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Department of Water Resources
Bay-Delta Office

METHODOLOGY FOR FLOW AND SALINITY ESTIMATES IN THE SACRAMENTO-SAN JOAQUIN DELTA AND SUISUN MARSH

TWENTY-SEVENTH ANNUAL PROGRESS REPORT TO THE STATE WATER RESOURCES CONTROL BOARD
in Accordance with Water Right Decisions 1485 and 1641

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Governor
State of California

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Secretary for Resources
The Resources Agency

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FOREWORD

This is the 27th annual progress report of the California Department of Water Resources' San Francisco Bay-Delta Evaluation Program, which is carried out by the Delta Modeling Section. This report is submitted annually by the Section to the California State Water Resources Control Board pursuant to its Water Right Decision 1485, Term 9, which is still active pursuant to its Water Right Decision 1641, Term 8.

This report documents progress in the development and enhancement of the Bay-Delta Office's Delta Modeling Section's computer models and reports the latest findings of studies conducted as part of the program. This report also includes contributions related to field work conducted by the Division of Planning and Local Assistance's Central District Special Studies Section that could be used to answer questions similar to those that are often directed to the numerical models also described here. This report was compiled by Michael Mierzwa, with assistance from Jane Schafer-Kramer and Wanda Headrick under the direction of Bob Suits, Senior Engineer, and Tara Smith, program manager for the Bay-Delta Evaluation Program.

Online versions of previous annual progress reports are available at:

http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/annualreports.cfm

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1 Introduction

Over the past 13 years, the Delta Modeling Section of the California Department of Water Resources' Bay-Delta Office has been developing and enhancing the Delta Simulation Model Version 2 (DSM2), the tools used to support DSM2 modeling, and other Delta flow and water quality estimation tools. The following are brief summaries of work that was conducted during the past year. The names of contributing authors are in parentheses.

Chapter 2 – Sacramento Deep Water Ship Channel Flow Monitoring

In support of the Sacramento Deep Water Ship Channel Fish Passage Facilities Project, the Department's Division of Planning and Local Assistance Central District Special Studies Section conducted a series of flow measurement studies near the boat lock of the Sacramento Deep Water Ship Channel in order to determine the flow of water leaking through the closed and opened boat locks. Although at present DSM2 does not simulate a lock structure at the end of the Sacramento Deep Water Ship Channel, this chapter represents the findings of the field studies in order to document the significance of the flows through the locks and to serve as a starting point for any future modeling effort concerning this particular area. (*Shawn Mayr*)

Chapter 3 – Developing a Residence Time Index to Study Changes in 1990 – 2004 Delta Circulation Patterns

In order to address questions related to the 2001-2004 decline in pelagic organism populations in the Delta, DSM2-PTM was used to calculate a daily residence time index. This index is based on the length of time groups of particles take to travel from the Delta inflow boundaries to various exit locations. Each daily resident time index is unique to a specific injection location and represents the cumulative hydrologic influences during the entire time it takes for these particles to exit Delta channels. This chapter focuses on the methodology used to create these indexes. (*Michael Mierzwa, Jim Wilde, Bob Suits, and Ted Sommer*)

Chapter 4 – Using Volumetric Fingerprinting to Study Sources of Salinity in the South Delta

In order to study the sources of water at locations in the south Delta for which SWRCB water quality standards exist to protect agriculture, a series of fingerprint simulations were conducted using hypothetical variations on historical hydrology and operations. This investigation examines the extent the San Joaquin River has historically been a source of water at these locations and how this contribution may be affected by State Water Project (SWP) operations and the installation of temporary barriers. (*Bob Suits*)

Chapter 5 –A Relationship between Vernalis and Brandt Bridge Electrical Conductivity

A relationship between the measured electrical conductivity in the San Joaquin River (SJR) at Vernalis and Brandt Bridge has been developed to estimate maximum allowable San Joaquin River electrical conductivity (EC) at Vernalis to ensure meeting the Brandt Bridge EC standard. The relationship was based on monthly-averaged EC data measured by the Department of Water Resources and the US Bureau of Reclamation at Vernalis, Mossdale, and Brandt Bridge over the period of 1994 through 2002. This analysis also focuses on establishing confidence intervals for these predictions. (*Bijaya Shrestha and Parviz Nader-Tehrani*)

Chapter 6 – Using DSM2 to Develop Operation Strategies for South Delta Improvements Program's Proposed Permanent Gates

An important component of the South Delta Improvement Plan (SDIP) is the proposed installation and management of several permanent operable gates. Designed to replace the current South Delta temporary rock barriers, these new structures can provide the operational flexibility to both improve conditions in the south Delta for irrigation and protect fish in the San Joaquin River. In order to evaluate the possible effects of the operation of the proposed gates, a reasonable strategy for gate operation needed to be developed for use in DSM2 simulations of Delta conditions. This chapter discusses the development of such strategies that are based on Delta hydrology, target minimum water levels, and average flows in key south Delta channels. (*Bijaya Shrestha and Parviz Nader-Tehrani*)

Chapter 7 – Estimates for Consumptive Water Demands in the Delta Using DETAW

DWR's Modeling Support Branch currently uses two models to estimate consumptive use in the Delta. These models both estimate land use acreage and calculate crop water needs in the Delta based upon crop types and meteorological data. However, due to differences in level of detail and independent formulation of water needs, the two models may not agree on estimates of historical conditions. The results of the Consumptive Use model, the more coarser of the models, are used by CALSIM II and consist of the total net water use for the Delta broken down by Delta uplands and lowlands. The Consumptive Use model is used to estimate both historical and projected conditions for planning studies. The Delta Island Consumptive Use model is used by DSM2 and first calculates water use and agricultural drainage for each island, then distributes these flows to individual DSM2 nodes. A third model, the Adjusted Delta Island Consumptive Use model, distributes net Delta water use estimated by the Consumptive Use model to DSM2 nodes for use in CALSIM-based DSM2 long-term planning studies. In order to unify estimates of Delta consumptive use, add important enhancements, and improve documentation, DWR and UC Davis have collaboratively developed a new model, DETAW. This chapter summarizes the key features of DETAW. (*Tariq Khadir*)

Chapter 8 – Priority 3 Clifton Court Forebay Gate Operations for Extended Planning Studies

DSM2 is being used to simulate hydrodynamics and water quality in the Delta as part of CALFED Common Assumptions. Hydrology from water years 1922-2003 output from the statewide planning model CALSIM is being used as the input in DSM2 for simulations of Delta conditions over the 82-year planning period. To perform such simulations, an operation schedule for the Clifton Court Forebay gates is needed. The Clifton Court Forebay gates can operate under a number of different schedules, but for the Common Assumptions simulations an operation known as "priority 3" is used to allow sufficient inflow into the Forebay while minimizing the impacts on water levels in adjacent channels. This chapter details the methodology used to generate a priority 3 operation schedule for the Forebay gates and discusses the effect of using the new extended schedule in DSM2. (*Jim Wilde*)

Chapter 9 – DSM2 Simulation of Historical Delta Conditions over the 1975 – 1990 Period

DSM2 can be used to simulate both synthetic and historical flows in the Delta. Historical simulations are important because, in addition to being used in the calibration and validation of models, they can provide estimates of Delta hydrodynamics and water quality to complement limited field data. Currently DSM2 historical simulations have been used to explain circulation patterns, hydrodynamics, and water quality in the Delta for the recent State Water Resources Control Board hearings and the Pelagic Organism Decline work for the period between 1990 and the present. This chapter describes the ongoing work to extend the DSM2 historical simulation of the Delta back to 1975. *(Myint Thein and Parviz Nader-Tehrani)*

Chapter 10 – Using Particle Tracking to Generate Indexes of Fish Entrainment Potential

The particle tracking module of DSM2, DSM2-PTM, was used to study the sensitivity of injection location and operation of the temporary south Delta barriers on the portion of injected particles ending up in Clifton Court Forebay. The DSM2 simulation of historical 2005 Delta hydrodynamics provided the foundation for the particle tracking simulations. The results of this work were incorporated into the 2005 temporary barrier report and are presented in more detail in this chapter. *(Bob Suits)*

Chapter 11 – DSM2 Users Group Update

The DSM2 Users Group is one of three model users groups sponsored by the Bay-Delta Office and California Water and Environmental Modeling forum. Created to bring together the users of DSM2 and DSM2-generated results, the quarterly DSM2 Users Group meetings are well attended. This chapter reviews some of the topics that have been presented to the group the past year, including many topics that have been included in this or previous annual methodology reports. *(Min Yu)*

Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

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Chapter 2: Sacramento Deep Water Ship Channel Flow Monitoring

Author: Shawn Mayr, Special Studies Section, Central District-Division of Planning and Local Assistance

2 Sacramento Deep Water Ship Channel Flow Monitoring

2.1 Introduction

Flow measurement work was performed in the Sacramento Deep Water Ship Channel near the William G. Stone boat lock in West Sacramento in support of the CALFED Sacramento Deep Water Ship Channel Fish Passage Facilities Project. The purpose of the project is to test fish passage concepts that may be applied near Hood, California for a proposed fish screened Thru-Delta Water Facility. Figure 2.1 is a USGS map of the project area showing the launching areas and sampling area located downstream of the boat lock. Closer views of the gates are shown in Figures 2.2 and 2.3. The primary objective was to measure the flow leaking through the closed boat lock.

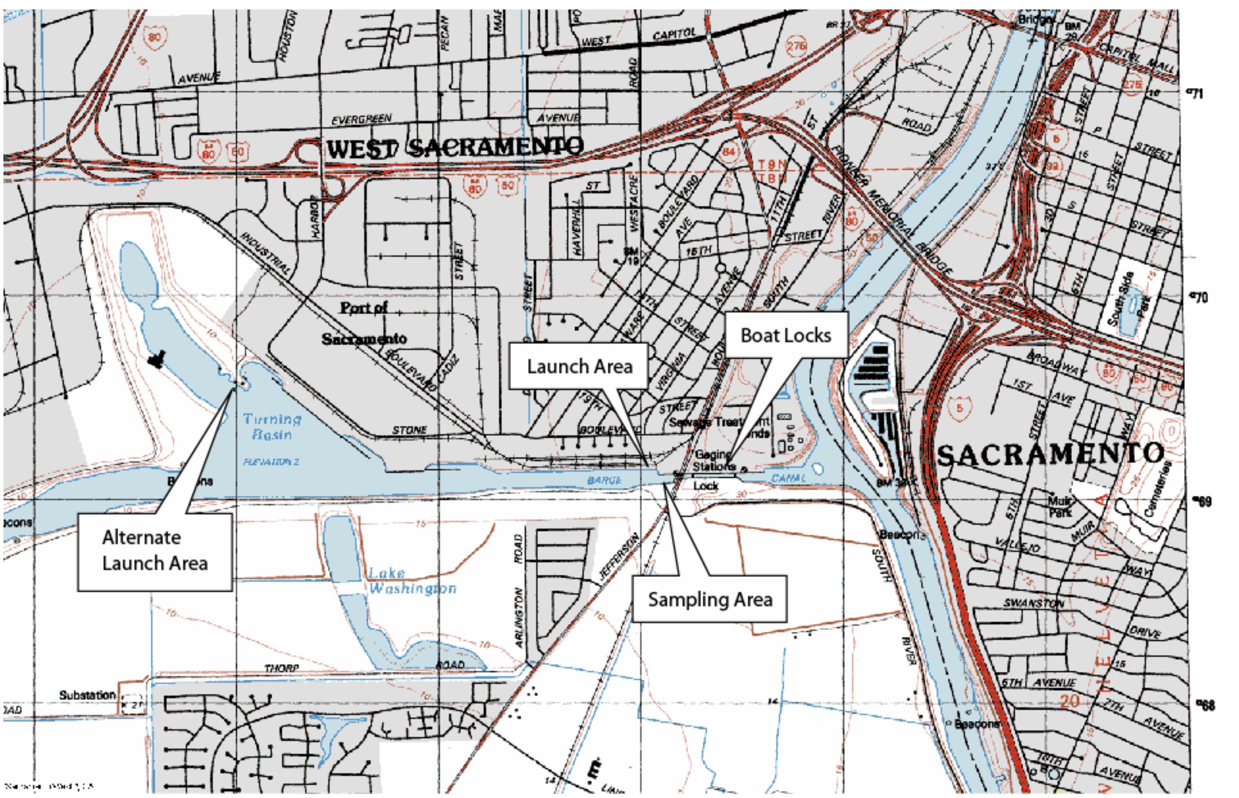
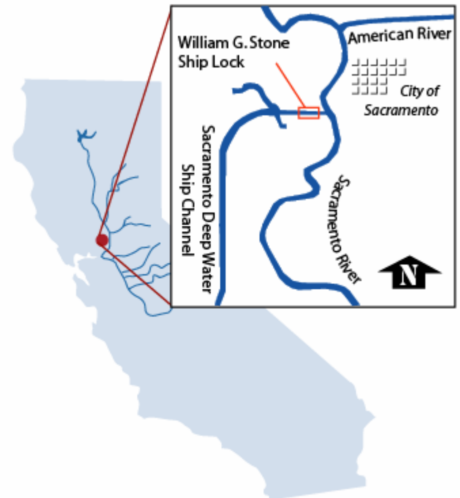


Figure 2.1: USGS quad map of the Sacramento Deep Water Ship Channel study area.

Figure 2.2: Sacramento Deep Water Ship Channel Boat Lock from upstream end near Sacramento River.

