provide adequate water quality. The EC of agricultural diversions in Old River upstream of the DMC gate, and in all of Middle River, would be improved (reduced) with the DC Plan. The EC of agricultural diversions along the SJR upstream of Columbia Cut also would be improved with the DC Plan.

Central Valley Project and State Water Project Export Electrical Conductivity with the Delta Corridors Plan

Table 5 gives the summary of the water source tracking and the EC source tracking for the CVP and SWP export pumps with the DC Plan. The SJR volume source contribution at the CVP pumps was reduced from about 45% to about 5%. The agricultural drainage source was reduced slightly (from 7.5 % to 6.8%) with the DC Plan because the agricultural drainage to the Old River corridor no longer was transported to the exports. The freshwater source volume at the CVP pumps increased from 47% for baseline conditions to about 88% with the DC Plan. The DC Plan changes in the water source contributions at the SWP pumps were similar to the CVP source changes. Because the CVP and the SWP exports both would come from the same water supply corridor from the Sacramento River through Middle River and Victoria Canal and West Canal, the source contributions are nearly identical with the DC Plan.

Figure 13 shows the DSM2-simulated water source tracking and EC source tracking for the combined SWP and CVP export pumps with the DC Plan for the 1976–1991 period. Comparison with Figure 9a indicates that the water contribution from the SJR was nearly eliminated with the DC Plan separation of the SJR–estuary corridor from the Middle River water supply corridor. The largest effect would be observed at the CVP pumps, which had an average SJR water contribution of about 45% for existing conditions that would be reduced to about 5% with the DC Plan. The SJR water contribution at the SWP also would be reduced substantially from about 30% for existing conditions to about 5% with the DC Plan.

The source tracking indicates some reduction in the average water contribution from agricultural drainage, from 8% to 5% with the DC Plan. The change in the average seawater intrusion water contribution at the exports was relatively small. The combined export source volume for Martinez boundary water was 0.8% for the existing conditions and about 0.7% with the DC Plan.

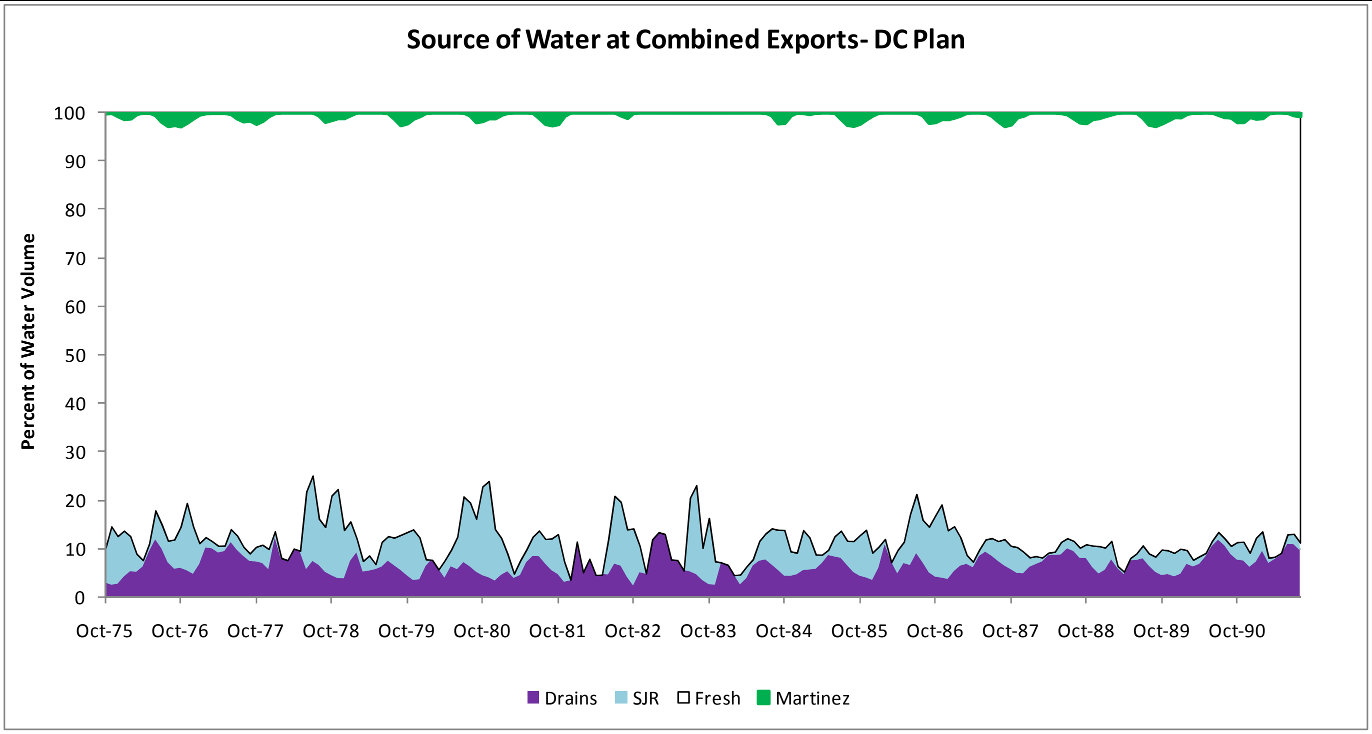
Figure 14a shows the comparison of the SJR volume fraction in the combined exports for the existing conditions and the DC Plan for 1976–1991. The reduction in the SJR volume fraction was very dramatic during periods of relatively high SJR flow when most of the SJR flow would have been exported under existing conditions. The DC plan would eliminate the direct export of any SJR flow (unless the SJR flow was greater than about 10,000 cfs). The SJR flow that is tracked to the exports was limited to the fall low Delta outflow months, when some SJR flow at Bradford Island (leaving Franks Tract) was tidally mixed along with seawater intrusion water upstream to the Middle River corridor.

Figure 14b shows the SJR excess salt load and the excess SJR salt load reaching the combined CVP and SWP exports for existing conditions and with the DC Plan for 1976–1991. Most of the SJR excess salt load was exported under existing conditions, whereas only during the fall period with low Delta outflow is a portion of the SJR excess salt load exported with the DC Plan.

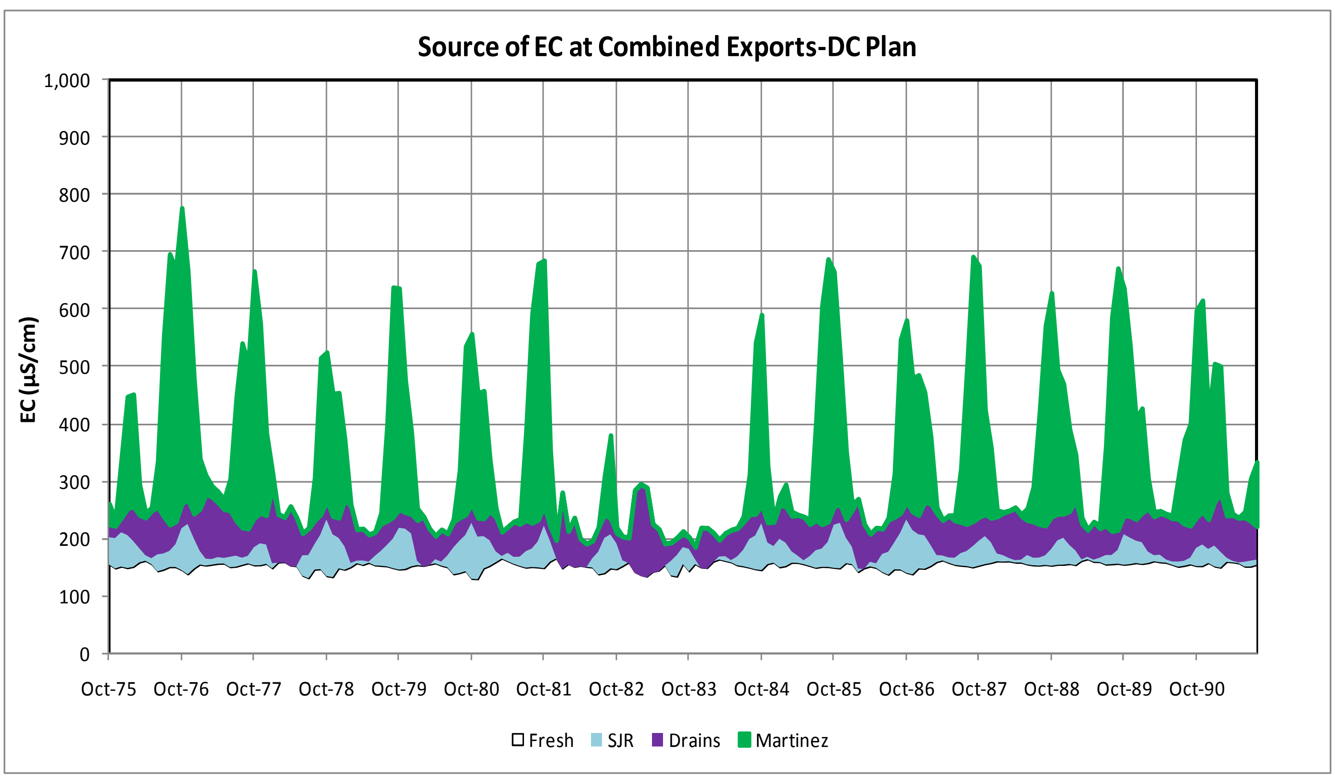
Figure 15a shows the comparison of simulated EC values in the SJR at San Andreas Landing (just downstream of the mouth of the Mokelumne River, see Map 5) for the existing conditions and with the DC Plan for the 1976–1991 study period. The winter and spring EC values with the DC Plan were usually about 250 µS/cm, but the fall EC values increased substantially in almost every year to between 750 µS/cm and 1,000 µS/cm. This fall increase was caused by seawater intrusion during months with low Delta outflows. The San Andreas EC would be increased by about 250 µS/cm in the fall months with the DC Plan because of more reverse flow in the SJR upstream of False River (i.e., QWEST). These reverse upstream flows move (i.e., stretch) the salinity gradient in the SJR upstream of Jersey Point.

Table 5. DSM2-Simulated Water Contributions (%) and EC Contributions (µS/cm) at the CVP and SWP Export Pumps for 1976–1991 with the Delta Corridors Plan

		Ag Drains	Fresh Inflows	Martinez Boundary	San Joaquin River
Flow Contribution at CVP Exports (%)					
Water—minimum		2.3	75.2	0.0	0.0
Water—average	100	6.5	87.8	0.6	5.1
Water—maximum		13.5	96.3	2.6	19.5
EC Contribution at CVP Exports (µS/cm)					
EC—minimum	184.2	15.8	129.1	0.0	0.0
EC—average	348.5	52.9	151.2	115.8	28.6
EC—maximum	783.1	157.3	165.1	520.6	100.2
Excess EC—average	177	42	___	115	29
Flow Contribution at SWP Exports (%)					
Water—minimum		2.4	73.8	0.0	0.0
Water—average	100	6.8	87.5	0.7	5.1
Water—maximum		13.8	96.2	2.6	20.8
EC Contribution at SWP Exports (µS/cm)					
EC—minimum	186.3	17.3	126.8	0.0	0.0
EC—average	353.1	57.9	150.6	116.0	28.6
EC—maximum	771.1	164.9	165.0	511.5	99.1
Excess EC—average	181	46	___	115	20
Flow Contribution at Combined Exports (%)					
Water—minimum		2.4	74.8	0.0	0.0
Water—average	100	6.6	87.7	0.7	5.1
Water—maximum		13.5	96.2	2.6	20.0
EC Contribution at Combined Exports (µS/cm)					
EC—minimum	185.5	16.7	128.8	0.0	0.0
EC—average	351.0	55.4	150.9	116.1	28.6
EC—maximum	776.4	159.0	165.0	515.5	99.5
Excess EC—average	179	44	___	115	20



13a. DSM2-Simulated Source Volume Tracking at the Combined CVP and SWP Export Pumps with the DC Plan for WY 1976–1991