Figure 2.3: Water leaking through the closed boat lock.

WILLIAM G. STONE SHIP LOCK



LOCATION: West Sacramento, Yolo County California

WATERWAY(S): Sacramento Deep Water Ship Channel & Sacramento River

COORDINATES: 38°33′40″ N - 121°31′36″ W

DATE OF CONSTRUCTION: 1963

CONSTRUCTED BY: US Army Corps of Engineers

OWNER: City of West Sacramento

STATUS: Decommissioned in mid 1980s, Deauthorized by Federal Govt. in 2000

STRUCTURE TYPE: Gated boat lock

SIZE: 640′ long x 86′ wide x 13′ deep

CONCERNS: Possible impediment to upstream salmon migration

2.2 Methods

The first attempt to measure flow was by the velocity indexing method, considered the state of the art method for monitoring flow in tidal areas. It uses a velocity meter that is permanently anchored at mid depth on one side of a channel. A series of boat-based flow measurements are used to develop a relationship between measured velocity and flow, and this relationship is subsequently used to calculate discharges from the measured velocity. See Ruhl (2005) for more details on this method. Two brands of side-looking Acoustic Doppler Current Profiling (ADCP) velocity meters were installed at three different positions in the channel. Due to the very low velocities at the site, persistently high noise levels, and the non-uniform nature of the flow field, this method was abandoned.

Fortunately, boat-based, downward looking Acoustic Doppler flow measurements proved successful even though some noise or natural fluctuations were present. A series of five separate flow measurements from 2003 to 2005 were used to calibrate a simple water surface level-based model to determine flow. The measured flow location was just downstream (west) of the boat locks, as shown in the sampling area in Figure 2.1. The best fit of observed flow rates proved to be a combination of an orifice flow equation (Equation 2.1) and a vertical slot flow equation (Equation 2.2) developed by Rajaratnam (1992). The ratio of the combination of the orifice flow to vertical slot flow equations was 3:1 (Equation 2.3).

$$Q_{orifice} = AK\sqrt{2g\Delta h} \qquad \text{[Eqn. 2.1]}$$

Where,

A = Area (in ft^2),
K = empirical constant (unitless),
g = gravity (in ft/s^2),
Δh = head difference, $y_0 - y_1$ (in ft),
y_0 = stage upstream of the gate at I Street Bridge (in ft), and
y_1 = stage downstream of the gate (in ft).

$$Q_{vertical\ slot} = \alpha\left(y_0/b_0\right) - \gamma \qquad \text{[Eqn. 2.2]}$$

Where,

α = empirical constant (in cfs),
γ = empirical constant (in cfs), and
b_0 = vertical slot width (in ft).

$$Q = 0.75\ Q_{orifice} + 0.25\ Q_{vertical\ slot} \qquad \text{[Eqn. 2.3]}$$

Equations 2.1 and 2.3 require stage data for the project area, which unfortunately is not currently recorded. Consequently, a relationship for y_1 (Equation 2.4) was created between recorded stage at the Rio Vista Bridge (RVB) site and just downstream of the boat lock to generate the needed stage.

$$y_1 = 1.22x - 0.4438 - 1.75 \qquad \text{[Eqn. 2.4]}$$

Where,

x = stage at RVB (in ft), and
1.75 = empirical number for stage equalization.

An empirical number was used to force the computed stage downstream of the boat lock to equal the I Street Bridge (IST) stage when the measured flow was zero, because it was assumed that at a zero stage difference there is zero flow past the gates.

Water surfaces upstream and downstream of the lock, RVB, and IST sites were used to compute flow rates from May 21, 2003 to June 1, 2004. The flow model combines equations 2.3 and 2.4 to calculate the flow when both gates are closed. In the event one gate is opened, as during a typical operation of the boat lock, the flow rate calculated by the model is increased by a factor of 2. This multiplication factor is based on flow measurements collected when the gates were operated.

2.3 Results

A combination of the orifice flow equation and vertical slot equation provides a flow calculation that accommodates the complicated flow characteristics at the boat lock since it is an open channel flowing into a vertical slot orifice. The model assumes a constant width of the leakage opening when both gates are closed. After several iterations, empirical constants of K = -2.5 in the orifice flow equation and α = 3.77 cfs, b_0 = 1 ft, and γ = -20 cfs in the vertical slot equation proved to be adequate. On May 25, 2003 the gates were operated and the flow calculated by the flow model was adjusted to fit the open gate condition. In Figure 2.4, the measured flow is compared to the calculated flow to show that, within the limits of noise, the model successfully calculates the average flow rate and flow direction.

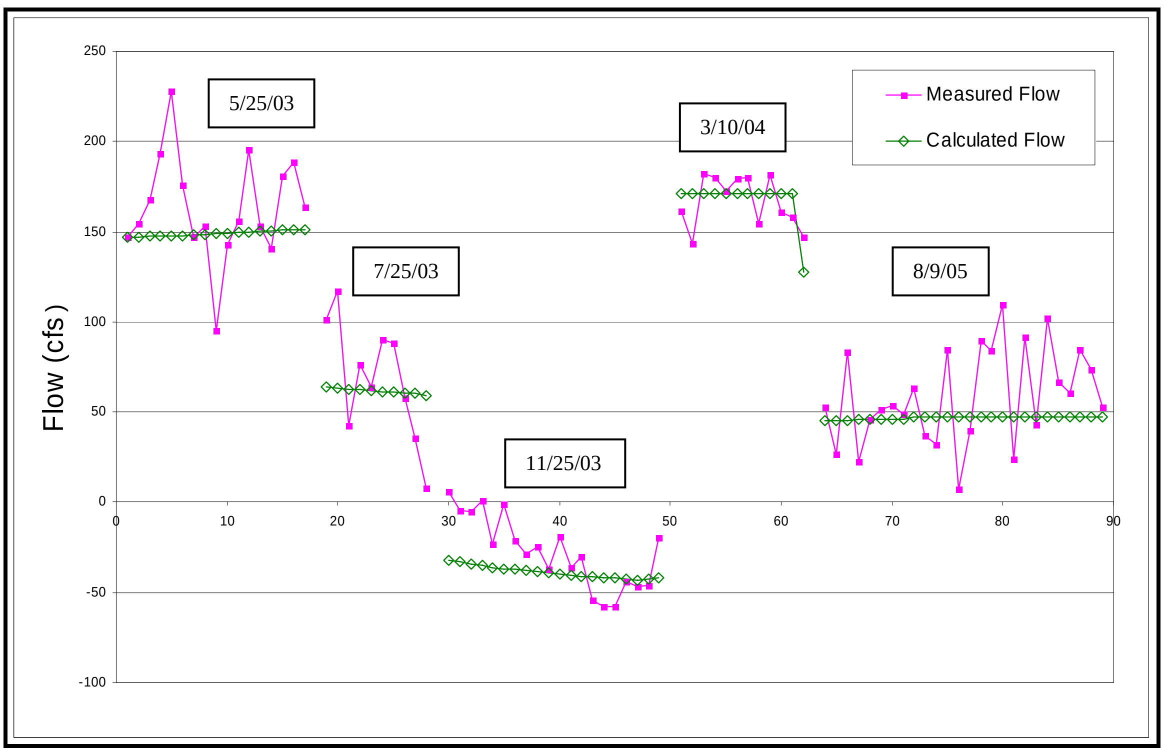


Figure 2.4: Calculated flow vs. measured flow just downstream of the locks.

2.4 Conclusions

The flow model uses a 3:1 ratio of the orifice flow and vertical slot flow equations to generate realistic estimated flow rates for this particular site. The flow rate through the lock can be obtained whether one of the gates at one end of the lock is open or both gates are closed. The described model may be used for flow estimation during any period when the flow producing leaks in the gates are similar to the May 25, 2003 through August 9, 2005 period. Additional measurements can be made to check the condition of the gate's leaks and applicability of the model in the future.

2.5 Reference

Rajaratnam, N., C. Katopodis, and S. Solanki. (1992). *New Designs of Vertical Slot Fishways.* Canadian Journal of Civil Engineering. 19(3): 402-14.

Ruhl, C. A. and M. R. Simpson. (2005). *Computation of Discharge Using the Index-Velocity Method in Tidally Affected Areas.* USGS Scientific Investigations Report 2005-5004. http://pubs.usgs.gov/sir/2005/5004/sir20055004.pdf

Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

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Chapter 3:
Developing a Residence Time Index to Study Changes in 1990 – 2004 Delta Circulation Patterns

Authors: Michael Mierzwa, Jim Wilde, Bob Suits, and Ted Sommer

3 Developing a Residence Time Index to Study Changes in 1990 – 2004 Delta Circulation Patterns

3.1 Introduction

Long-term trends in historical Sacramento-San Joaquin Delta circulation patterns were studied by developing indexes of residence time for the two major sources of inflow to the Delta. Hydraulic residence time is an important factor affecting a number of estuarine processes. By releasing particles at the major estuary inflows and tracking them until they are no longer in Delta channels, it is possible to calculate the length of time and path those particles took through the Delta. An index of residence time can be created by using a series of daily injections and the associated travel times and particle fates for each day. These indexes were used by DWR in support of its current investigations related to the Pelagic Organism Decline (POD). This chapter presents the methodology used to generate residence time indexes, briefly describes results from the POD studies, and discusses future applications of this modeling methodology. A more detailed paper describing this methodology and its appropriateness to addressing estuarine ecological processes is being drafted for publication.

3.2 Methodology

The residence time indexes were developed by modeling the movement and fate of particles traveling with the Sacramento River and San Joaquin River inflows. Daily residence time indexes are defined to be the time it takes a given percent of buoyant particles that are inserted at a Delta inflow boundary to either travel out of the Delta or be removed from Delta channels. Thus, an index of Delta residence time is defined by the location of particle injection and by the threshold of the portion of injected particles no longer in Delta channels.

For this study two modules of the Delta Simulation Model 2 (DSM2), DSM2-HYDRO and DSM2-PTM, were used to simulate historical Delta hydrodynamics and particle movement respectively. DSM2 is a numerical model that can simulate non-steady state hydrodynamics, water quality, and particle tracking in a network of riverine or estuarine channels. DSM2 has been used to perform various studies of the Delta including water quality compliance forecasts and Delta impacts due to proposed features of the South Delta Improvements Program, In-Delta Storage Program, and through-Delta facilities.

In order to develop an indexes of residence time, DSM2-HYDRO, a 1-dimensional hydrodynamic model, first calculated hourly velocities throughout the Delta based on historical operation of Delta structures, the 15-minute stage at the downstream boundary, daily historical inflows, exports and diversions, and estimated monthly consumptive use. The results of the historical Delta hydrodynamic simulation by DSM2-HYDRO of January 1990 through December 2004 were input into DSM2-PTM.

DSM2-HYDRO is a 1-dimensional hydrodynamics model that, when simulating Delta in-channel velocity, stage, and flow, uses a downstream boundary tide at Martinez and flows at the upstream boundaries.

DSM2-PTM is a quasi 3-dimensional particle tracking model that first converts the 1-dimensional velocity input from DSM2-HYDRO to a 3-dimensional velocity profile and then uses dispersion and diffusion terms to move particles through the Delta's network of channels. DSM2-PTM is capable of tracking injections at multiple locations over the extent of the Delta, a requirement for generating residence time indexes. The interaction of the two DSM2 modules is shown in Figure 3.1 and a more detailed description on the methodology used to generate a series of residence time indexes is given below.

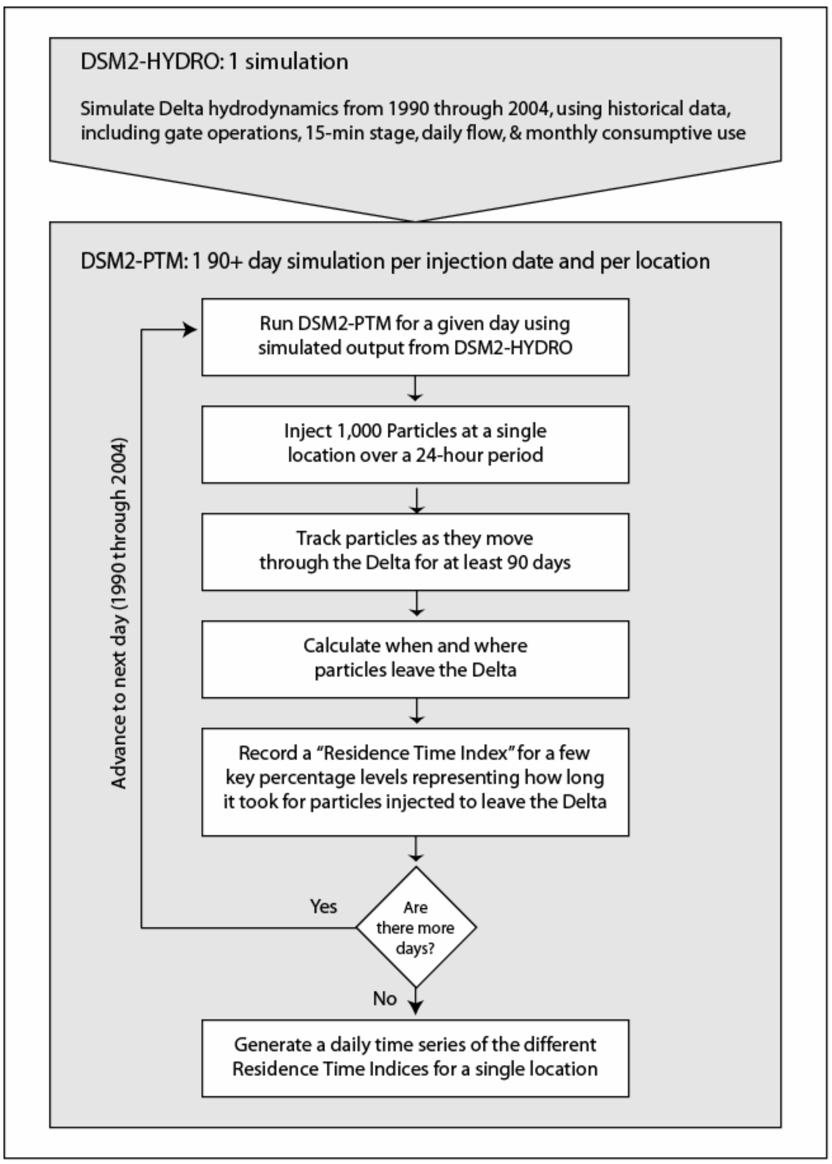

Figure 3.1: Overview of modeling methodology to calculate residence time indexes.

3.3 Model Calibration

DSM2-HYDRO was calibrated to flow and stage in the Delta by a multi-agency group under the direction of the IEP (Nader-Tehrani, 2001). Due to the limited data available throughout the Delta, four month-long periods (May 1988, Apr. 1997, Apr. 1998, and Sep.-Oct. 1998) were chosen as the calibration periods in which the model's friction parameter was adjusted until simulated values best matched observed daily average and instantaneous flow and stage data. The DSM2-HYDRO was then validated by comparing simulated flow and stage with field data from 1990 through September 1999. The results of the 2000 IEP calibration and validation are available on the Department of Water Resources' modeling support web page:

http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/dsm2studies.cfm

DSM2-PTM uses average channel velocities computed by DSM2-HYDRO to create a quasi 3-dimensional velocity cross section, with the 3-dimensional profiles assuming a zero slip condition at the bottom and sides of the channels and locating the fastest moving particles at the water surface in the center of the channel (Wilbur, 2000). Acoustic Doppler current profiler (ADCP) velocity data collected at 16 different sites in the Delta by the USGS (Oltmann, 1998) were used to calibrate the DSM2-PTM transverse and vertical velocity profiles (Wilbur, 2000). Simulated quasi 3-dimensional profiles in the model were validated using dye concentration data collected from three stations in the Delta as part of a U.S. Geological Survey rhodamine WT tracer dye study.

3.4 Calculation of Residence Time Indexes

Consistent with the definition of residence time by Monsen et al. (2003), the residence time indexes developed using DSM2 particle injections were based on two specific injection locations: the Sacramento River at Freeport and the San Joaquin River at Vernalis. The daily resident time index was defined as the time required for a specified percentage of particles continually injected at a location over a period of 24 hours to leave or be removed from Delta channels. Each index value reflected the hydrology and hydrodynamics when the particles were injected and during the subsequent time that the particles were in the Delta channels.

The process of counting particles passing by or through a specific location is referred to as particle flux. For the present analysis, DSM2-PTM tracked the cumulative hourly particle flux for the following locations: the State Water Project (SWP) and Central Valley Project (CVP) pumps, the Contra Costa Water District (CCWD) and North Bay Aqueduct intakes, the Delta island diversions, and the Sacramento River at Chipps Island. With the exception of Chipps Island, particles exiting a Delta channel through a diversion were physically removed from the Delta. The cumulative particle fluxes at these locations therefore uniformly increased over time and the final fate of particles at these locations was known. In contrast, the particle flux at Chipps Island fluctuated as particles moved past Chipps towards the ocean during an ebb tide and then back inland on the following flood tide. Much of this tidal signal in the flux results was removed by taking the daily average of the cumulative particle flux of particles passing past Chipps Island. These average values were assumed to be the net count of particles that moved out of the Delta.

An example of tracking particles injected on a single day at Vernalis is shown in Figure 3.2. In this example, 1,000 particles were injected on June 15, 2003 and tracked for the next 90 days. On the day of the injection, 100% of the particles were still in the Delta channels. Five days later, 21% of the injected particles had already exited the Delta channels, with the majority of these particles having been entrained on the Delta islands or by the CVP pumps. Fifteen days after the injection, the Delta islands had entrained 22% of the originally injected particles and the CVP pumps had removed 38%. On July 23, thirty-eight days after the initial injection, 97% of the particles were no longer in the Delta channels.

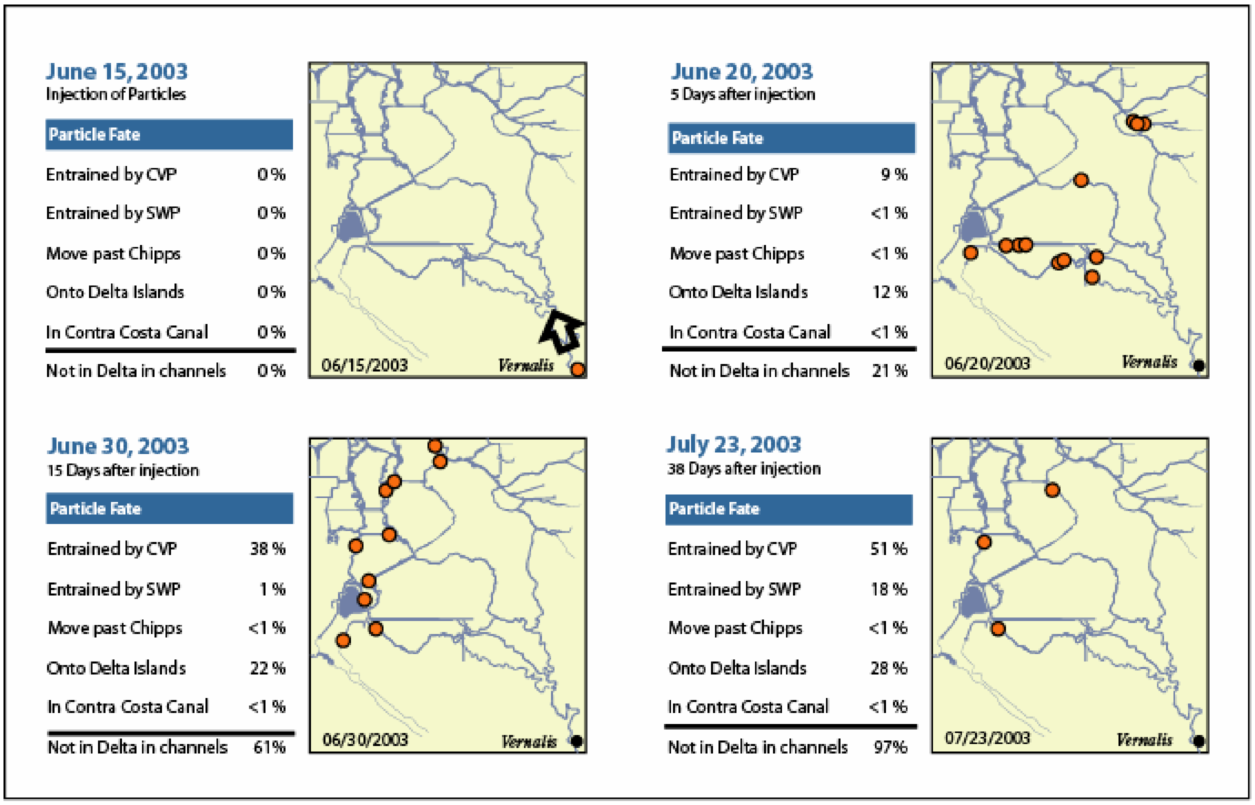

Figure 3.2: Example of tracking a single Vernalis particle injection.

The net cumulative flux of particles leaving the Delta was found by summing the daily cumulative fluxes for each source of particles being removed. This daily sum was then used to create a cumulative distribution function of residence time (see Figure 3.3) for each injection date for each of the two injection locations. Each daily residence time distribution represents the number of days it took for a given percentage of the particles originally injected to no longer be located in the Delta channels. As the percentage of particles removed increases, the total number of days required for the particles to be removed increases.

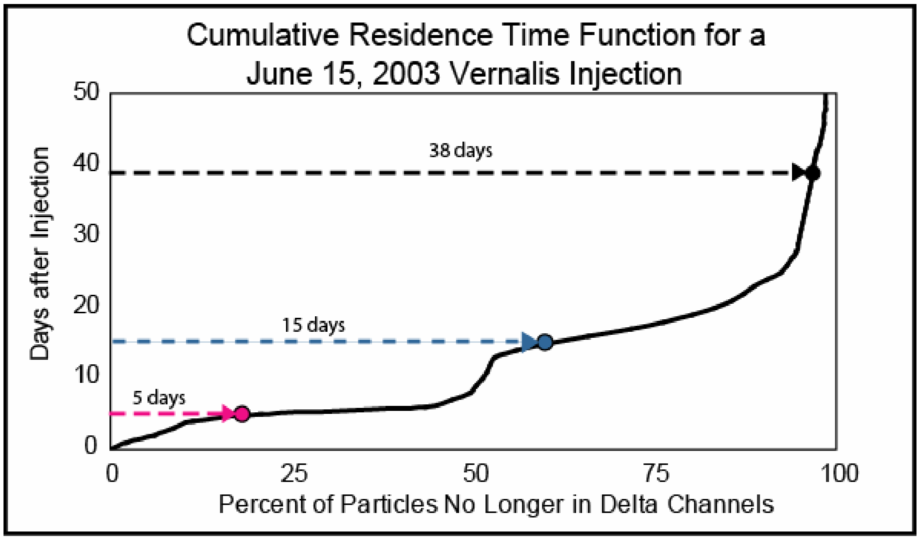

Figure 3.3: Cumulative residence time function for a single date of particle injection.

Using these daily cumulative residence time functions, a residence time index for the particle injection date can be found for any given percent of particles removed that is of interest. Thus, for any given milestone of percentage of particles no longer in the Delta, the associated daily residence time can be used to construct a time series of residence time indexes. Each of these daily index values is specific to the location and date of injection and is a function of the number of particles no longer left in the Delta. Figure 3.4 shows an example of using the daily cumulative residence time functions for June 15, 2003 to develop two residence time indexes for 2003, one representing when 25% of the injected particles have been removed from or left the Delta and the other for 75%.

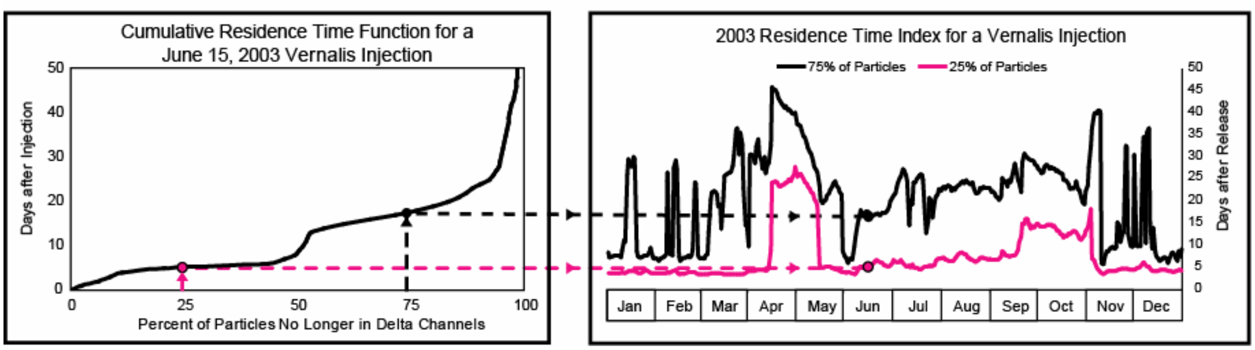

Figure 3.4: Creating annual residence time indexes using daily cumulative residence time functions.

There are advantages and disadvantages to using smaller and larger percent of injected particles moving out of or being removed from Delta channels as a residence time index criterion. For the purpose of analysis of residence time indexes, only a few percentage levels were studied. The residence time associated with a small fraction of particles, for example when 25% of the particles injected have left the Delta, is the product of a shorter period of time. Shorter periods have a greater probability of a more uniform distribution of flows. Such a more homogenous set of conditions makes it easier to relate a specific location's residence time to Delta hydrodynamics. However, a large percentage of particles are still unaccounted for during shorter periods and the particles could be days or weeks away from exiting the Delta. A residence time representing a larger fraction of particles, such as when 75% of the particles injected have left the Delta, tends to be more variable than an index based on a lower amount of particles; however, there will be more information included about the particles that exited the Delta. This results in less uncertainty about the fate of the remaining particles.

3.5 Model Boundary Conditions

Historical hydrology during the period 1990 through 2004 was used as the basis for the DSM2 simulations (Figure 3.5). The simulation included the installation and operation of the south Delta temporary barriers which were modeled instantaneously installed and removed according to when observed flows and water levels were significantly affected. Daily average flow was input at the major tributaries to the Delta, including the Sacramento, San Joaquin, Mokelumne, and Cosumnes rivers and the Yolo Bypass. Daily average exports were input for the SWP and CVP pumping plants, Contra Costa's diversion, and the North Bay Aqueduct. Monthly average diversions to Delta islands and the corresponding return flows from these islands were calculated using the Department's Delta Island Consumptive Use (DICU) model (CDWR, 1995). DICU uses total monthly precipitation and pan evaporation in the Delta and assumed land use patterns to calculate island consumptive use, which DICU then distributes for use in DSM2. Observed 15-minute tidal data at Martinez was used as the downstream boundary condition.