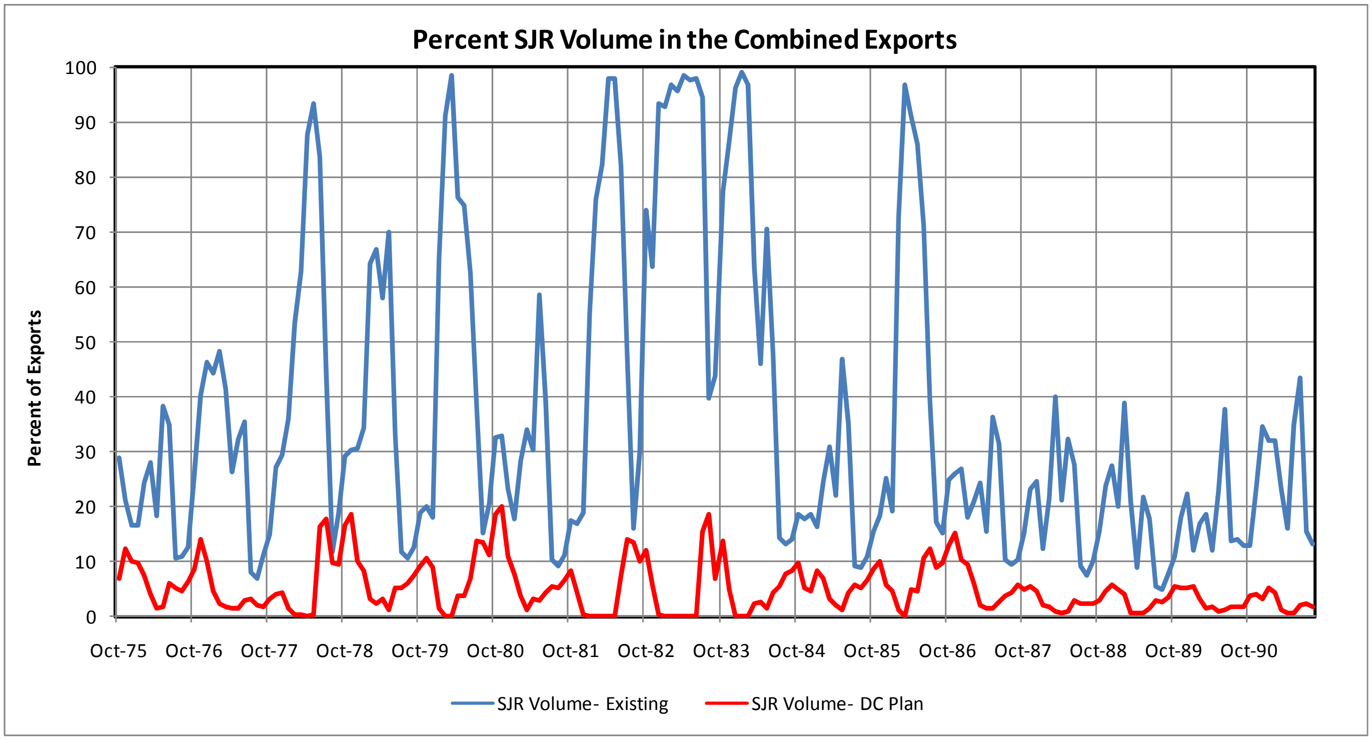


13b. DSM2-Simulated Source EC Tracking at the Combined CVP and SWP Export Pumps with the DC Plan for WY 1976–1991

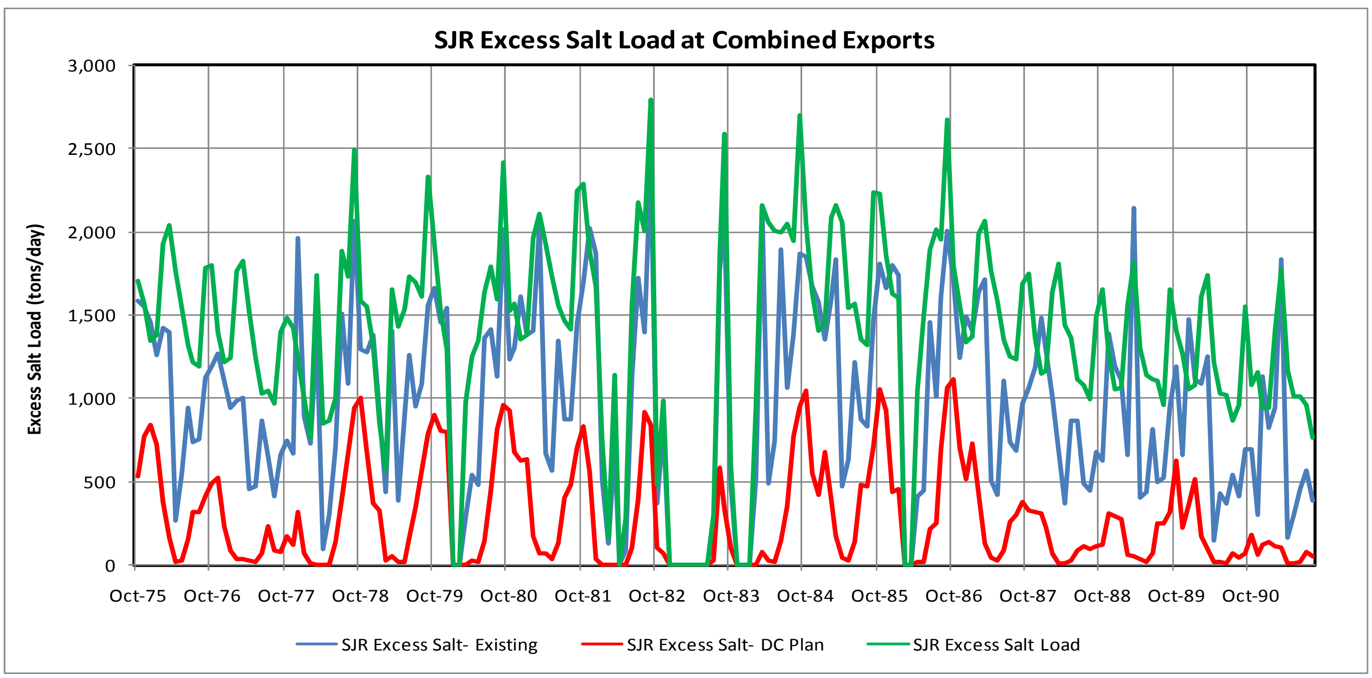
00086.09

ICF Jones & Stokes
an ICF International Company

Figure 13



14a. Comparison of DSM2-Simulated SJR Volume in the Combined CVP and SWP Exports for the Existing Conditions and the DC Plan for WY 1976–1991

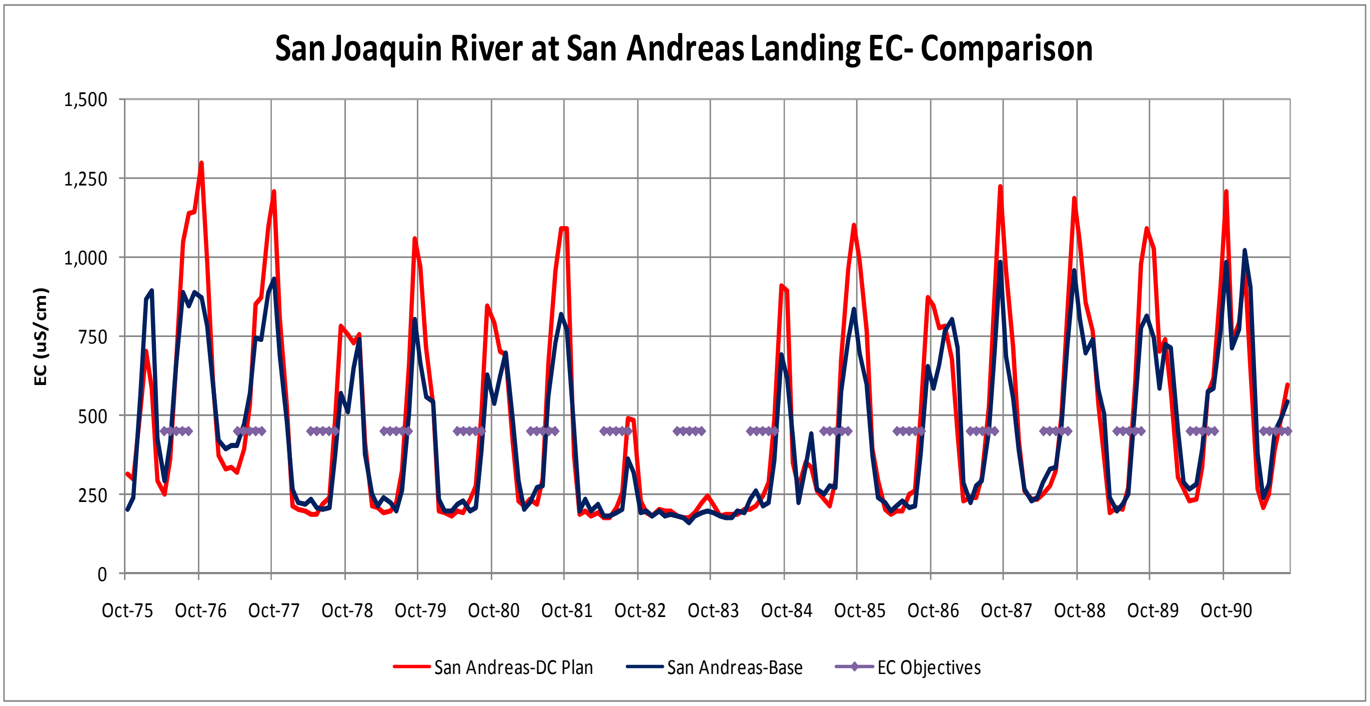


14b. Comparison of DSM2-Simulated SJR Excess Salt Load in the Combined CVP and SWP Exports for the Existing Conditions and for the DC Plan for WY 1976–1991

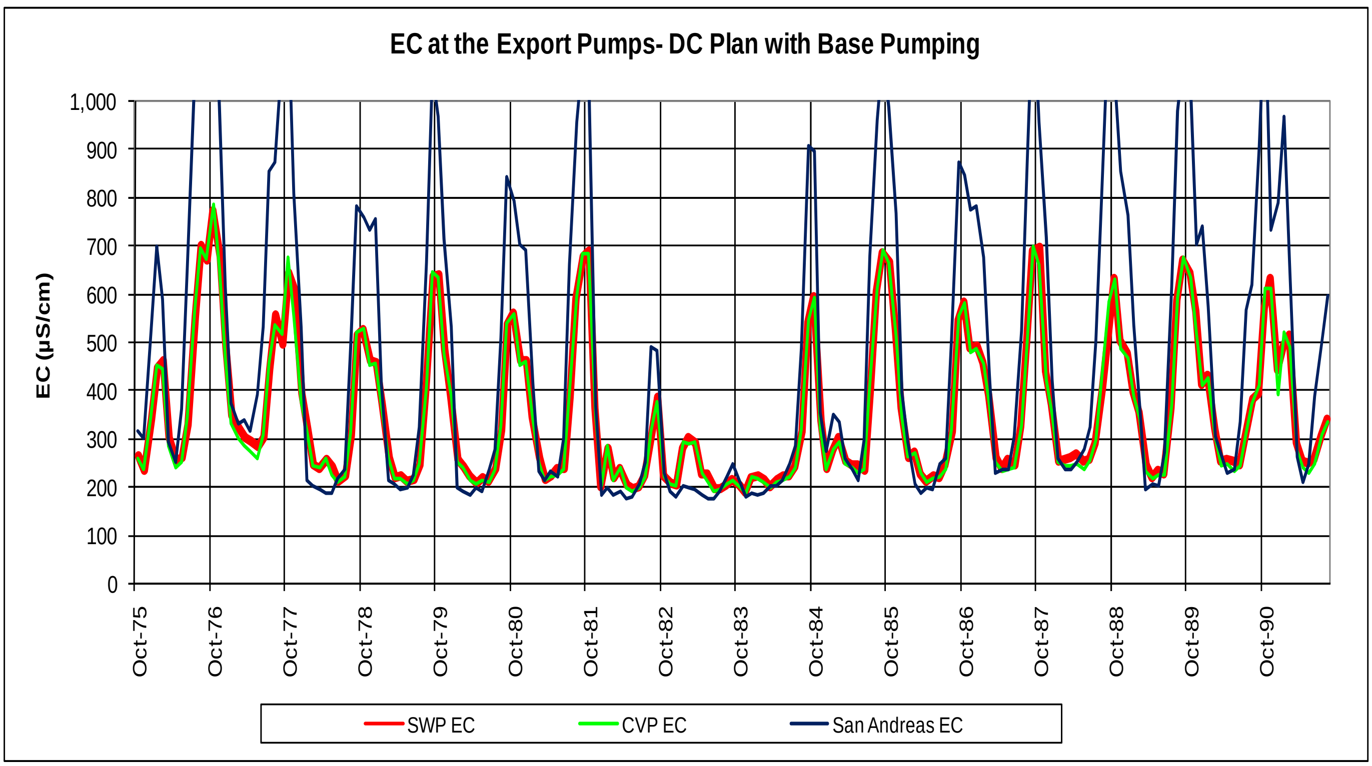
00086.09

ICF Jones & Stokes
an ICF International Company

Figure 14



15a. Comparison of DSM2-Simulated San Andreas Landing EC for the Existing Conditions and the DC Plan for WY 1976–1991



15b. DSM2-Simulated EC in the CVP and SWP Export Pumping with the DC Plan for WY 1976–1991

00086.09

ICF Jones & Stokes
an ICF International Company

Figure 15

Figure 15b shows the simulated CVP and SWP EC with the DC Plan for the 1976–1991 study period. The winter and spring EC values with the DC Plan were usually about 250 µS/cm, and the fall EC values increased substantially in almost every year to between 600 µS/cm and 700 µS/cm because of seawater intrusion at San Andreas during months with low Delta outflow. The export EC values with the DC Plan were less than the San Andreas EC values because about 25% of the DCC and Georgiana Slough diversions enter the SJR through Little Connection Slough to Columbia Cut and Turner Cut and are not directly affected by seawater intrusion at San Andreas.

Figure 16a shows the comparison of the CVP export EC for the existing conditions and with the DC Plan for 1976–1991. There was a substantial reduction in the EC at the exports during the spring and summer of many years. The highest EC values in the fall of the low-flow years (caused by seawater intrusion) were reduced slightly with the DC Plan, because of the separation of the SJR flow and EC from the exports. The 16-year average CVP EC was 477 µS/cm for the existing conditions and was reduced to 348 µS/cm with the DC Plan. Figure 16b shows the comparison of the SWP export EC for the existing conditions and with the DC Plan. The average SWP EC was 450 µS/cm for the existing conditions and was reduced to 353 µS/cm with the DC Plan.

The average EC of the combined exports was 463 µS/cm for the existing conditions and was reduced by 112 µS/cm to 351 µS/cm with the DC Plan. This represents a 25% reduction in the average EC or average salinity (reduced by about 70 mg/l TDS). Table 5 indicates that the excess EC of the combined exports was reduced from 293 µS/cm to 179 µS/cm with the DC Plan. This was about a 40% reduction in the excess EC and the excess salt load. Map 6 illustrates the reduction in the excess salt load at the combined exports. About 80% of the excess salt load from the SJR would reach the estuary with the DC Plan.

The DC Plan would be very effective in eliminating the export of SJR water at the CVP and SWP pumps. The DSM2 simulations indicate that an average of 420 cfs of SJR water would be exported with the DC Plan, compared to about 2,500 cfs for existing conditions. Comparison of the excess EC source tracking and the excess salt load for the combined exports with existing conditions and with the DC Plan indicates that the SJR excess EC source contribution was reduced from 93 µS/cm for existing conditions to about 20 µS/cm with the DC Plan. The excess salt load from the SJR in the combined exports was reduced from about 975 tons/day for existing conditions to about 275 tons/day with the DC Plan. The export of SJR water would be reduced by 85% and the export of SJR excess salt load would be reduced by about 70% with the DC Plan.

The average Martinez source EC (seawater intrusion) at the exports was 142 µS/cm for existing conditions and 116 µS/cm for the DC Plan. The reduction in the seawater intrusion salt load (i.e., seawater EC contribution x exports) was about 15%. The DC Plan would reduce seawater intrusion reaching the exports by eliminating the seawater intrusion pathway from the lower SJR (Antioch) into Franks Tract and Old River, and forcing seawater intrusion to move farther upstream before entering the water supply corridor. The next section will discuss the possibility of reducing seawater intrusion effects by reducing export pumping in some months with the lowest Delta outflow.

Reducing the EC of the exported water would have beneficial effects for the agricultural soils irrigated from the DMC and for the SJR EC, because the steady-state soil EC and the drainage EC entering the groundwater or flowing back to the SJR would be reduced accordingly. Reclamation (DMC Recirculation) and the Central Valley Regional Water Quality Control Board and State Water Board are involved in basin-wide programs (CV-SALTS and salt and boron TMDL) to manage salinity on the SJR. The DC Plan would reduce the exported excess salt load by about 1,000 tons/day. The reduced salinity would have value for municipal water supplies because it would reduce the replacement costs for water appliances and increase the potential for water reuse (recycling).

Seawater Intrusion Effects

The relationship between the seawater intrusion salt load at the exports and the SJR excess salt load is important to understand. About half of the CVP exports are delivered along the DMC, which extends to the SJR at Mendota Dam and Pool. The other half of the CVP water is delivered to Westlands Water District from the San Luis Canal (California Aqueduct) and to the San Filipe Division from San Luis Reservoir. A major fraction of the salt load delivered along the DMC returns to the SJR (through tile drainage or shallow groundwater) and causes most of the SJR excess salt load. Because most of the SJR excess salt load is exported at the CVP pumps, a major fraction of the excess salt load in the SJR is returned to the DMC in a partial salt-recycle loop. Seawater intrusion adds an increment of salt load to this DMC–SJR salt-recycle loop. The DC Plan will effectively eliminate this SJR salt-recycle loop and allow most of the SJR excess salt load to return to the estuary and the ocean.

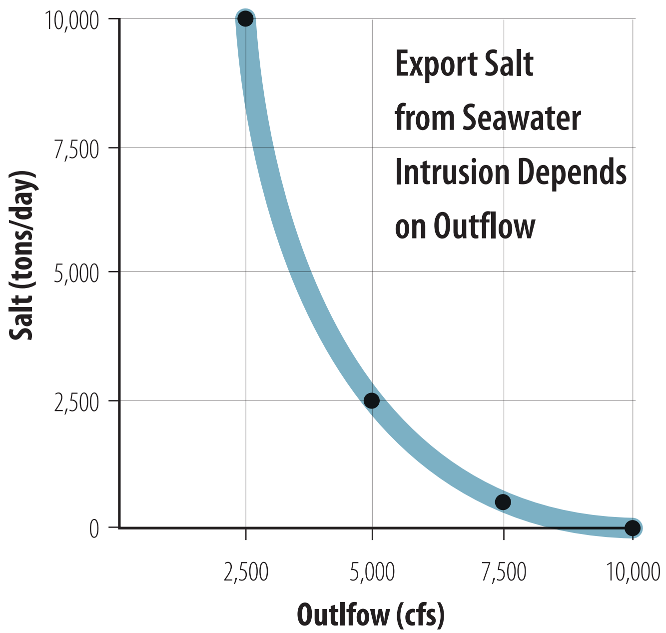
The simulation of the DC Plan used the CALSIM-simulated existing conditions (D-1641) CVP and SWP export pumping and corresponding Delta outflow sequence for 1976–1991. The Delta exports were not changed, and so the Delta outflow was not changed for this initial evaluation. Seawater intrusion, as indicated by Jersey Point or San Andreas EC values, increased dramatically for both the existing conditions and the DC Plan when effective Delta outflow was less than about 10,000 cfs (See Figure 2b). Seawater intrusion, as indicated by Jersey Point or San Andreas EC values, was highest at the lowest existing conditions outflows (less than about 5,000 cfs).

Table 6 compares the simulated excess salt load (tons/yr) and the seawater intrusion salt load (tons/yr) at the combined exports for the existing conditions and with the DC Plan for the 1976–1991 study period. The average existing conditions excess salt load at the exports was about 1,225,000 tons/yr. The simulated existing conditions seawater intrusion contribution averaged about 660,000 tons/yr (54% of total excess salt load). The DC Plan would reduce the excess salt load at the exports to an average of about 825,000 tons/yr (68% of existing conditions) without changing exports or Delta outflow. The DC Plan

Table 6. Estimated Changes in Seawater Intrusion at Exports for Delta Corridors Plan and with Higher Minimum Delta Outflows for the 1976–1991 Period

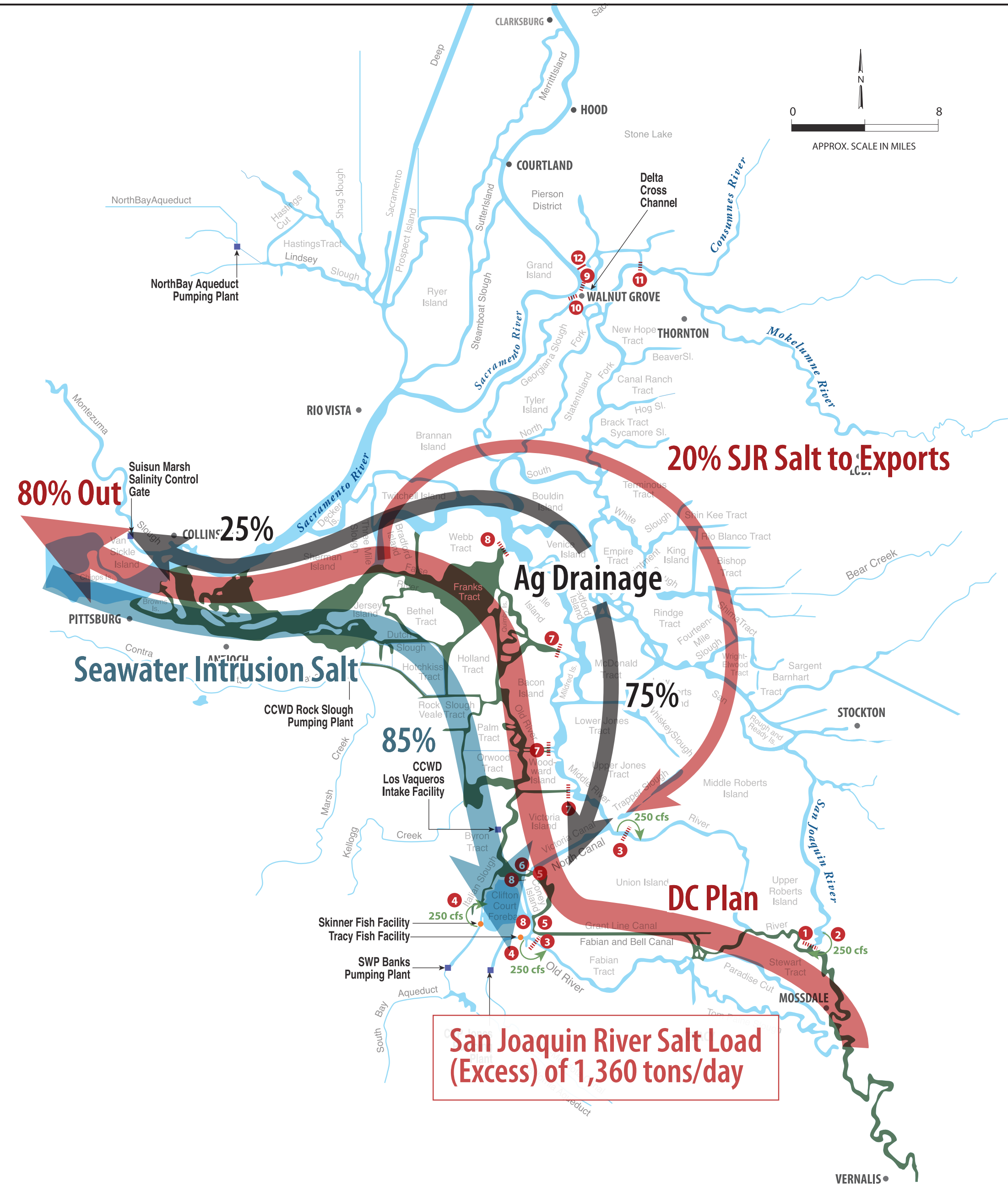
	Existing Conditions with D-1641 Outflow			DC Plan with D-1641 Outflow		DC Plan Minimum Outflow = 3,500 cfs		DC Plan Minimum Outflow = 4,000 cfs		DC Plan Minimum Outflow = 4,500 cfs		DC Plan Minimum Outflow = 5,000 cfs	
Water Year	Combined Exports (taf/yr)	Excess Salt Load (tons/yr)	Seawater Salt Load (tons/yr)	Excess Salt Load (tons/yr)	Seawater Salt Load (tons/yr)	Reduced Exports (taf/yr)	Reduced Seawater Salt Load (tons/yr)	Reduced Exports (taf/yr)	Reduced Seawater Salt Load (tons/yr)	Reduced Exports (taf/yr)	Reduced Seawater Salt Load (tons/yr)	Reduced Exports (taf/yr)	Reduced Seawater Salt Load (tons/yr)
1976	5,150	1,720,461	1,127,983	1,085,713	810,129	5	9,981	38	63,518	175	245,165	332	374,408
1977	2,626	1,078,425	606,567	736,179	573,158	30	24,182	63	59,232	154	166,481	306	266,195
1978	5,501	1,114,684	407,742	713,783	407,292	0	9,011	3	19,777	64	74,890	124	119,248
1979	6,352	1,329,199	682,365	1,046,758	695,802	0	0	14	27,180	86	153,060	207	300,694
1980	6,449	1,178,686	656,738	970,317	636,419	0	0	0	11,028	0	42,073	52	140,708
1981	5,987	1,754,708	1,076,258	1,282,743	969,747	0	0	0	181	35	68,417	155	296,127
1982	6,882	1,118,458	443,909	694,336	392,738	0	0	0	44	30	32,985	85	90,701
1983	5,662	202,002	10,233	214,538	9,244	0	0	0	0	0	1	0	1
1984	5,800	644,875	207,205	431,497	223,255	0	0	19	32,405	79	101,639	140	150,020
1985	6,066	1,711,479	997,579	1,195,782	863,052	0	0	0	10,943	15	69,652	76	203,832
1986	6,412	1,285,128	625,889	997,716	623,533	0	0	0	0	30	48,753	85	158,087
1987	5,143	1,809,588	1,143,164	1,195,881	882,847	30	55,976	90	144,360	154	227,927	274	393,400
1988	3,424	1,035,730	502,599	567,520	385,705	57	60,660	118	106,039	208	149,552	329	190,370
1989	4,457	1,442,848	892,712	969,761	768,245	0	14,855	0	28,436	52	106,378	142	207,774
1990	3,412	1,241,107	763,975	685,016	494,956	30	18,861	60	28,582	131	74,309	303	189,059
1991	2,425	902,623	464,165	429,248	289,978	0	9,989	50	45,319	153	86,541	295	128,797
Average	**5,109**	**1,223,125**	**663,068**	**826,049**	**564,131**	**10**	**12,720**	**28**	**36,065**	**85**	**102,989**	**182**	**200,589**
Percent Reduction from DC Plan with D-1641						**0.2%**	**2.3%**	**0.6%**	**6.4%**	**1.7%**	**18.3%**	**3.6%**	**35.6%**