Figure 3.5 presents important Delta hydrology for the 1990 through 2004 period of simulation. Shown are inflows from the Sacramento and San Joaquin rivers, combined SWP and CVP export pumping, and a daily Net Delta Outflow Index. This calculated index was the sum of the major flow sources and sinks input in the DSM2 simulation (see Anderson, 2004 for details on calculating Net Delta Outflow). Figure 3.5 shows high San Joaquin River flows and a high Net Delta Outflow Index in the winter months of 1995 through 1998. The floods of 1997 resulted in high Net Delta Outflows and San Joaquin River flows that extend beyond the scale used in the graphs for only a few days in early January. During those floods, water overtopped San Joaquin River levees in the south Delta. Although DSM2 confined the high San Joaquin River flows to the channels, the January 1997 daily residence time indexes appear similar to other January periods. Thus it can be assumed that the DSM2 assumption of no overtopping did not negatively affect the indexes during the flood event. This additional flow is accounted for in the corresponding Net Delta Outflow Index.

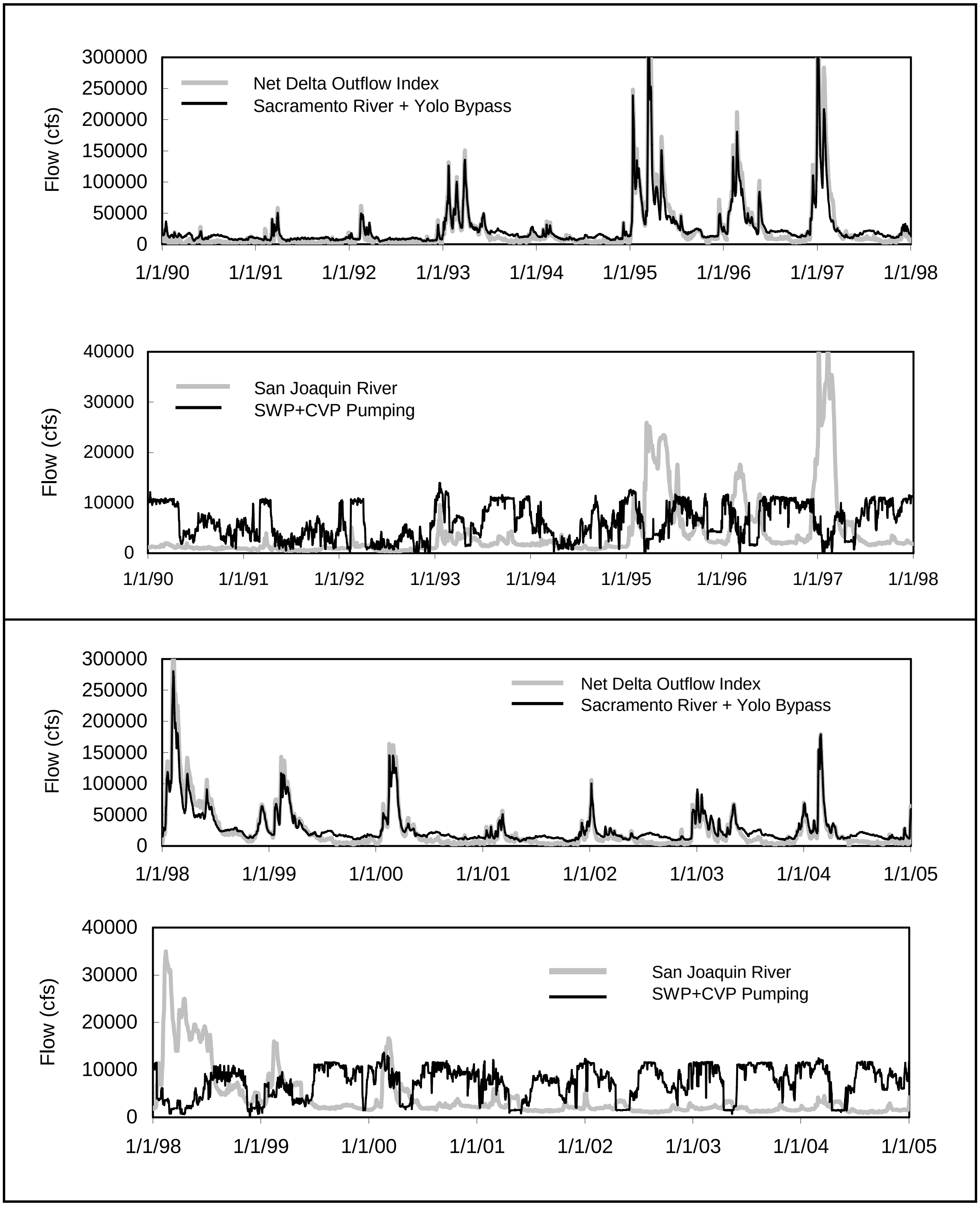

Figure 3.5: Significant Delta boundary flows and exports (1990 – 2004).

3.6 Results

Although the daily residence time indexes for criteria of 25%, 50% and 75% of the injected particles from Freeport and Vernalis were examined, only the monthly-averaged results of the 75% residence time index are presented here for brevity. The 25% and 50% indexes often provided little insight into patterns of residence time and circulation because of very small values (e.g. one or two days). The greater variability in the 75% index between 1990 and 2004 relative to the variability in the 25% and 50% indexes provides a better means with which to assess the potential scale of any large-scale changes in Delta circulation patterns.

The monthly averages of the 75% residence time index for particles injected in the Sacramento River at Freeport and the San Joaquin River at Vernalis were summarized graphically to examine long-term trends, and in tabular format to examine statistical trends. For each month a time series of monthly-averaged residence time indexes was plotted for the period of study (see Figures 3.6 and 3.7). The long-term mean for each monthly time series was then plotted to illustrate the annual variability in the monthly-averages. The statistical variability in the residence time indexes was further expressed as the minimum, mean, and maximum monthly-averages for each month (Table 3.1).

Table 3.1: Range of monthly-averaged 75% residence time indexes for Freeport and Vernalis injections (in days).

Month	Freeport			Vernalis		
	Min	Mean	Max	Min	Mean	Max
Jan	3	21	56	6	16	28
Feb	3	16	38	6	17	27
Mar	4	22	58	7	21	46
Apr	5	34	89	8	33	54
May	5	39	87	13	29	49
Jun	6	38	80	9	18	25
Jul	16	35	70	6	17	27
Aug	22	40	71	7	16	29
Sep	25	49	82	17	28	62
Oct	37	51	74	18	31	70
Nov	19	40	70	18	32	60
Dec	6	28	64	12	21	42

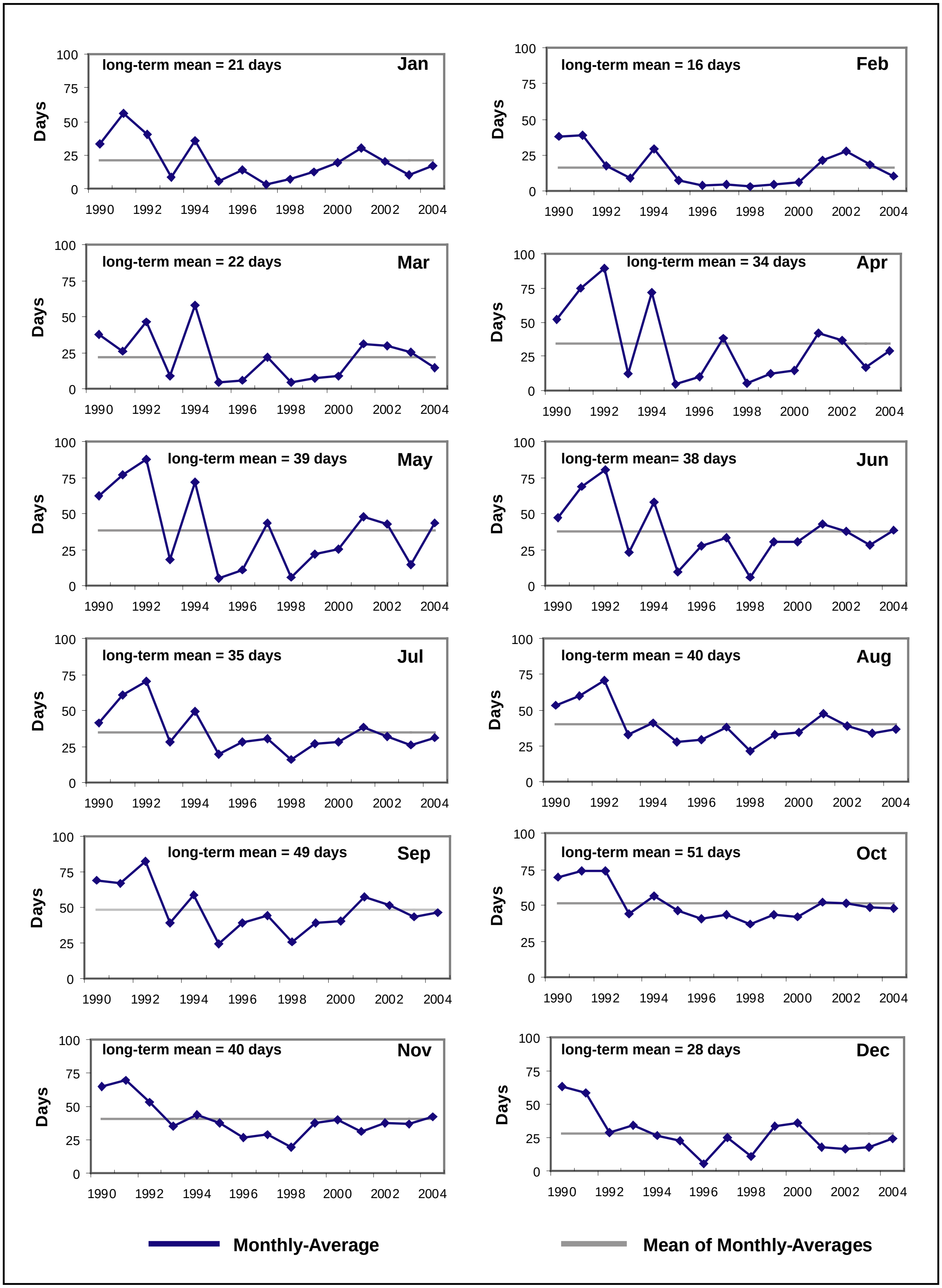

Figure 3.6: Monthly-averaged 75% residence time indexes for a Freeport injection.

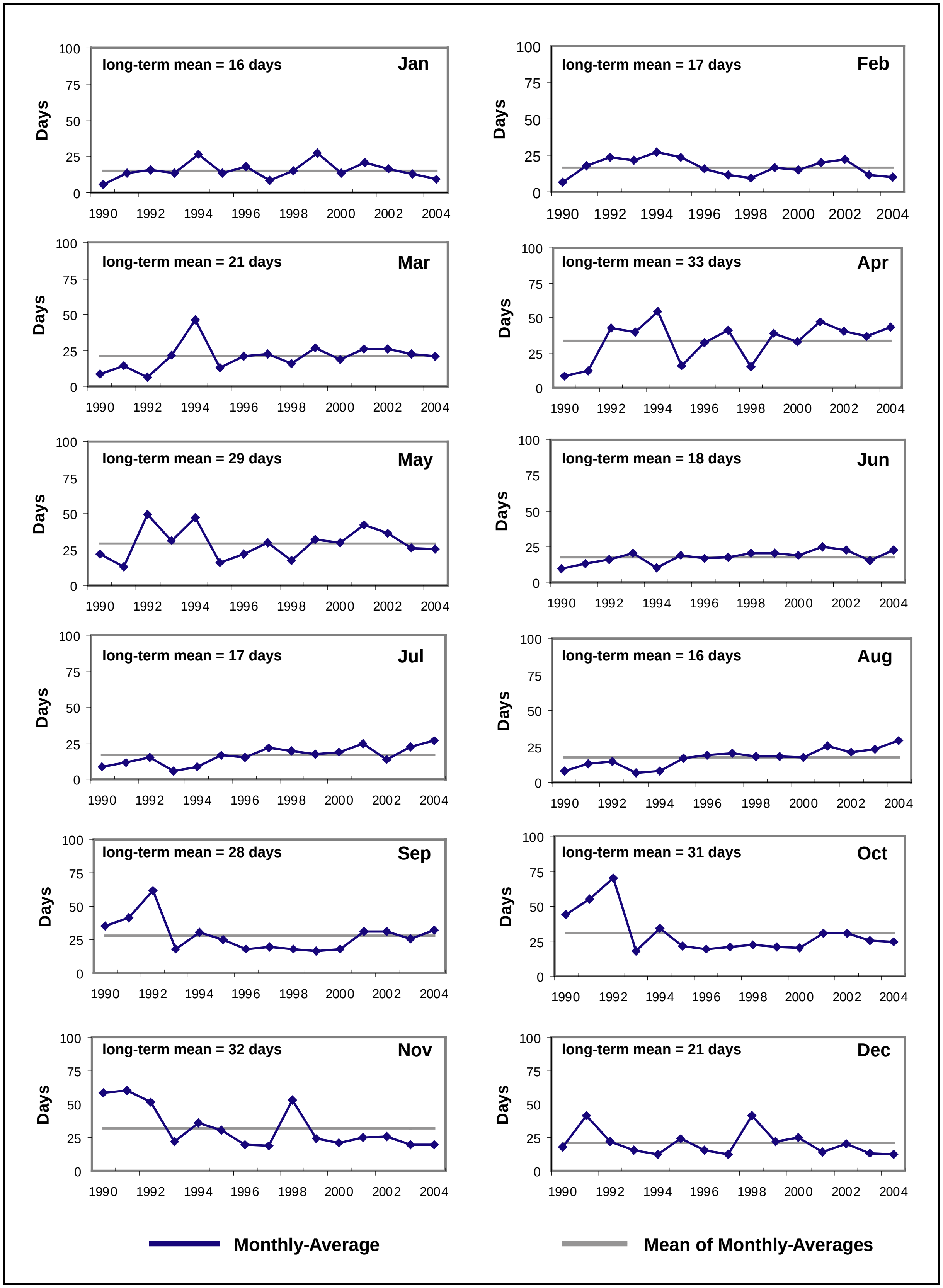

Figure 3.7: Monthly-averaged 75% residence time indexes for a Vernalis injection.

3.7 Future Directions

A future analysis might compare the distribution of final particle destinations (also known as flux locations) with residence time indexes. Similar in concept to comparing water quality fingerprints (Anderson and Wilde, 2005) with hydrologic information, such a comparison would allow a visual means to associate changes in the ratio of particle destinations with changes in residence time index (as shown in the left pane of Figure 3.8). For example, Figure 3.8 compares the Vernalis daily 75% residence time index in 2001 with the percentage of particles from each daily injection that exited the Delta by passing Chipps Island or being entrained at the project exports (SWP and CVP) or Delta islands (via the agricultural diversions).

Another possible study would be to explore how hydrologic boundary conditions affect a greater extent of the estuary by injecting particles in the interior of the Delta to (see the middle pane in Figure 3.8). Since particles injected at locations closer to the major exit vectors out of the Delta will not remain in the estuary as long as particles injected at Freeport or Vernalis, the two residence time indexes presented here could be used as upper bounds on the simulation length for any additional simulations with particles injected at interior locations. In addition to providing more detailed insight into internal circulation patterns, the particle injection locations can also be chosen to address entrainment related questions.

DSM2-PTM can be used to calculate regional residence time indexes by simultaneously injecting particles at multiple locations in a given region and then tracking how long these particles remain in the region (see the right pane of Figure 3.8). This approach calculates the number of particles in the channels in the region during each model time step and the time it takes for fixed percentages of particles to leave a predefined region.

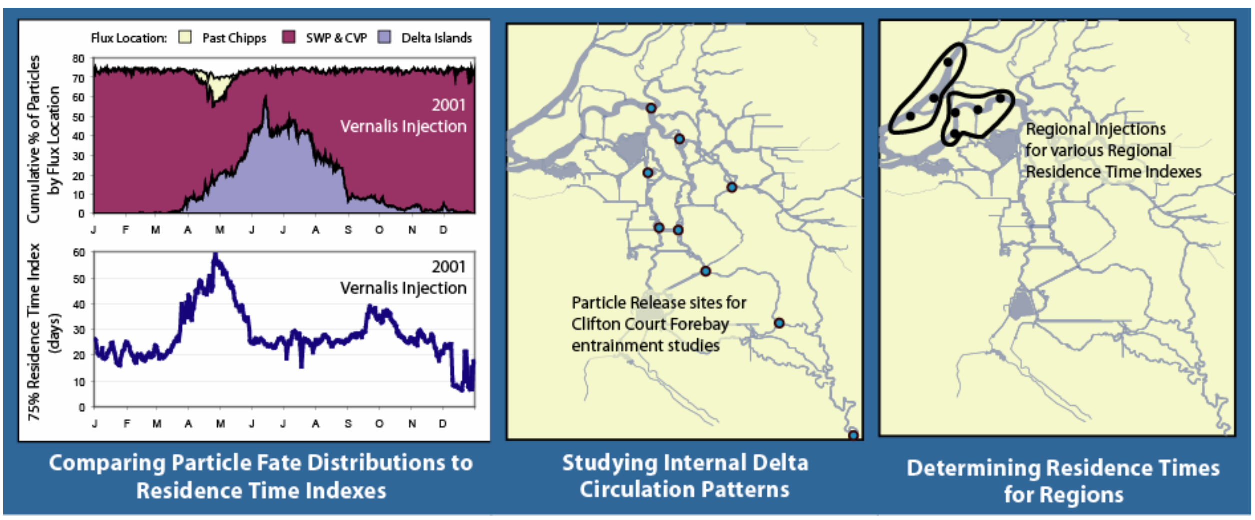

Figure 3.8: Examples of potential future applications for residence time indexes.

Summary of Key Findings

- Residence time indexes based on when a smaller percentage (25% or 50% compared to 75%) of particles exited the Delta were less sensitive to changing hydrologic conditions.
- Residence time indexes for the Sacramento and San Joaquin Rivers were not significantly lower in recent years (2002 – 2004) compared to long-term averages.
- The Sacramento River tended to have higher (longer) residence time indexes in the early 1990s (drier years), and the San Joaquin River tended to have higher residence times in the late Fall / early Winter months in the early 1990s.
- Late summer and early fall tended to have higher residence time indexes, while late winter tended to have lower residence time indexes.
- Residence time indexes have greater variability in the spring.

3.8 References

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Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

27th Annual Progress Report
October 2006

Chapter 4:
Using Volumetric Fingerprinting to Study Sources of Salinity in the South Delta

Author: Bob Suits

4 Using Volumetric Fingerprinting to Study Sources of Salinity in the South Delta

4.1 Introduction

Using volumetric fingerprinting, the Department of Water Resources (DWR) investigated the sources of water at three of the four locations where southern Delta electrical conductivity (EC) objectives were established by the State Water Resources Control Board (SWRCB). The purpose of this investigation was to study the extent the San Joaquin River has historically been a source of water at these locations and how this contribution may be affected by State Water Project (SWP) operations and the installation of temporary barriers. This information, when viewed along with modeled EC at the three locations, can give insight into the reasons behind the degree of changes to EC after modifying SWP exports and barrier operations.

4.2 Background

Recent interest has been shown in understanding the role that San Joaquin River inflow plays in determining salinity, as expressed as EC, at the three 'interior' locations where southern Delta EC objectives were specified in the SWRCB's *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, 95-1 WR May 1995*. These locations, San Joaquin River at Brandt Bridge, Old River near Middle River, and Old River at Tracy Road are all downstream of the fourth objective location, San Joaquin River at Vernalis (Figure 4.1). The objectives at all four locations are the same: a 30-day running average EC of 0.7 mmhos/cm (700 µS/cm) between April and August and 1.0 mmhos/cm (1,000 µS/cm) between September and March for all year-types.

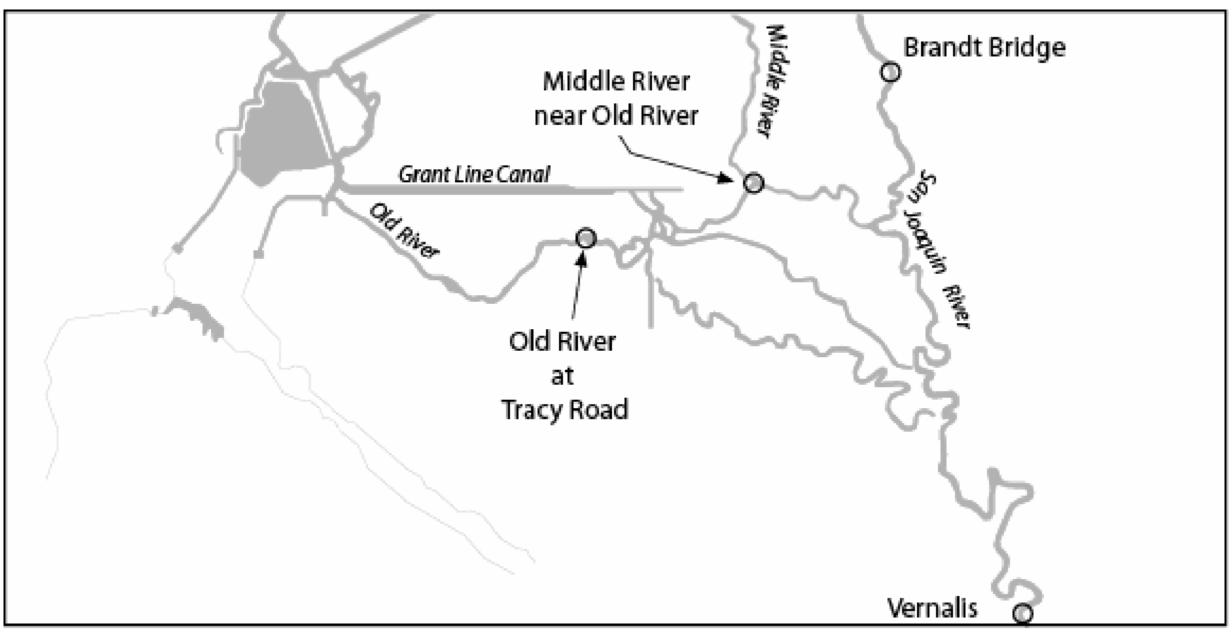

Figure 4.1: Locations of south Delta water quality objectives.

A plot of observed EC at these locations in 2001, 2002, and 2003 (Figure 4.2) shows that the EC at Vernalis during this period was consistently lower than the EC at the downstream locations. Thus, if Vernalis just meets its EC objective, the EC at the other locations may exceed the same objective. As Figure 4.2 shows, the relationship between EC at Vernalis and the other three locations is not constant; however, the San Joaquin River inflow does appear at times to strongly influence the EC in the south Delta. Better understanding was sought of the role San Joaquin River inflow has in determining salinity in the south Delta and the extent to which SWP pumping and temporary barrier operations may affect this role. In order to investigate these questions, volumetric fingerprinting of historical and modified conditions was done at the three interior EC objective locations.

Volumetric fingerprinting refers to the tracking of the relative volumetric contribution of various sources in a column of water at a specified location in the Delta. The methodology and applications of volumetric fingerprinting using DSM2 have been previously discussed (Anderson, 2002; Anderson and Wilde, 2005; Mierzwa and Wilde, 2004). Studies of volumetric fingerprinting in the Delta have tended to focus on Clifton Court Forebay in order to study the origin of the water exported by the State Water Project (SWP). DWR’s Municipal and Industrial Water Quality Investigations (MWQI) program publishes a weekly report of current Delta water quality conditions. These reports include a volumetric fingerprint inside Clifton Court Forebay that is based on recent historical Delta hydrodynamic conditions as modeled by DSM2. A recent fingerprint appearing in MWQI’s weekly report is shown in Figure 4.3 which shows that from the first of November 2005 through early January 2006 approximately 75% of the water being exported by the SWP originated in the Sacramento River. Then beginning in January 2006 and persisting at least through April 2006, most of the water in Clifton Court Forebay came from the San Joaquin River. This pattern of shifting between the Sacramento River and San Joaquin River as the main source of water in Clifton Court Forebay is repeated for most years and has been used to help explain observed variations in dissolved organic carbon and EC in the forebay.

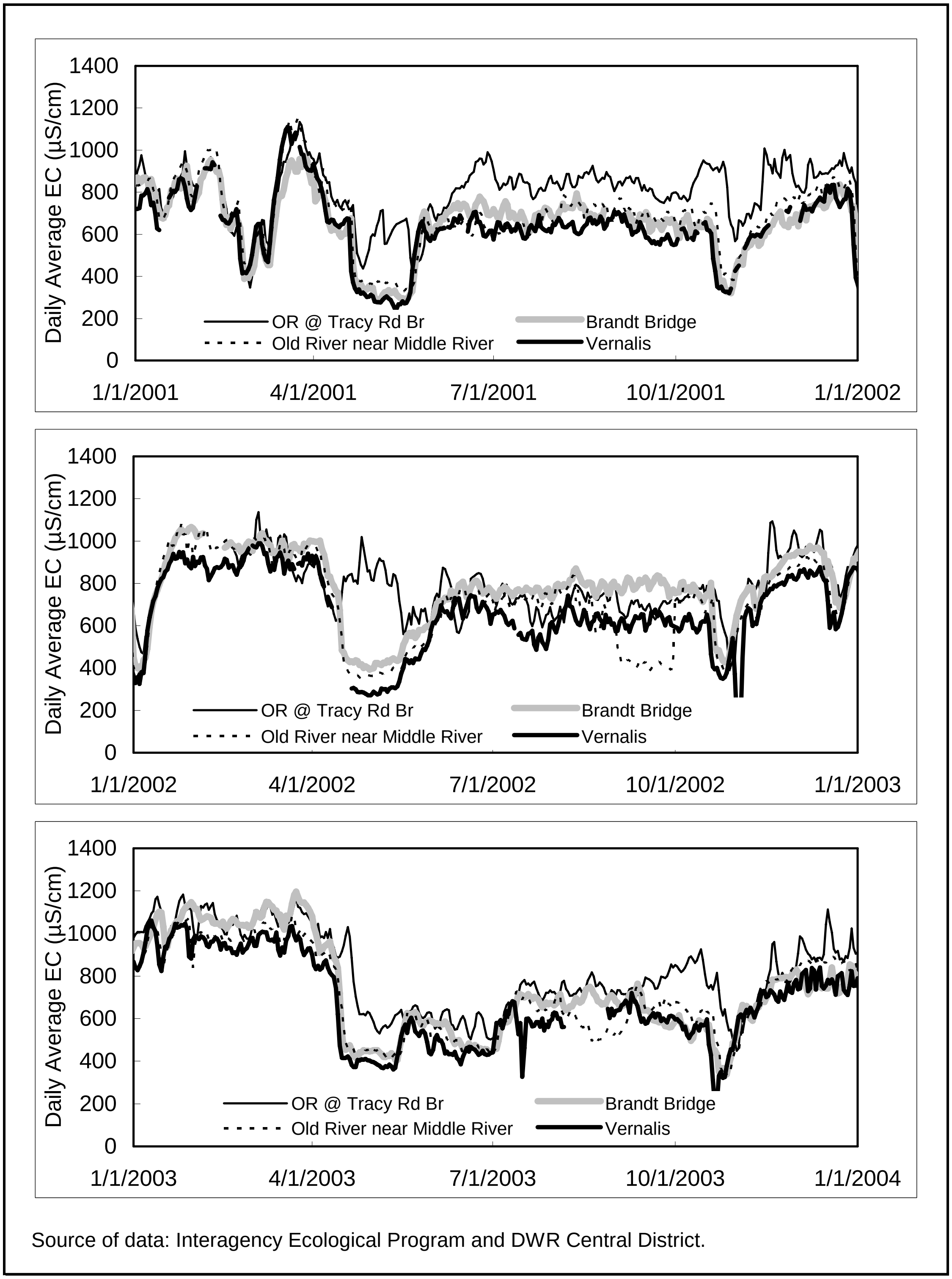

Figure 4.2: Historical EC at locations of south Delta water quality objectives, 2001-2003.