Salinity Benefits of the Delta Corridors Plan



Exported Excess Salt Load (tons/day)

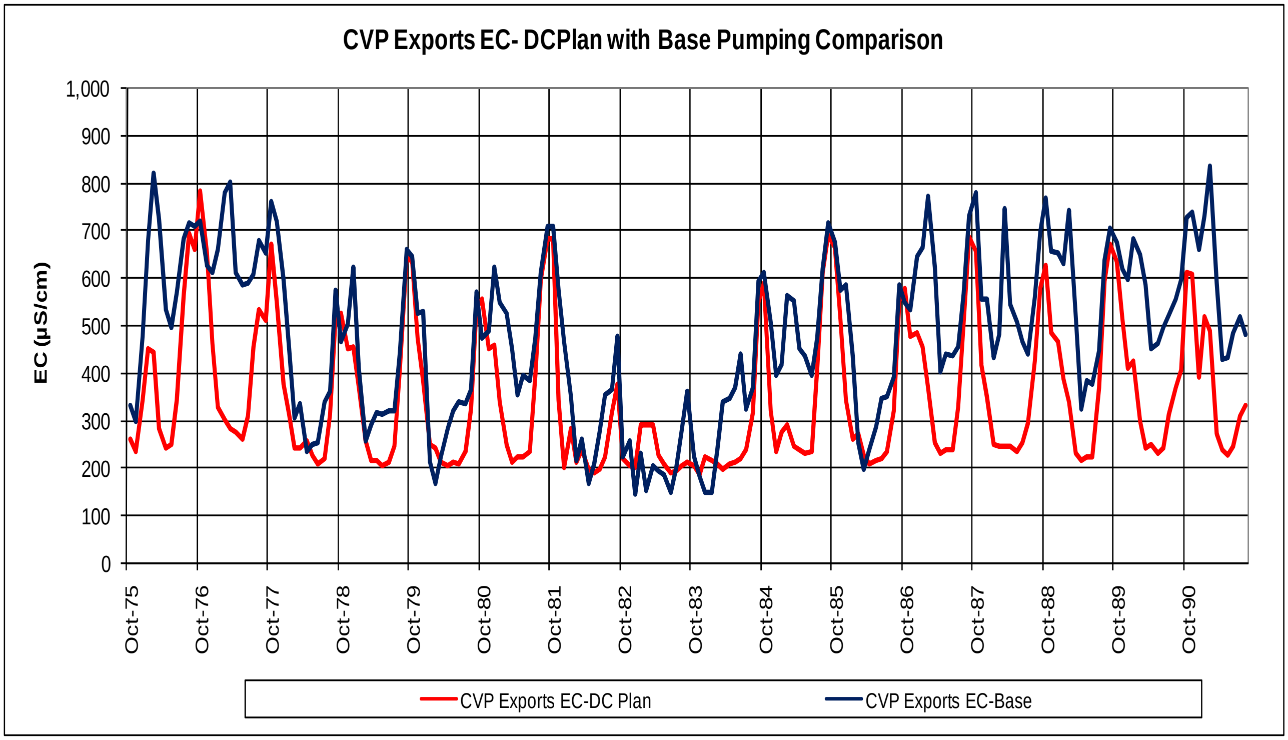
	Existing	DC Plan	% Existing
San Joaquin River	975	275	28%
Ag Drain	635	490	77%
Seawater	1,800	1,535	85%
Total	**3,410**	**2,300**	**67%**



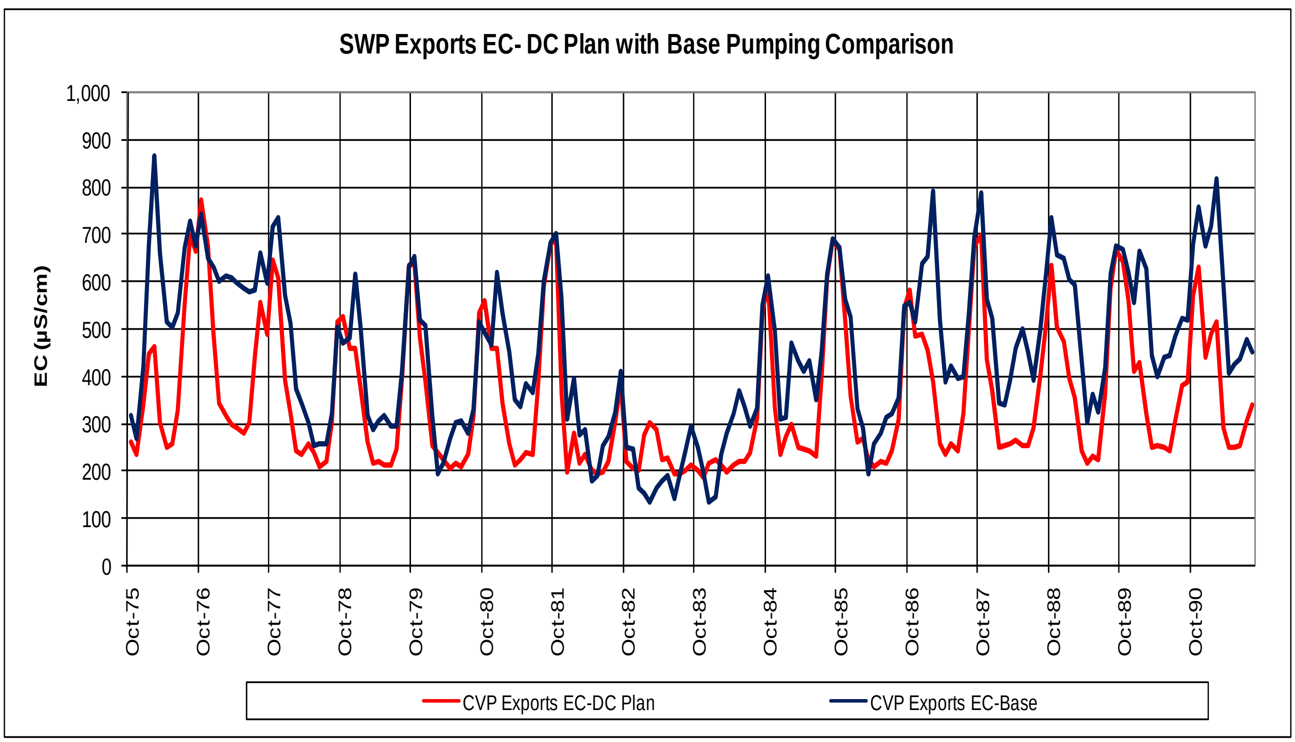
Graphics\Projects\00086.09 Delta Corridors/(08-09) SS

ICF Jones & Stokes
an ICF International Company

Map 6
Changes in Excess Salt Load at the Exports with the Delta Corridors Plan



16a. Comparison of DSM2-Simulated CVP Export EC for the Existing Conditions and the DC Plan for WY 1976–1991



16b. Comparison of DSM2-Simulated SWP EC for the Existing Conditions and the DC Plan for WY 1976–1991

00086.09

ICF Jones & Stokes
an ICF International Company

Figure 16

would reduce the seawater intrusion contribution to about 565,000 tons/yr (85% of existing conditions).

Seawater intrusion at the CVP exports represents the major salt load source (once the initial salt was leached from the irrigated lands) that has been applied to the DMC irrigated lands since the DMC began operation more than 50 years ago. Eliminating this seawater intrusion salt-load source would significantly reduce the excess salt load that is exported and applied to the CVP (and SWP) irrigated lands. The next section shows the strong relationship between Delta outflow and seawater intrusion at the export pumps, and the following section describes how slightly increased minimum Delta outflows would dramatically reduce seawater intrusion at the CVP and SWP exports.

Seawater Intrusion with the Delta Corridors Plan

The results of this evaluation indicate that, without changing Delta outflow, the DC Plan would reduce seawater intrusion at the CVP and SWP export pumps by blocking the most direct pathway for seawater intrusion from the lower SJR at Antioch into Franks Tract and Old River to the exports. With the DC Plan, the combined exports and dilution flows of 1,000 cfs would be supplied from the Sacramento River diversions (DCC, Georgiana Slough, and Threemile Slough) or the Mokelumne River inflow (usually small, see Table 1). When the combined exports exceed this water supply corridor flow, some of the SJR outflow at False River would be recycled upstream in the SJR past Bradford Island to the Middle River water supply corridor. The DC Plan would cause the SJR at Bradford flows to reverse more often than for the existing conditions (See Table 1). This would cause the maximum San Andreas EC values in the fall months to be higher with the DC Plan than with existing conditions. However, the combined effects of the DC Plan reduced the simulated seawater intrusion (salt load) at the exports by about 15%, from about 665,000 tons/yr to about 565,000 tons/yr.

Figure 17a shows the comparison of simulated Collinsville EC and Antioch EC for the existing conditions and with the DC Plan for the 1976–1991 study period. Because the Delta outflow would not be changed with the DC Plan, the seawater intrusion in Suisun Bay and the resulting EC at these western Delta locations would be nearly the same with the DC Plan as for existing conditions.

Figure 17b shows the comparison of simulated Jersey Point EC and San Andreas EC for the existing conditions and with the DC Plan for the 1976–1991 study period. The simulated SJR at Bradford Island reverse (upstream) flows for existing conditions and with the DC Plan are shown for reference in Figure 17b. The SJR at Bradford Island flow usually was reversed (upstream) during periods with the lowest Delta outflows and the highest EC values at Jersey Point and San Andreas. The reverse SJR flow at Bradford Island was generally higher with the DC Plan than for the existing conditions. During periods of relatively low Delta outflow, these higher reverse flows at Bradford Island would cause the San Andreas EC to be higher than for existing conditions. The reverse SJR flows at Antioch would not change with the DC Plan, and so the simulated changes in the

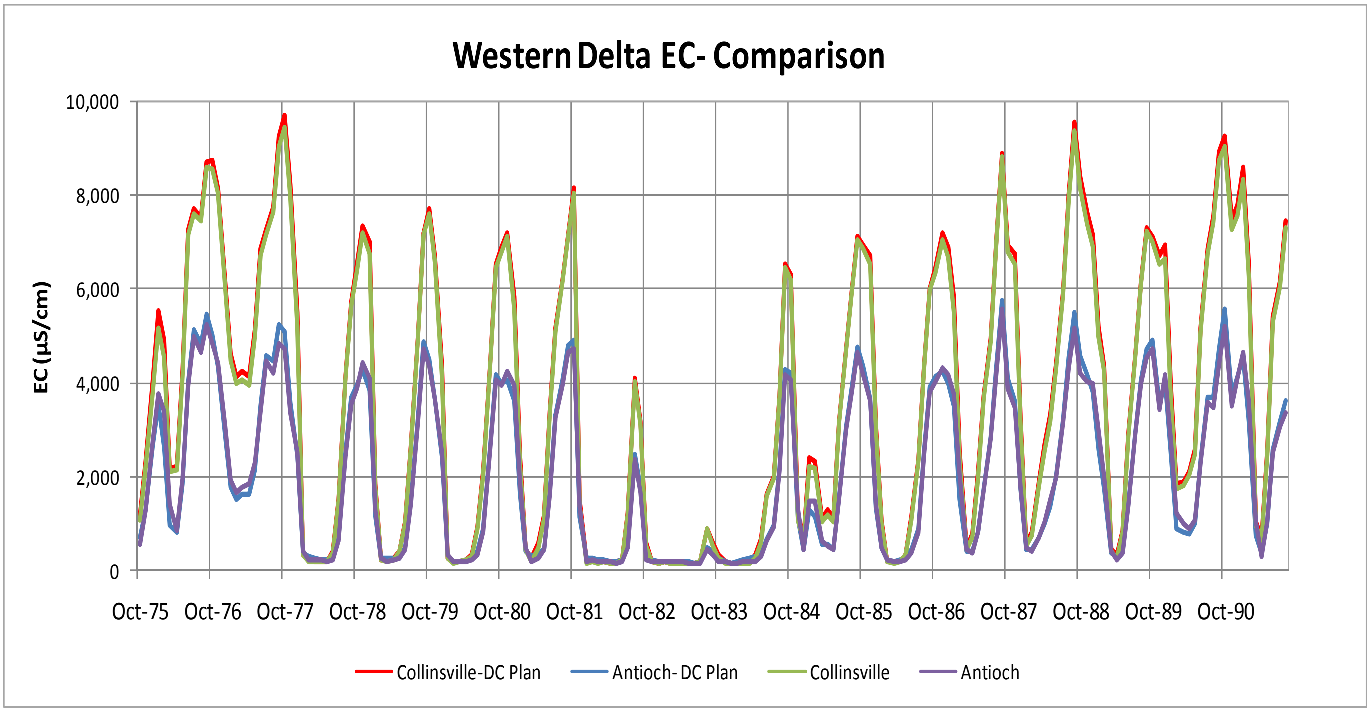
Jersey Point EC were less than the simulated changes in the San Andreas EC. The Jersey Point and San Andreas EC values were both generally controlled by the effective Delta outflow.

Figure 18a shows the simulated effects of Delta outflow on the seawater intrusion (Martinez EC source) at the combined exports for the existing conditions and with the DC Plan for the 1976–1991 study period. The peak seawater intrusion EC values were a little higher for the DC Plan, reflecting the higher reverse flows in the SJR at Bradford Island. But the DC Plan reduced some periods of seawater intrusion during months when the Sacramento River inflow increased moderately. The DC Plan would allow increased Sacramento diversions (because the DCC would be open) to flush the isolated water supply corridor more rapidly than under existing conditions. The separation of Old and Middle River channels would be a major advantage following a major levee failure, when one or more Delta islands could fill with relatively high-EC water (DWR 2009b). Higher-EC water would be discharged through each levee breach during ebb tides. The DC Plan would reduce the effects of this higher-EC water at the exports from any levee breaches located along the SJR–estuary corridor and would allow the higher-EC water from levee breaches along the Middle River water supply corridor to be flushed more rapidly into the Old River channel (by opening the flood gate at the north end of West Canal). A relatively short flushing period (e.g., 1 month) likely would be sufficient to tidally exchange the higher-EC water from the flooded islands and flush the water supply corridor, so that nearly full pumping of low-EC water could be resumed more quickly with the DC Plan.

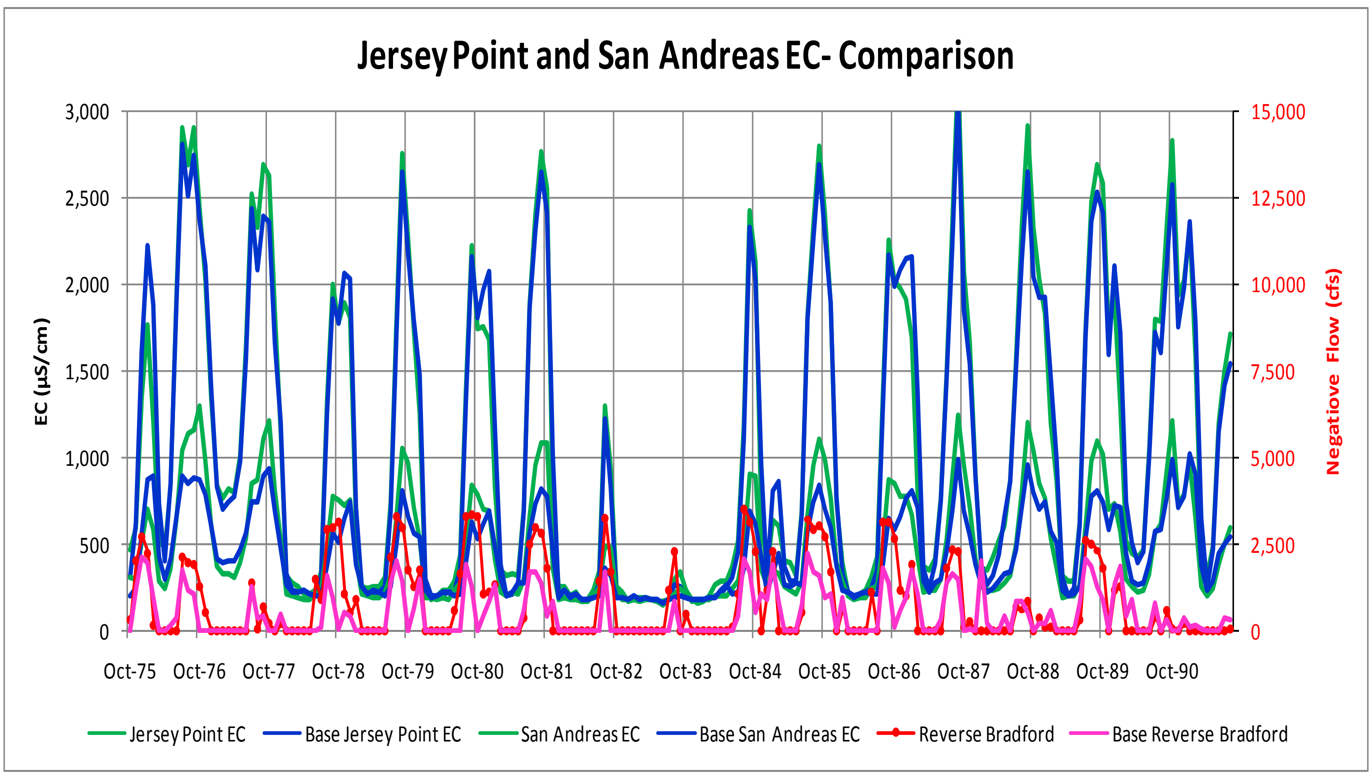
Figure 18b shows the relationship between the effective Delta outflow and the simulated Martinez EC source contribution at the combined exports for the existing conditions and with the DC Plan. The simulated seawater intrusion at the exports for both the existing conditions and the DC Plan was strongly controlled by the effective Delta outflow, just like the EC values at the Suisun Bay and western Delta stations. The simulated Martinez EC source contribution at the combined exports increased exponentially as the effective Delta outflow was reduced to less than about 6,000 cfs. This negative exponential relationship was similar for the existing conditions and with the DC Plan.

The seawater intrusion at the exports was increased when the SJR flow at Bradford Island was reversed. The reverse flow at Bradford Island had the same effect as reducing the effective outflow by about half of the reverse flow at Bradford. For example, a reverse flow of –1,000 cfs had the same effect on export EC as reducing the effective outflow by about 500 cfs. The DSM2-simulated Martinez EC contribution at the combined exports can be approximated with an equation that is similar to the relationships for western Delta EC stations as a function of effective outflow:

Martinez EC at exports (μS/cm) = 3,000 x exp (–.0006 x [effective outflow (cfs) – 0.5 x reverse SJR flow at Bradford (cfs)])



17a. Comparison of DSM2-Simulated EC at Collinsville and Antioch for the Existing Conditions and the DC Plan for WY 1976–1991

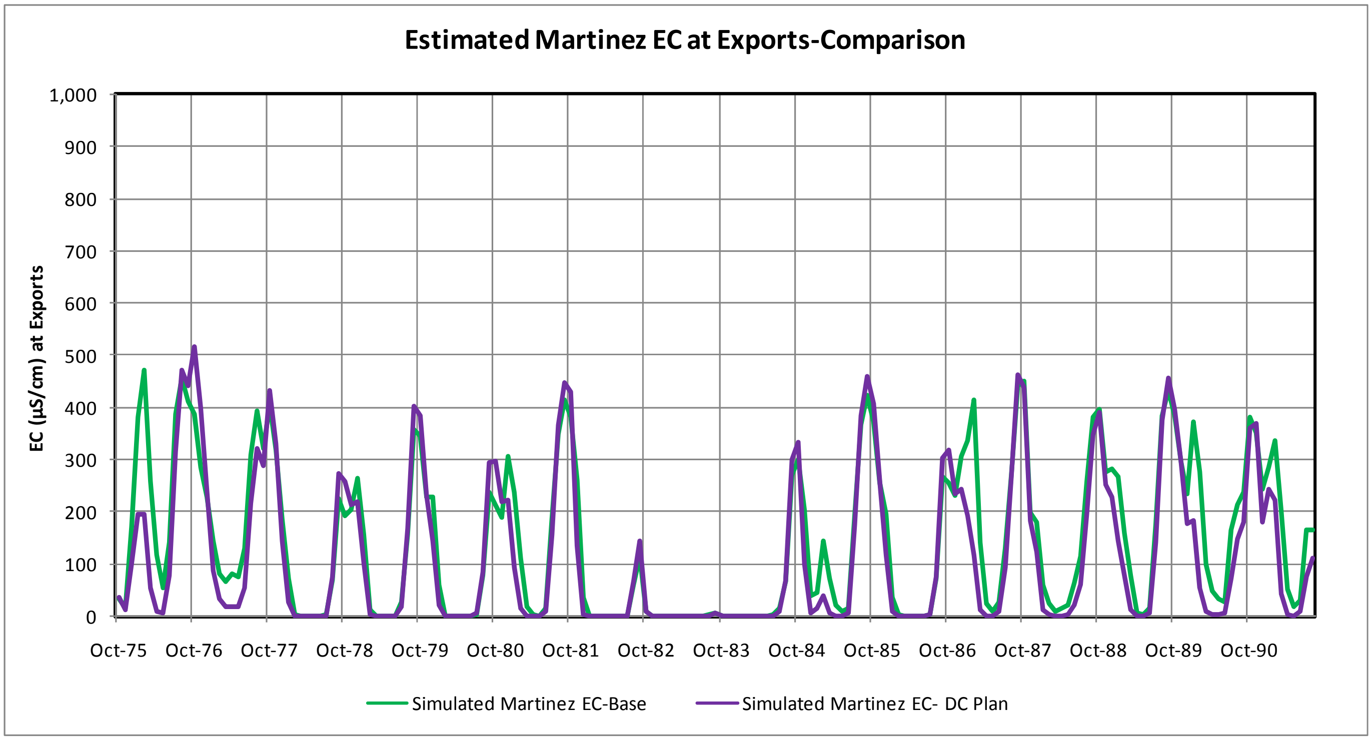


17b. Comparison of DSM2-Simulated EC at Jersey Point and San Andreas Landing for the Existing Conditions and the DC Plan for WY 1976–1991