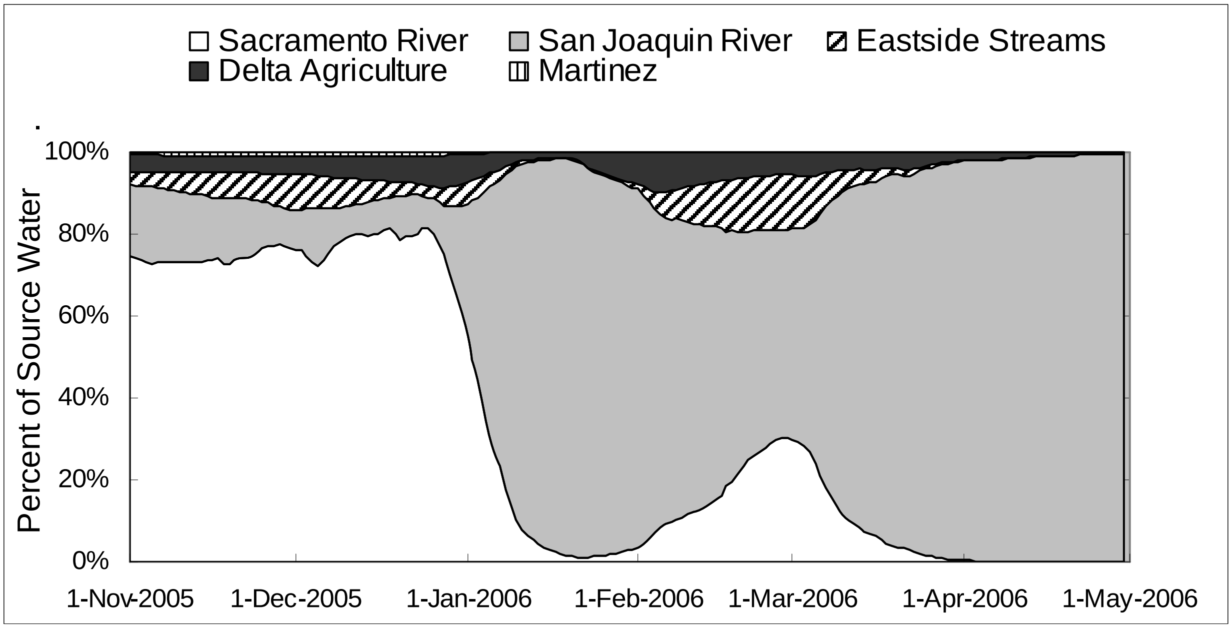

Figure 4.3: Volumetric fingerprint of historical conditions in Clifton Court Forebay (Source: DSM2 simulation of historical conditions).

4.3 Comparing Observed EC to Results of Modeled Fingerprinting

At the three south Delta locations, historically observed EC were plotted with the DSM2-generated fingerprint of the percent of water at the location that originated from the total of San Joaquin River inflow and Delta agricultural discharges (Figures 4.4, 4.5, and 4.6). These two sources were combined because they are usually considered outside the influence of DWR. In the figures below, the combination of San Joaquin River and Delta agricultural discharges frequently account for nearly all of the water at all three sites. When the combination of the two sources dips below 100%, other possible sources of water are Sacramento River inflow, Mokelumne River inflow, and water from the west Delta. Of these additional sources, Sacramento River inflow is predominant, most likely due to a combination of barrier operation and hydrology.

The figures below show that the predominance of the San Joaquin River and Delta agricultural drainage as the source of water varies at the three sites. Most strongly determined by the two sources of water is San Joaquin River at Brandt Bridge, next is Old River at Middle River, and least is Old River at Tracy Road. The figures below generally show no obvious relationships between fingerprints and EC. An important exception may be the fingerprint and EC at Old River at Tracy Road in 2003. Twice in that year sudden decreases in EC coincided with sudden decreases in the contribution of San Joaquin River water and agricultural drainage. In other words, twice in 2003 water originating from the Sacramento River reached the Old River at Tracy Road location, and both times the EC there decreased.

The results mentioned above for Old River at Tracy Road have created interest in studying what conditions cause water from the Sacramento River to reach the south Delta. Specifically, the question arises as to how DWR operations in the Delta affect the origin of the water in the south Delta. DSM2 simulations of modified Delta conditions were performed to study this question.

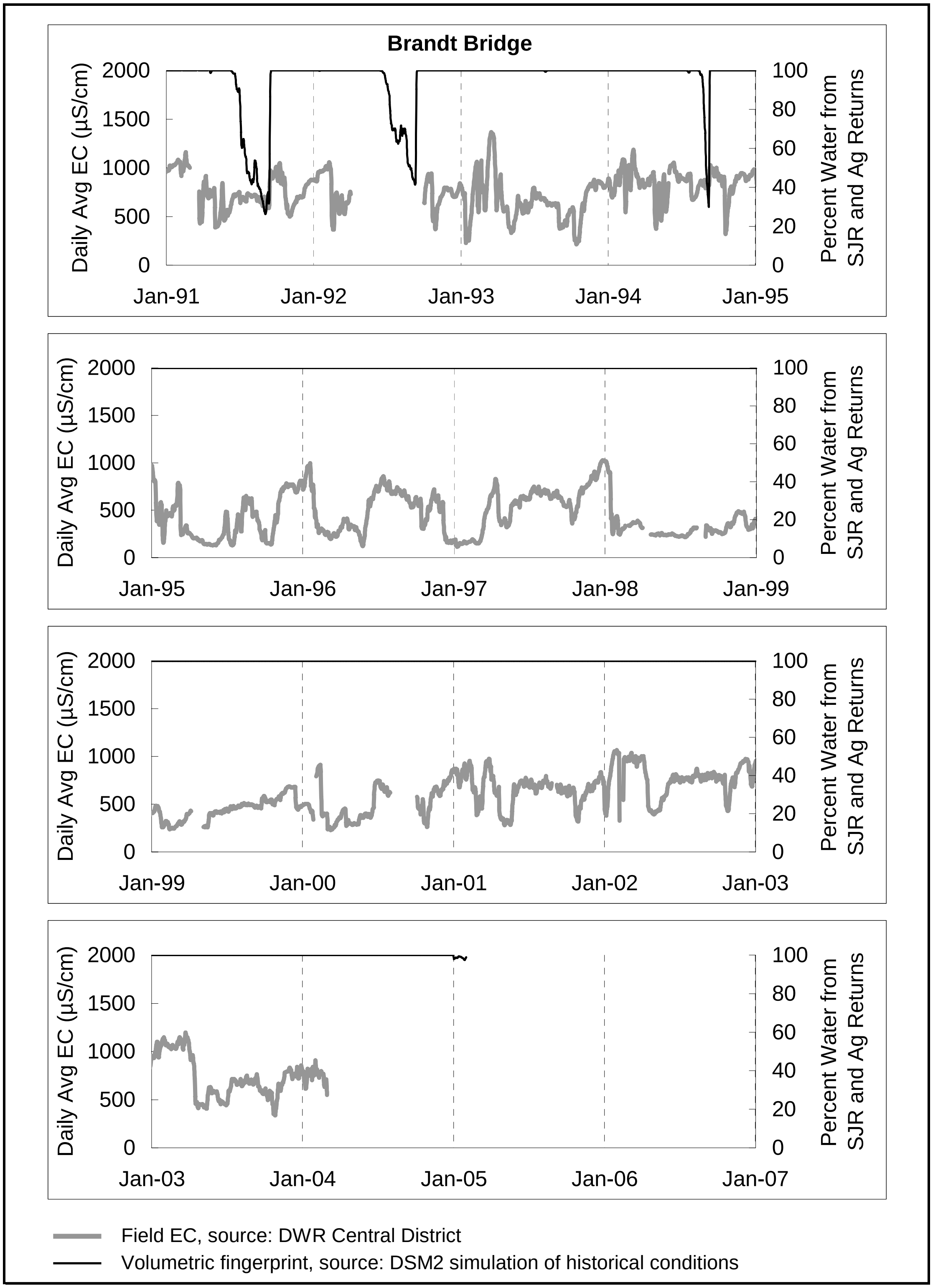

Figure 4.4 Observed EC and DSM2-generated volumetric fingerprint of historical conditions at Brandt Bridge.

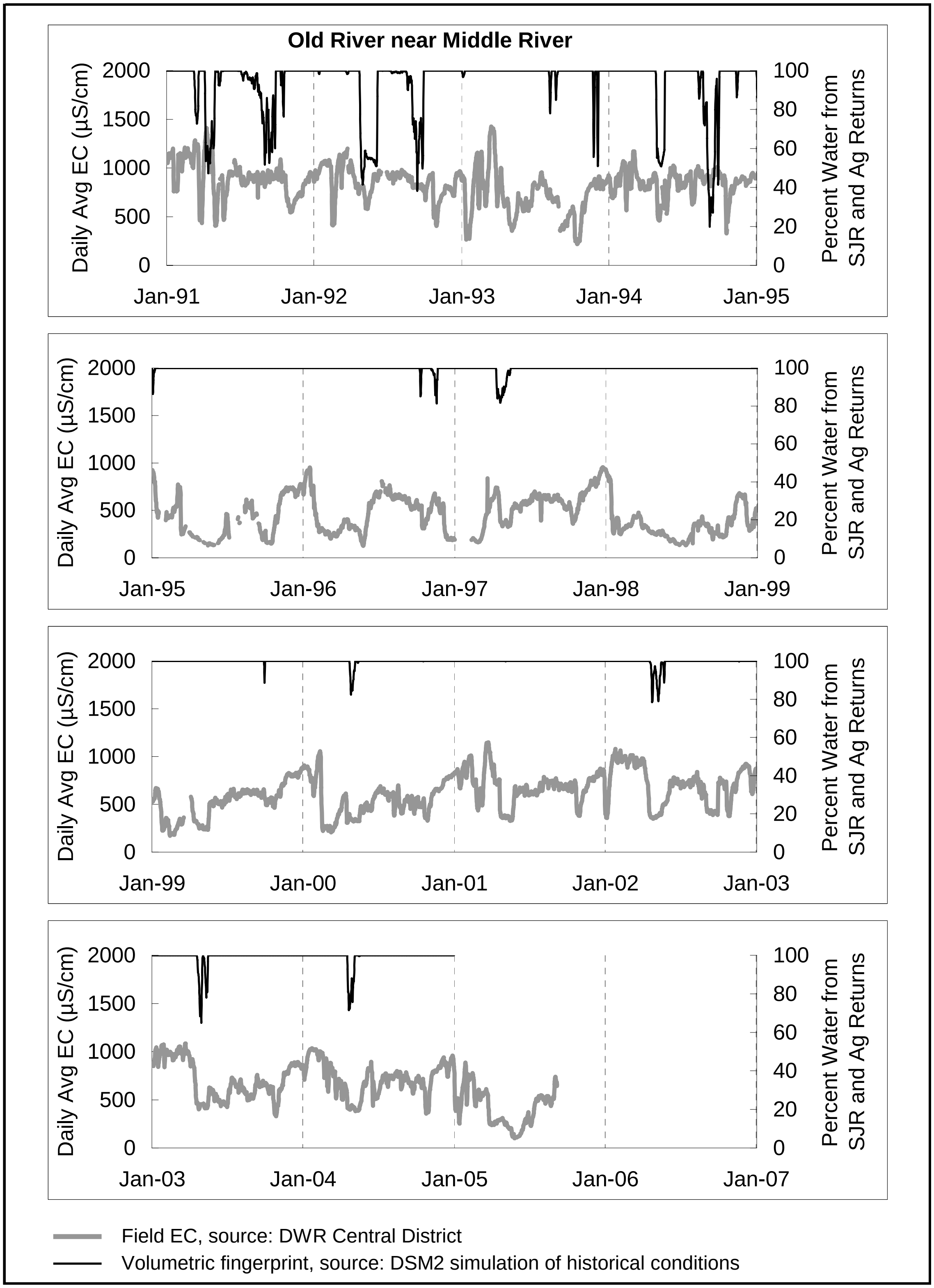

Figure 4.5 Observed EC and DSM2-generated volumetric fingerprint of historical conditions at Old River near Middle River.