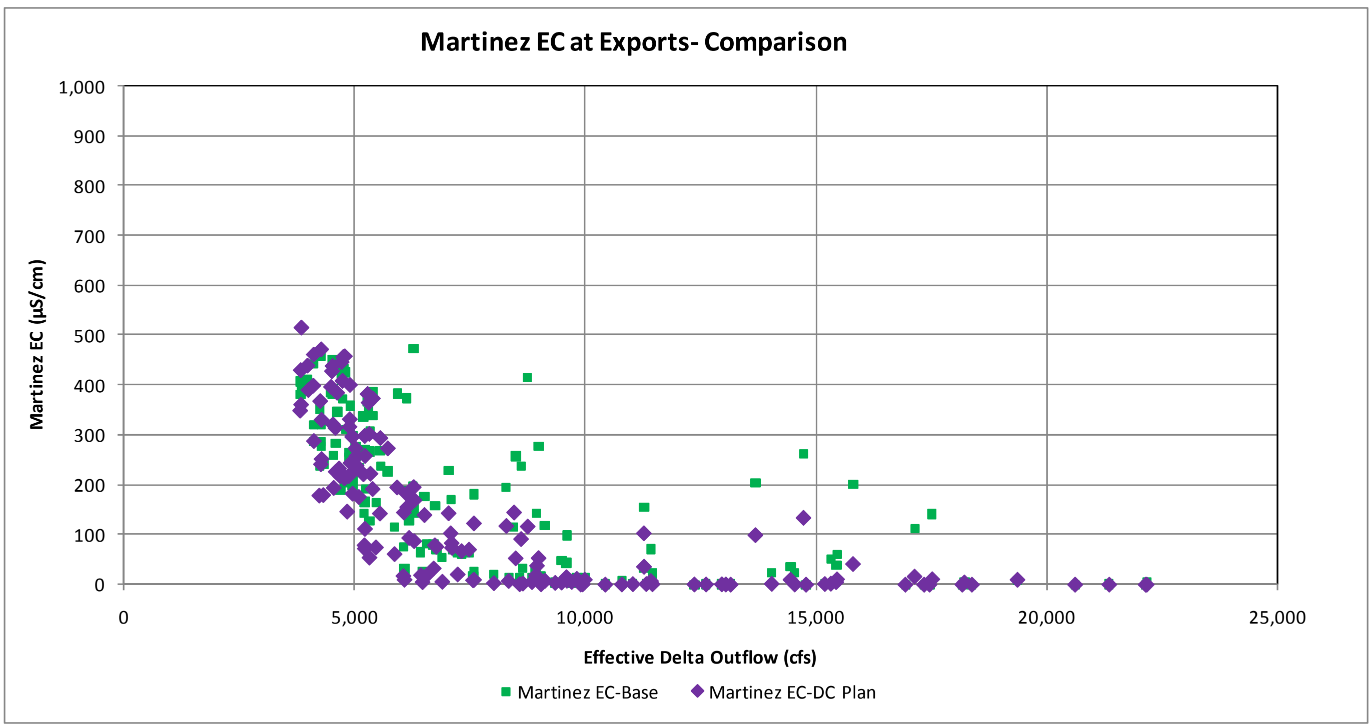
00086.09

ICF Jones & Stokes
an ICF International Company

Figure 17



18a. Comparison of DSM2-Simulated Martinez EC at the Exports (Seawater Intrusion) for the Existing Conditions and with the DC Plan for WY 1976–1991



18b. Relationship between DSM2-Simulated Martinez EC at the Exports and Effective Delta Outflow (G-model) for the Existing Conditions and the DC Plan

00086.09

ICF Jones & Stokes
an ICF International Company

Figure 18

The maximum seawater intrusion EC with the DC Plan was similar to existing conditions, but the seawater intrusion EC was flushed out more rapidly when Sacramento River flow increased with the DC Plan. The Martinez EC source values for the DC Plan simulation are therefore closer to the estimated monthly relationship with effective outflow.

Seawater Intrusion with Higher Outflows

Seawater intrusion at the exports could be reduced substantially if the minimum Delta outflow were increased (the D-1641 minimum outflow is 3,000 cfs in September). A considerable reduction in the export EC and salt load could be achieved by reducing export pumping by 500 cfs or 1,000 cfs in a few months each year to increase the lowest Delta outflows (to more than 3,000 cfs). This would be an effective approach for reducing seawater intrusion with the existing Delta configuration, and would be even more effective with the DC Plan (because of the more rapid EC flushing when the Sacramento River flow increases and the DCC is open).

Table 6 indicates the volume of export reductions needed during the 1976–1991 period to increase the minimum Delta outflow from 3,000 cfs to 3,500 cfs or to a higher minimum outflow value. These salt reduction estimates were based on the DSM2 simulation of the DC Plan. A minimum Delta outflow was selected, and the monthly outflows were increased (by reducing exports) to this specified minimum. The reduced pumping was calculated for each year, and the monthly predictive equation (shown above) for the Martinez source EC at the exports was used to estimate the salt load reduction that would be achieved with the DC Plan for each year. A monthly reduction in exports was assumed to increase Delta outflow and to reduce (or eliminate) the reverse SJR flow at Bradford by the same amount.

Table 6 indicates that the amount of outflow adjustment (thousand acre-feet per year [taf/yr]) would vary from year to year, and the reduction in seawater intrusion salt load (tons/yr) at the exports would vary accordingly. The benefit of the export reduction for controlling the combined export salt load might be judged by comparing the percentage of the water supply reduced and the percentage of the seawater salt load reduced. Because this export reduction would be in months with the highest export EC, the salt load reduction would be greater than the water supply reduction. For example, adjusting the minimum Delta outflow from 3,000 cfs to 3,500 cfs would require an average of 10 taf/yr, which is 0.2% of the existing conditions average export of 5,109 taf/yr. The exports would be reduced by this same amount. The calculated reduction in the salt load from seawater intrusion was about 12,720 tons/yr, which is 2.3% of the simulated combined export salt load of 564,131 tons/yr for the DC Plan with the existing conditions pumping and outflow sequence.

The 4,000 cfs–minimum outflow case would reduce the exports by an average of 28 taf/yr (0.6%), and would reduce the DC Plan seawater intrusion salt load by about 36,000 tons/yr (6%). The 4,500 cfs–minimum outflow case would reduce the exports by an average of 85 taf/yr (1.7%) and would reduce the seawater intrusion salt load by about 103,000 tons/yr (18%). The 5,000 cfs–minimum outflow case would reduce the exports by an average of 182 taf/y (3.6%) and would reduce the salt load by about 200,000 tons/yr (35%).

A considerable reduction in the combined exports salt load could be achieved for a relatively small percentage change in total exports. Each 1% reduction in exports (50 taf/yr) during the lowest outflow months would reduce the existing conditions seawater intrusion salt load by about 10% (50,000 tons/yr) with the DC Plan. These estimated effects should be confirmed with DSM2 simulations of these adjusted exports and outflow sequences. The simulated reductions in seawater intrusion with the DC Plan would likely be greater than for the existing conditions, because the DC Plan provides a more rapid response to changes in Delta outflow because of the separation of Old and Middle Rivers and the increased flushing of the central and south Delta as the Sacramento River flow increases. Increased outflow also may provide benefits for fish habitat conditions.

Other Potential Changes in Delta Operations

This report has described the salinity effects from the DC Plan without any changes in the Delta operations. The simulated exports and outflows meet all D-1641 objectives and with some additional measures could avoid water quality degradation in the south and central Delta. The seawater intrusion effects have been shown to depend strongly on relatively low Delta outflow. The possibility of increasing the minimum Delta outflow to reduce seawater intrusion has been described in the previous section. The DC Plan might allow other changes in the existing Delta operations (D-1641 objectives) to be considered. These should be investigated with additional studies.

For example, the Vernalis Adaptive Management Plan (VAMP) export restrictions in April and May are made to protect SJR Chinook salmon from export entrainment. Because the DC Plan will separate the SJR flow and fish from export entrainment, the VAMP export restrictions should no longer be necessary.

The recently imposed reverse Old and Middle River (OMR) flow limits might be reconsidered if the DC Plan were implemented, because the connection (tidal transport or movement) between the estuary fish habitat and the exports should be greatly reduced. Because fish screens at DCC and Georgiana Slough would reduce the fraction of the Sacramento fish that are diverted into the central Delta, the export entrainment of Chinook salmon and steelhead should be greatly reduced. It is possible that higher exports during the January–June period of OMR restrictions could be allowed with the DC Plan (without increasing fish entrainment). The DC Plan may provide sufficient reduction in the entrainment of SJR, Sacramento River, and estuary spawning fish to allow higher SWP exports during periods of high inflow. The DC Plan would increase the effectiveness of any future DMC recirculation actions (i.e., releasing DMC water to increase SJR flow and reduce SJR EC), because the DMC EC would be lower (30% less in April–August) and less DMC water would be needed to provide any needed salinity reduction in the SJR. New Melones Reservoir releases or DMC releases still may be required during periods of low SJR flows. Although not included in the modeling comparison, the SJR EC at Vernalis likely would be lower with the DC Plan because the irrigation water supplied from the DMC would have a lower EC. Drainage EC from these irrigated lands to the SJR should therefore be lower (over time). More investigation of the fraction of the SJR excess salinity that originates from the DMC water would allow this future Vernalis EC reduction to be better estimated.

The DC Plan would improve Delta operations following a major earthquake with multiple levee failures, as described in the DWR Delta Risk Management Strategy (DWR 2009b). The DC Plan would allow the levees on the four islands separating Old and Middle Rivers (i.e., Victoria, Woodward, Bacon, and Mandeville) to be repaired as the first priority following a multiple levee failure. Once the levees separating Old and Middle Rivers were repaired, the Sacramento River diversions into the Middle River corridor would rapidly flush the salinity out the Middle River corridor (to Old River at the Victoria Canal box culvert) and allow full exports to resume. Increased salinity along the Old River–estuary corridor would not limit exports. The DC Plan would allow the SJR inflows to be exported (after the pumps and canals were inspected and repaired) following a major levee failure because the Old and Middle River corridors could be temporarily closed at the Victoria Canal box culvert, isolating the export of the SJR water from any seawater intrusion or levee breach salinity effects.

Potential Delta Corridors Plan Fish Benefits

This study has evaluated the salinity benefits from the DC Plan by comparing the DSM2-simulated EC at the exports and along the SJR–estuary corridor for the existing conditions (D-1641) and with the DC Plan channel configuration. The salinity benefits from the DC Plan would be substantial, and the DC Plan should be seriously considered as an interim or permanent Delta configuration because of these major improvements in the export and south and central Delta EC.

The DC Plan also may provide substantial fish benefits that should be considered and further evaluated. Other improvements for Delta flood control and habitat restoration also should be considered and evaluated (SDWA 2006, Delta Vision 2008). The DC Plan has several features to improve fish habitat and reduce the fish entrainment impacts that are observed under existing conditions at the CVP and SWP export pumps. The basic fish features in the DC Plan are described briefly in this final section of the report to allow these potential fish benefits to be considered. Further evaluation of these potential fish benefits is needed. The basic fish features of the DC Plan are:

1. The DC Plan would separate the entire SJR flow from the CVP and SWP pumping and would eliminate entrainment (i.e., salvage and loss) of migrating SJR fish. This would allow all SJR fall-run Chinook salmon, and the proposed-to-be-restored spring-run Chinook salmon juveniles to migrate

to the estuary without any risk of CVP or SWP entrainment losses. Migrating SJR steelhead and splittail (in wet years) also would be fully protected from entrainment losses. Upstream migrating adult Chinook salmon would more easily detect the (entire) SJR flow leaving Franks Tract and migrate upstream in Old River to the SJR and tributaries.