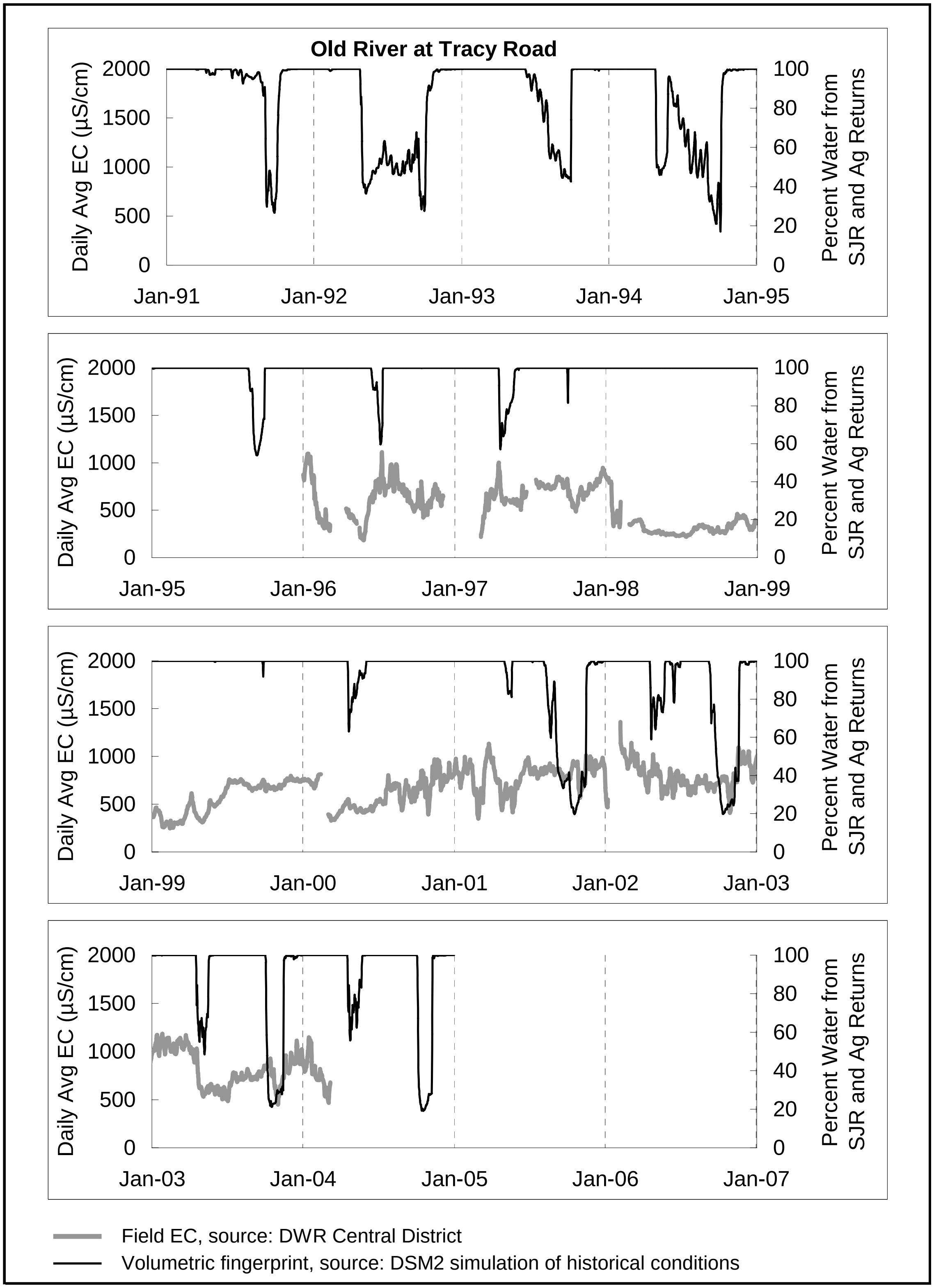

Figure 4.6 Observed EC and DSM2-generated volumetric fingerprint of historical conditions at Old River at Tracy Road.

4.4 Modeling Fingerprinting and EC for Modified SWP Pumping

EC and fingerprints of modified historical Delta conditions were simulated by DSM2 to determine how much SWP pumping and temporary barrier installation may have affected south Delta conditions in 2002 and 2003. Since the current validation of DSM2 does not include this period, an extended EC validation of DSM2 at the three locations of concern is first provided.

4.4.1 Validation of DSM2's Simulation of EC in the South Delta

Historical EC was simulated at the three interior locations for south Delta objectives in order to view the accuracy of DSM2's simulation of EC in the south Delta for years since 1999. The currently published validation of DSM2-QUAL (water quality module of DSM2) covers the time of April 1990 through September of 1999 and contains errors in the posted measured EC at Old River at Tracy Road. Figures 4.7, 4.8, and 4.9 compare DSM2-simulated to field-measured EC at the three locations over the period of 1990 through 2004. Vernalis EC is not presented because it is an input to DSM2 that is based on observed data.

The figures below show generally good agreement between DSM2-simulated and field-measured data. However, DSM2 does tend to underestimate EC at Old River at Tracy Road. As shown in Figure 4.2, the EC here can be substantially higher than what is seen in the San Joaquin River inflow at Vernalis. This implies that a source of salinity other than the San Joaquin River at times contributes to localized higher EC in Old River at Tracy Road. DSM2's tendency to underestimate EC here may mean that DSM2 fails to fully account for the phenomena occurring to raise the EC at this location in the south Delta.

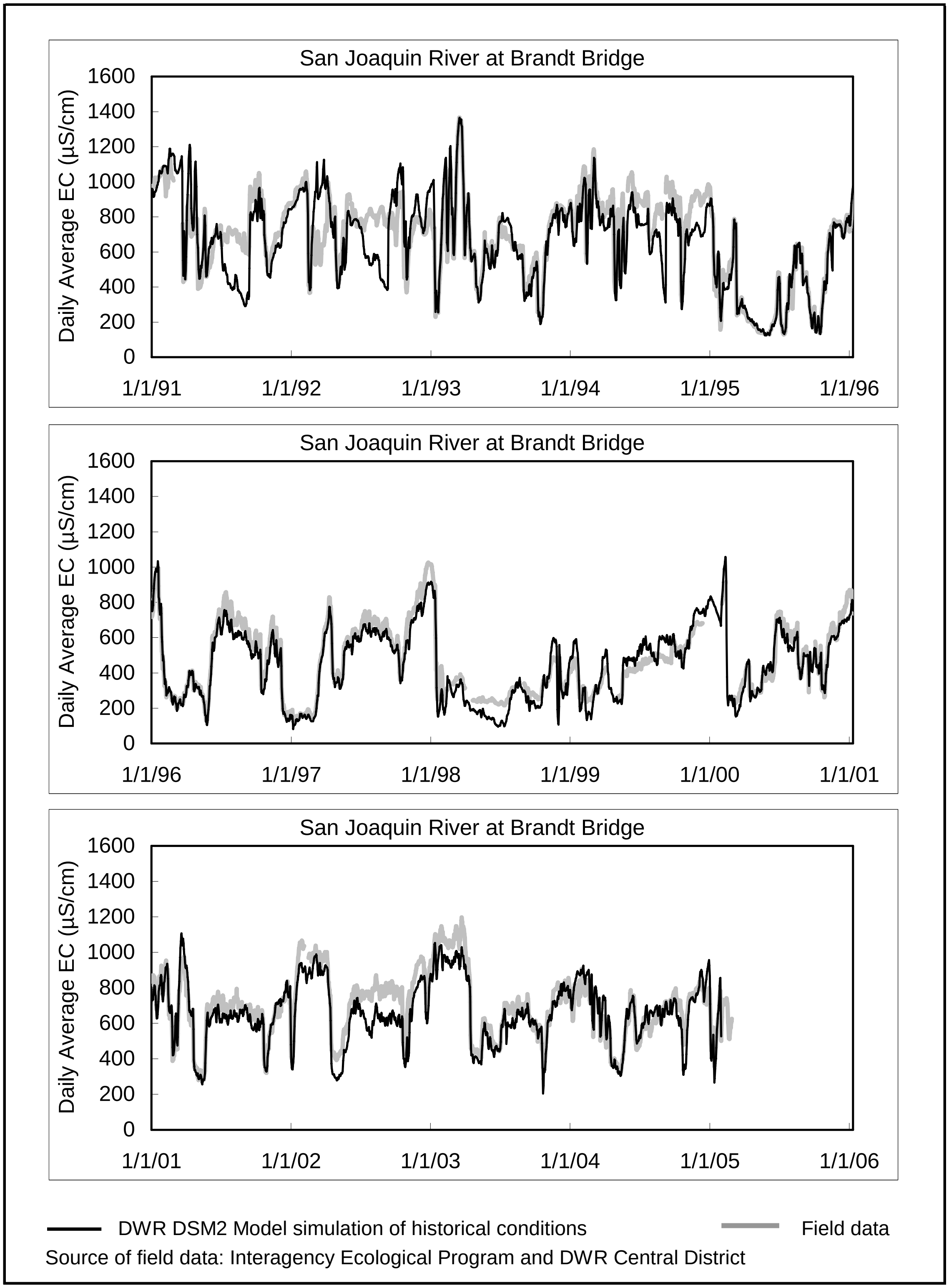

Figure 4.7: Observed and DSM2-simulated EC at Brandt Bridge, 1991-2004.

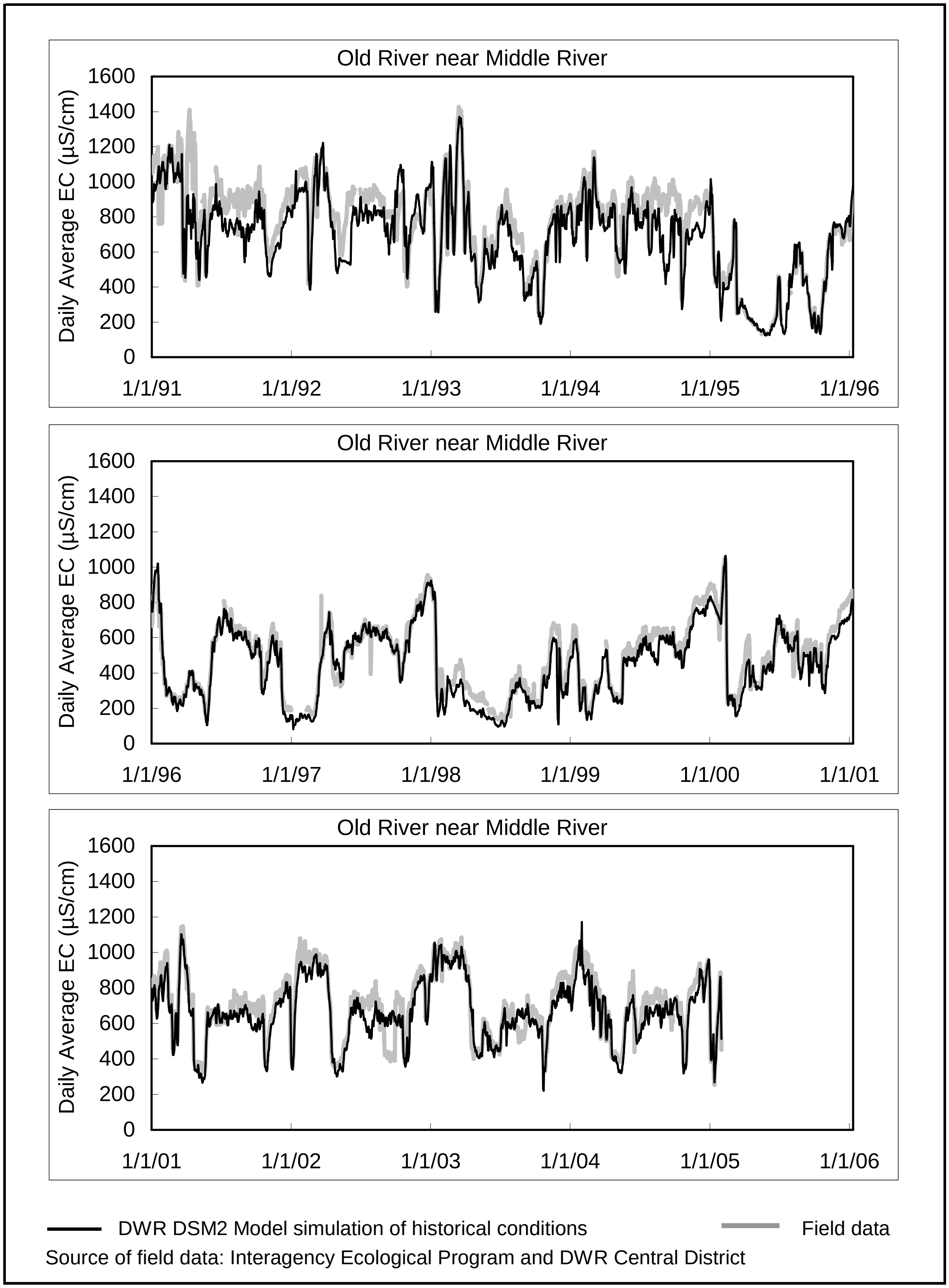

Figure 4.8: Observed and DSM2-simulated EC at Old River near Middle River, 1991-2004.