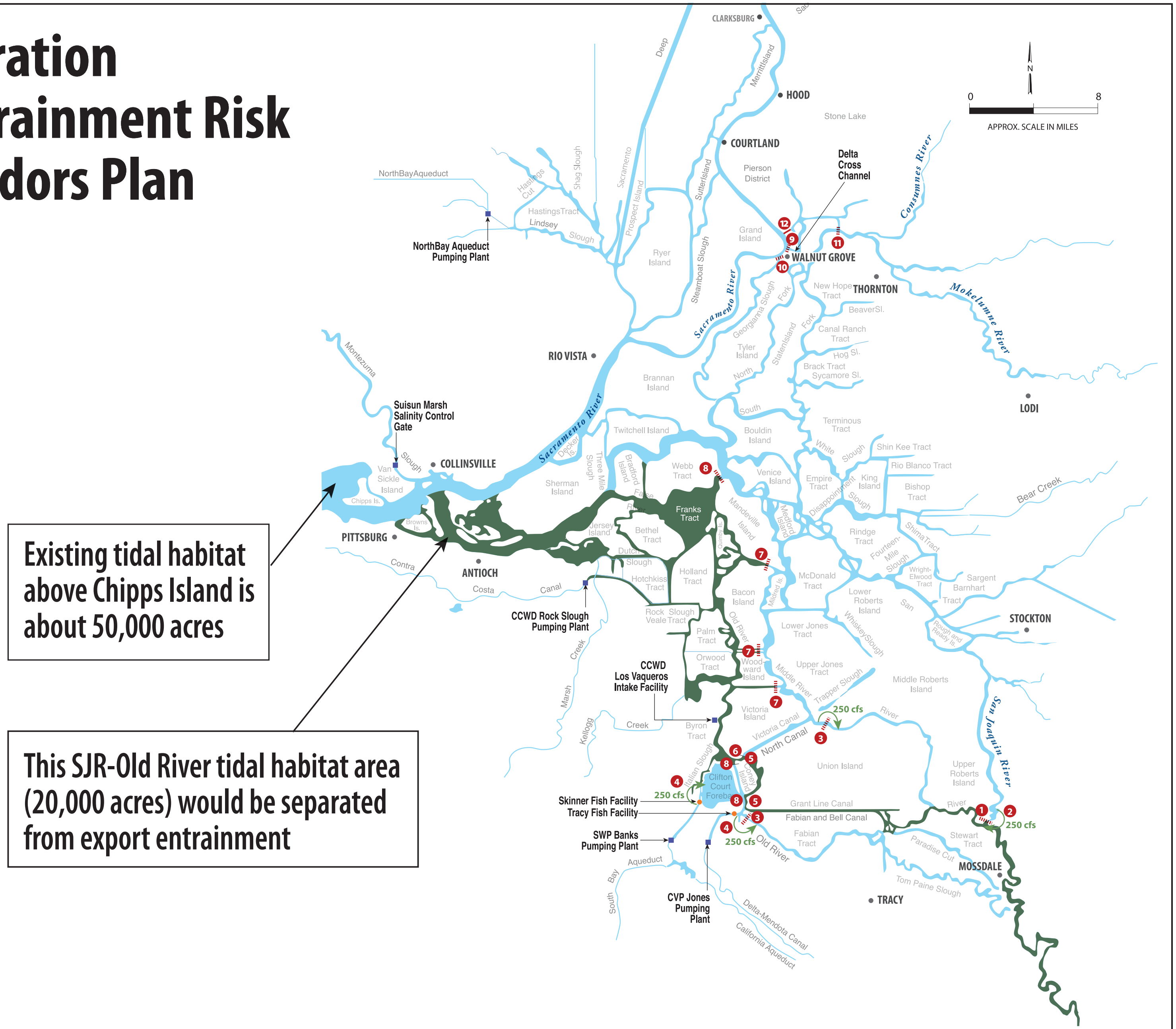
2. The separation of the SJR–estuary corridor along Old River, Grant Line Canal, Franks Tract, and the lower San Joaquin would separate about 20,000 acres of tidal channel habitat upstream of the confluence (with 5,000 acres upstream of Franks Track) from entrainment risk at the SWP or CVP pumps. This would remove the existing entrainment risk from about 40% of the habitat area upstream of Chipps Island (total habitat of 50,000 acres) and allow delta smelt spawning and rearing in these separated channels, without any entrainment losses of adult or juvenile fish. Map 7 illustrates the protection of the SJR–estuary corridor tidal habitat from entrainment risk at the CVP or SWP pumps.

3. A fish-friendly pump with a capacity of 250 cfs would provide a dilution flow from the Stockton DWSC into the head of Old River near Lathrop. Any fish in this dilution flow would be discharged without harm into the SJR–estuary corridor. Similar low-head pumps are being used at the Banta-Carbona fish screen near Vernalis, and at the Red Bluff Diversion Dam to supply water to the Tehama-Colusa Canal. A fish ladder (or gate opening) may be needed to allow movement of larger fish from the DWSC upstream to the SJR and tributaries. Because the SJR algae and the treated wastewater discharge from Stockton no longer would flow into the DWSC, the historical episodes of low dissolved oxygen (DO) in the Stockton DWSC no longer would occur with the DC Plan.

4. The Tracy fish facility would be modified to divert the primary fish louver bypass flow of 250 cfs to Old River upstream of the tidal gate with another fish-friendly pump. This would improve the survival of fish separated with the primary louvers, avoiding fish losses at the secondary louvers and losses from holding, handling, trucking, and release operations. For example, if the primary and secondary louvers each have an efficiency of 50%, only about 25% of the fish would be salvaged under existing conditions. Diverting the primary louver bypass flow would allow 50% of the fish to be discharged to Old River and the SJR–estuary corridor. Fish survival would be doubled with the DC Plan (from 25% to 50% survival) for this example. The fish survival improvement would be less if the louver efficiency was higher, and would be only 9% if the louver efficiency was 90%. This also would eliminate the fish salvage capacity limits that are encountered when more fish or debris enter the facility than can be handled effectively in the holding tanks. The secondary fish louvers and the holding tank operations would be discontinued.

5. Rock barriers or walls would be constructed on Woodward Canal, Santa Fe Canal, and Connection Slough. The barriers could be located near the east end of each channel to increase the fish habitat connected with the SJR–estuary corridor. These 2-mile-long tidal sloughs (75 acres each) would have strong tidal exchange and may provide good delta smelt spawning and rearing habitat.

Habitat Separation from Fish Entrainment Risk—Delta Corridors Plan



Graphics\Projects\ 00086.09 Delta Corridors/(08-09) SS

ICF Jones & Stokes
an ICF International Company

Map 7
Changes in Fish Habitat Protection with the Delta Corridors Plan

6. A rock barrier or wall placed across the mouth of Old River would fully isolate the existing Franks Tract aquatic habitat from CVP or SWP entrainment risk. A considerable portion of the suspended sediment (i.e., turbidity) from the SJR inflow may reach Franks Tract and by limiting the available light may reduce the existing coverage of water weed beds Additional habitat improvements may be possible within Franks Tract once it is separated from the water supply corridor.

7. The Skinner fish facility would be modified to divert the primary fish louver bypass flow of 250 cfs to Italian Slough and the SJR–estuary corridor. This would avoid fish losses at the secondary louvers and from holding, handling, trucking, and release operations. The operations of the Skinner (and Tracy) fish facilities might be improved once the water supply corridor is separated from the SJR inflow because a substantial portion of the fish and debris originates from the SJR. The louvers (1-inch openings) might be replaced with smaller-opening screens, or secondary fish screens or nets might be installed downstream of the louvers during periods when small fish are present in the water supply corridor. A rock levee along the south end of CCF could be constructed to provide a direct route from the CCF gates to the Skinner fish facility when Banks pumps are operating to reduce the potentially high predation losses in CCF. New fish-counting procedures would be required to monitor fish in the primary louver bypass flows.

8. A new fish screen facility might be considered at the southern end of Victoria Canal just upstream of the SJR–estuary corridor crossing. This would allow all fish in the water supply corridor to be screened and immediately discharged to Old River and the SJR–estuary corridor. If this design were adopted, the new fish screen facility would replace the Tracy and Skinner fish facilities.

9. Both the DCC and Georgiana Slough would have in-river fish screens to separate the migrating Sacramento River fish from the water supply diversions. Each of these screens would be about 2,000 feet long and 15 feet high, with bottom and surface panels to reduce the number of fish encountering the screens and limit the amount of bottom sediment (sand) and floating debris. These fish screens would be operated throughout the tidal cycle, with several weir gates (between the screens and the levee bank) to maintain a uniform approach velocity of less than 0.25 ft/sec to reduce impingement of small fish. These screens would protect migrating Chinook salmon and other Sacramento fish from higher predation that is assumed to occur within the central Delta. One panel on each screen could be opened in the summer and fall to allow upstream migrating Chinook salmon (and other fish) to move upstream from the Mokelumne channels to the Sacramento River. These fish screens would be no larger than the fish screens planned for the proposed peripheral canal intake of 15,000 cfs. If nonstructural barriers (e.g., acoustics, lights, bubbles) prove more effective than physical screens, these techniques could be used to increase fish avoidance of the screens or might replace the physical screens.

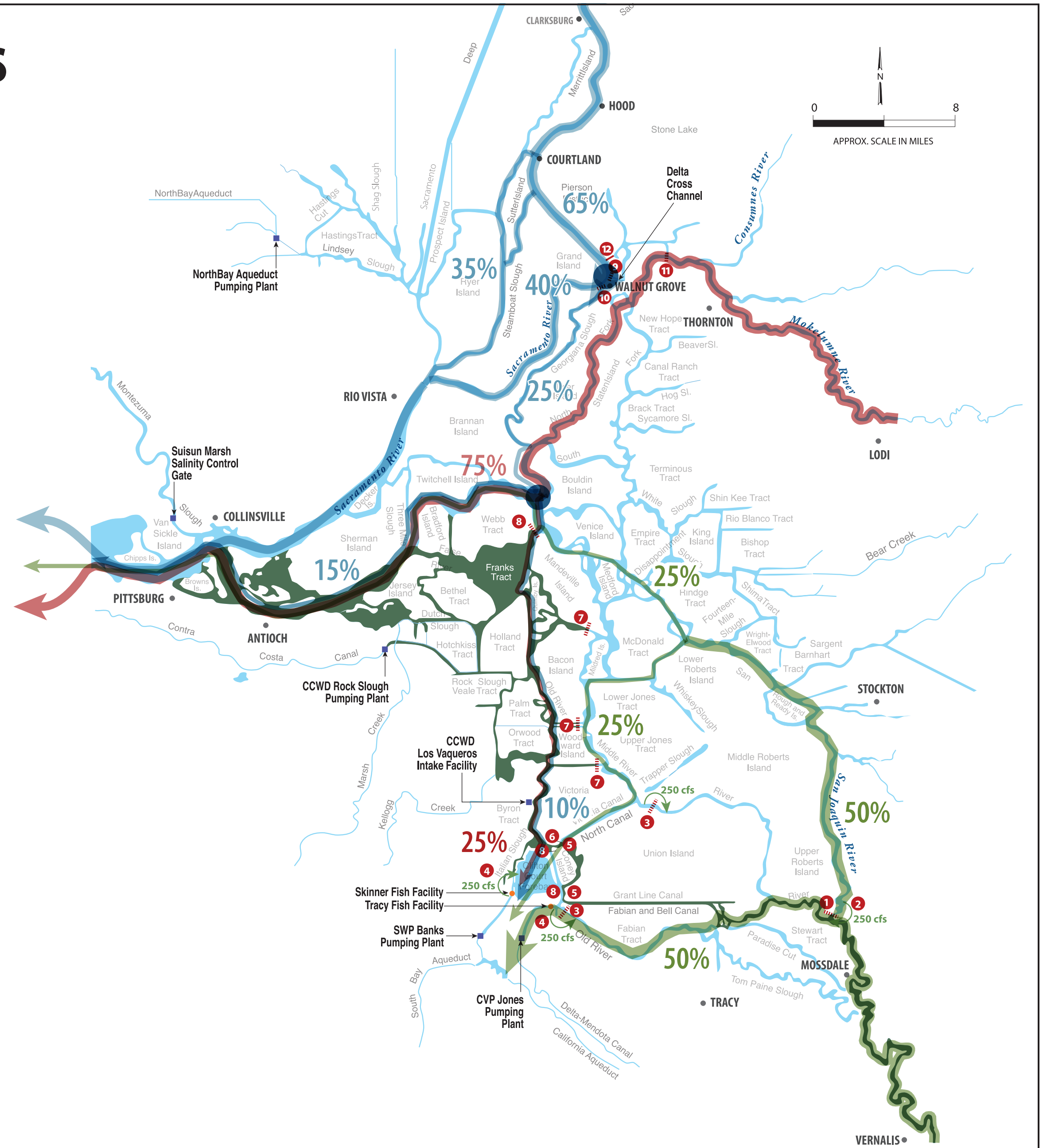
10. The Mokelumne River channel would be routed from Thornton to the Sacramento River above Walnut Grove to reduce the predation losses and entrainment of migrating Mokelumne and Cosumnes River fish that otherwise would enter the water supply corridor. A river gate would divert the Mokelumne River flow into Middle Slough (at the upstream end of McCormack-Williamson Tract), Snodgrass Slough, and The Meadows Slough, and a river gate through the Sacramento River levee about 1 mile north of Walnut Grove would connect the Mokelumne River to the Sacramento River. The gate at Middle Slough would open and the river gate at the Sacramento River levee would close when the Mokelumne River flow reached 5,000 cfs or when the average daily elevation of the Sacramento River at Walnut Grove (DCC) reached about 5 feet msl (50,000 cfs). The downstream migration survival for the Mokelumne River Chinook salmon and steelhead should be improved. The fish abundance (i.e., spawning and rearing use) and productivity of the floodplain and tidal habitat areas along the Cosumnes River might be improved with this direct connection to the Sacramento River. Adult migrants should more easily locate the Mokelumne River outflow to the Sacramento River with this connection.

The DC Plan has several features that would reduce the entrainment of fish at the Tracy and Skinner fish facilities. The DC Plan will eliminate the entrainment of all SJR migrating fish, and will greatly reduce the diversion of migrating Sacramento River fish into the central Delta. Estimating the increased survival for these migrating fish with the DC Plan should be feasible. Map 8 illustrates the migration pathways for Sacramento River, SJR, and Mokelumne River fish under existing conditions. A considerable portion of the fish on these existing migration pathways may be entrained (or salvaged) at the CVP or SWP export pumps. Map 9 compares the fish migration pathways with the DC Plan channel configuration. A major portion of the fish on each of these migration pathways would be protected from entrainment (or salvage).

The potential effects of the DC Plan on adult delta smelt survival are more difficult to evaluate. Estimating how many adult delta smelt enter the SJR channels (active migration or passive tidal transport), and determining how many would spawn in the SJR–estuary corridor between the confluence and Franks Tract or upstream in Old River, is uncertain. Only adult delta smelt that move upstream in the SJR past Bradford Island or from the Sacramento River through Threemile Slough to the water supply corridor would be vulnerable to entrainment at the CVP or SWP pumps with the DC Plan. Additional salinity measures such as increased outflow to reduce seawater intrusion or increased dilution flows in Old River also may improve delta smelt habitat conditions.

Other changes in Delta fish habitat conditions, and potential changes in the distribution and abundance of fish within the Delta that might be influenced by the DC Plan, can only be generally imagined and described. For example, turbidity along the SJR–estuary corridor should remain relatively high, providing more suitable habitat conditions for adult delta smelt (e.g., predation avoidance) and juvenile delta smelt (e.g., feeding). More of the SJR phytoplankton and zooplankton may be available for juvenile fish feeding along the SJR–estuary

Fish Migration Pathways —Existing Conditions

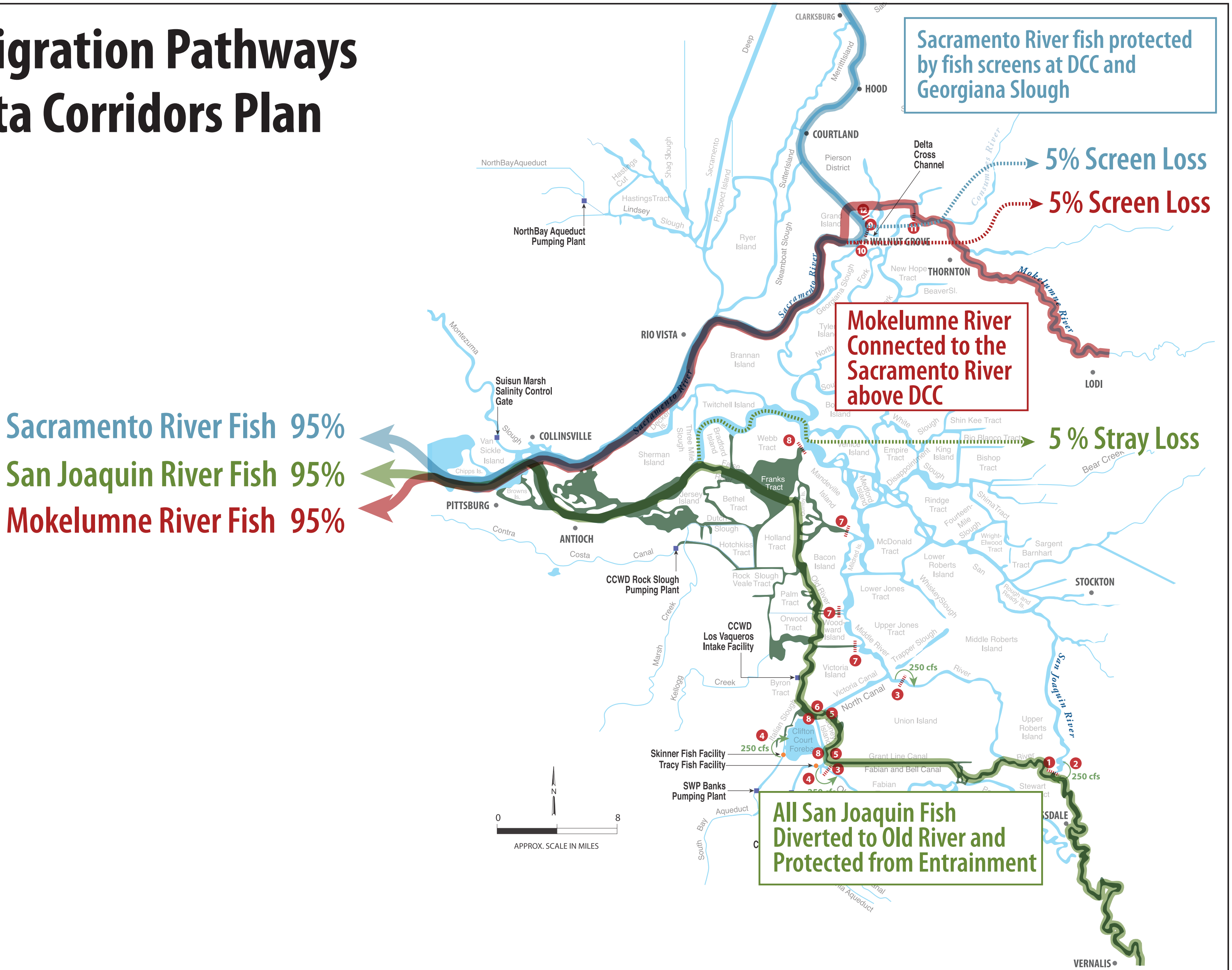


Graphics\Projects\ 00086.09 Delta Corridors/(08-09) SS

ICF Jones & Stokes
an ICF International Company

Map 8
Migration Pathways for Sacramento, San Joaquin, and Mokelumne Fish with Existing Conditions

Fish Migration Pathways —Delta Corridors Plan



Graphics\Projects\00086.09 Delta Corridors/(08-09) SS

Map 9
Migration Pathways for Sacramento, San Joaquin, and Mokelumne Fish with the Delta Corridors Plan

corridor. More investigation and evaluation of the possible fish effects of the DC Plan are needed.

Pilot Testing and Implementation

Several of the DC Plan features might be implemented rapidly as interim measures that could be tested and evaluated for salinity improvements and for fish habitat and survival benefits. The Two-Gate Project, proposed by Metropolitan Water District (MWD) and Reclamation, would be a good initial step to partially separate the Old River and Middle River corridors. However, the gates probably need to be closed during flood tides (or more of the time) to prevent upstream movement of adult delta smelt toward the CVP and SWP export pumps. The Threemile Slough tidal gate project, proposed by DWR, would allow improvements in SJR salinity intrusion during periods of low Delta outflow and might provide some reduction in adult and juvenile delta smelt transport between the Sacramento and the San Joaquin channels. However, the operation of tidal gates to control fish transport requires that the fish abundance (density) upstream and downstream of the gates be monitored. The physical separation of Old and Middle Rivers would not require monitoring to control gate operations (they remain closed), and the resulting fish movement or fish protection benefits would be detected more easily with comparative abundance measurements.

The fish screens at DCC and Georgiana Slough could be tested as a pilot demonstration. A pilot screen facility might be constructed and evaluated with specific fish monitoring procedures, including underwater cameras (video and acoustic imaging). A 250-foot section of fish screen might be installed and tested at Georgiana Slough. A flat-plate fish screen might be combined with a bubble-curtain or with acoustic and light barriers (similar to the 2009 head of Old River barrier installed by DWR) to improve fish avoidance of the in-river screens.

The Mokelumne River and Cosumnes River connection to the Sacramento River could be implemented independently of other DC Plan features. This feature could be tested during the spring when the DCC is usually closed. For this demonstration test, the North Fork and South Fork Mokelumne channels would be blocked (with panels on the Walnut Grove bridges), and the Mokelumne River would flow to the Sacramento River through the DCC. The survival of Chinook salmon (coded-wire-tagged [CWT] or acoustic tags) released during the demonstration could be compared to previous CWT recovery rates.

The DC Plan would provide about 40% of the salinity reduction that could be provided by the full Peripheral Canal (with no south Delta pumping). This could be demonstrated during the fall months (with reduced agricultural diversions) with a temporary barrier in the SJR at the head of Old River, and temporary barriers between Old and Middle Rivers (using a simple “pilings with panels” design). The mouth of Old River barrier would not be necessary for this demonstration, as long as the SJR flow at Bradford Island remained positive. Moderate export pumping of about 5,000 cfs should be possible without dredging

Victoria Canal. A temporary river crossing (box culvert) at Victoria Canal and barrier at the north end of West Canal also would be needed to demonstrate the reduced salinity from the separation of the SJR from the exports. An SJR flow of at least 1,500 cfs may be needed to provide sufficient flows for diversions along the SJR–estuary corridor. Boat locks or other boat passage facilities would be installed as part of the DC Plan features (gates and barriers). These boat passage facilities should be installed and tested as part of these pilot demonstrations.

The full separation of the SJR flow from the water supply corridor and export entrainment would require all of the DC Plan features to be implemented as a complete package. Dredging of Victoria Canal will be needed for full export pumping. However, the DC Plan features would be constructed using a modular design that could be easily modified or removed based on operational performance. This report demonstrates that the DC Plan would have substantial salinity-reduction benefits, and the potential fish habitat and fish survival benefits are sufficiently large to be given increased attention and discussion. The DC Plan should be more actively described and receive more serious consideration and continued evaluation by the BDCP planning groups and by other Delta resource managers and Delta stakeholders.

The DC Plan components should be tested and demonstrated as soon as possible and, if found to be beneficial for salinity and fish protection, should be installed permanently and operated as the future Delta configuration, or perhaps as the in-Delta components of the proposed BDCP Dual-Conveyance. The costs for the DC Plan components are likely to be much less than the Peripheral Canal construction costs, and the implementation schedule for the DC Plan components is likely to be much shorter than the construction schedule for the Peripheral Canal. The DC Plan changes in salinity and fish entrainment are large enough to be observable; the sooner the DC Plan is implemented, the sooner these salinity and estuary fish benefits will be realized.

References

Bay-Delta Conservation Plan (BDCP). 2009. Bay Delta Conservation Plan Draft Conservation Strategy. Available: http://resources.ca.gov/bdcp

California Department of Water Resources (DWR). 2005. South Delta Improvements Program draft environmental impact report/environmental impact statement. Available: http://baydeltaoffice.water.ca.gov/sdb/sdip/documents/draft_eis_eir.cfm

———. 2009a. Delta Modeling Section. Delta Simulation Model II. Available: http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/index.cfm

———. 2009b. Delta Risk Management Strategy Final Phase 1 Report. Available: http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp

Contra Costa Water District (CCWD). 2007. Trends in hydrology and salinity in Suisun Bay and the western Delta. Available: http://www.ccwater.com/salinity/HistoricalSalinity.pdf

Delta Vision. 2008. Delta Vision Strategic Plan. Available: http://www.deltavision.ca.gov

Jones & Stokes. 2007. Tidal hydraulics modeling (DSM2) of the Delta Corridors Plan. November. (J&S 00881.07) Sacramento CA. Prepared for the South Delta Water Agency and Central Delta Water Agency. Available: http://www.DeltaCorridors.com

Public Policy Institute of California. 2008. Comparing Futures for the Sacramento-San Joaquin Delta. Authors: Jay Lund, Ellen Hanak, William Fleenor, William Bennett, Richard Howitt, Jeffrey Mount, and Peter Moyle. Available: http://www.ppic.org

South Delta Water Agency. 2007. A comprehensive flood conveyance and ecosystem restoration plan for the south Delta. Available: http://www.deltavision.ca.gov/BlueRibbonTaskForce/Oct2007/Handouts/Item_7_Attachment_2.pdf