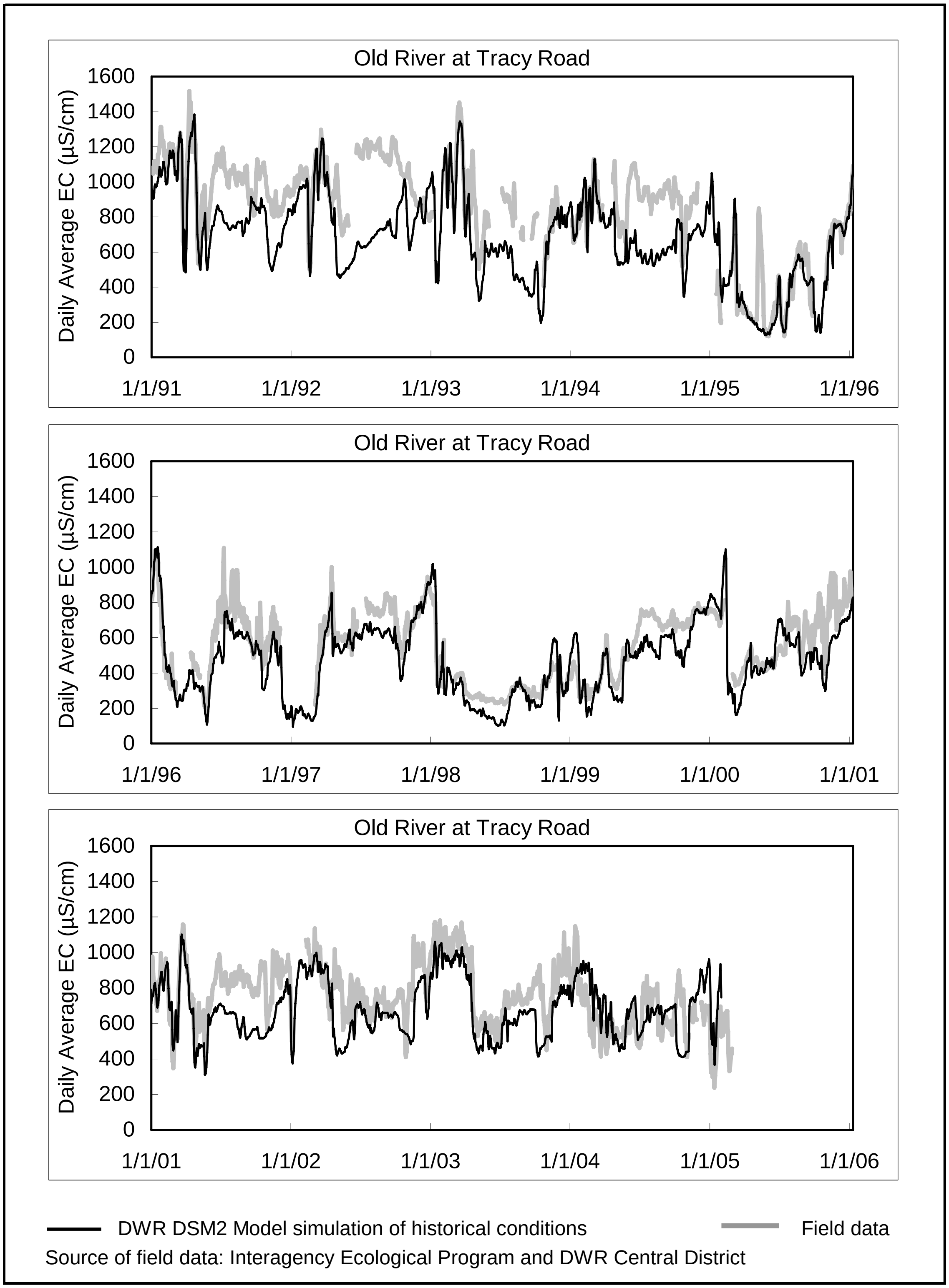

Figure 4.9: Observed and DSM2-simulated EC at Old River at Tracy Road, 1991-2004.

4.4.2 Delta Conditions with Modified SWP Pumping

Delta conditions were simulated for historical 2002 and 2003 conditions with SWP pumping eliminated for much of each year. These years were chosen because they are recent, SWP pumping was high at times, and 30-day running average of the historical EC at the three locations exceeded 0.7 mmhos/cm in the springtime.

Figures 4.10 and 4.11 show the SWP and Central Valley Project (CVP) pumping and the San Joaquin River inflow for 2002 and 2003. In the historical simulations, SWP pumping in both years exceeded 7,000 cfs for extended periods and the San Joaquin River inflow during the periods of interest ranged from 1,500 cfs to 3,000 cfs in both years (Figures 4.10 and 4.11). The periods of January 6, 2002 to September 9, 2002 and January 4, 2003 to May 30, 2003 were then selected as the times to eliminate SWP pumping.

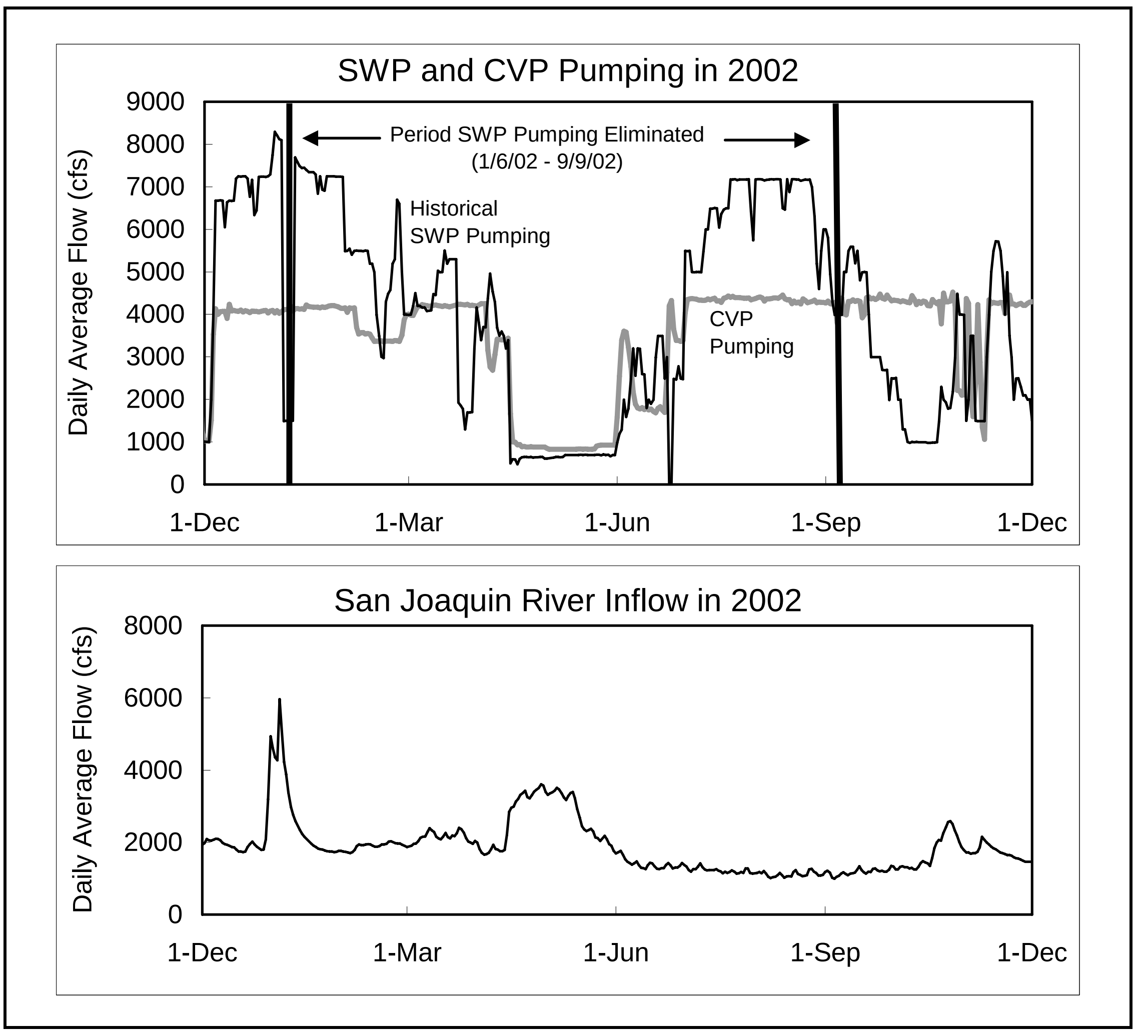

Figure 4.10: Historical SWP and CVP pumping and San Joaquin River inflow in 2002.

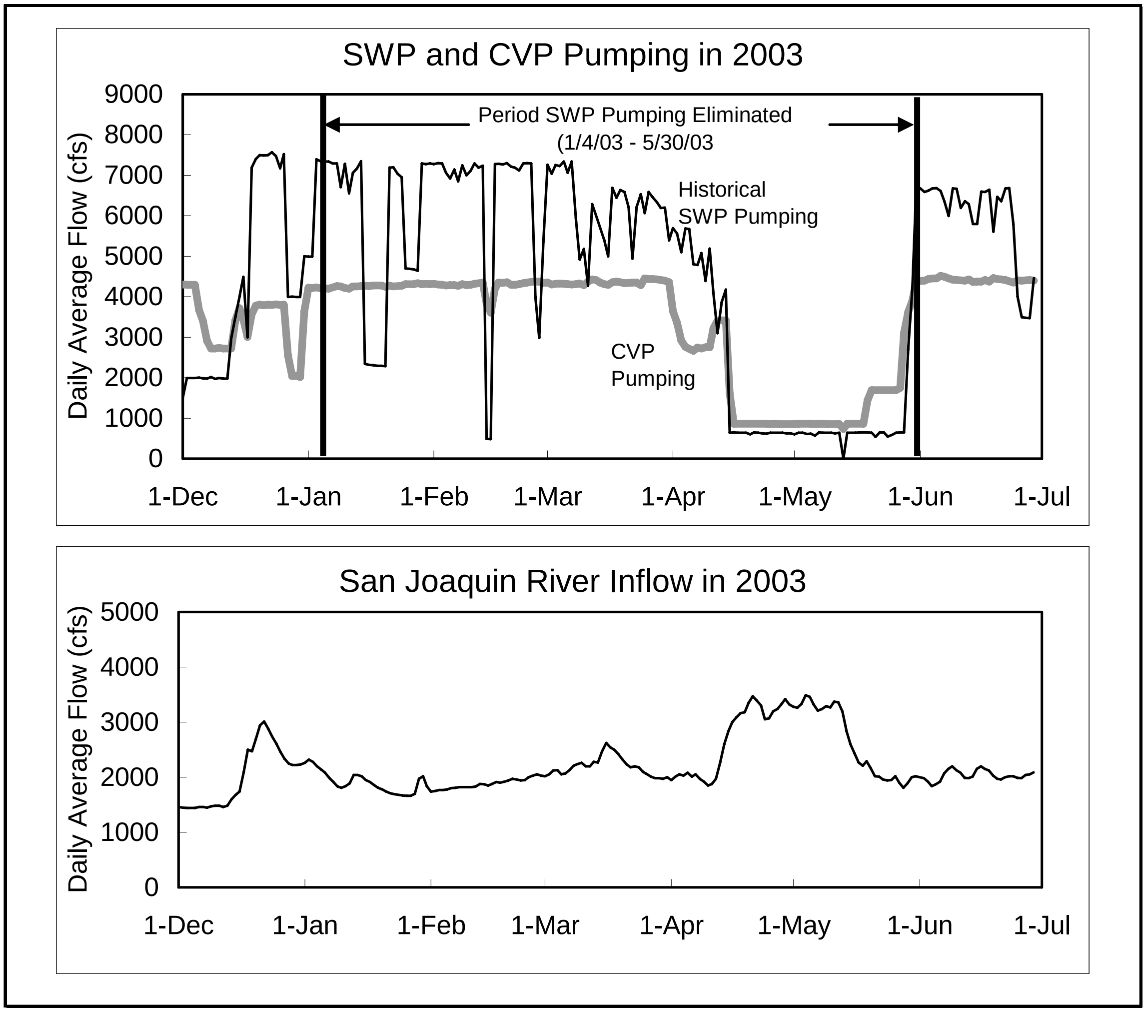

Figure 4.11: Historical SWP and CVP pumping and San Joaquin River inflow in 2003.

4.4.3 2002 Fingerprinting and EC

DSM2 simulations of both EC and fingerprinting were then performed for both the historical and modified Delta conditions. Figures 4.12, 4.13, and 4.14 show for Brandt Bridge, Old River near Middle River, and Old River at Tracy Road respectively the daily average EC and volumetric fingerprints for historical 2002 Delta conditions and when SWP pumping was eliminated during the January 6, 2002 through September 9, 2002 period. The fingerprints are broken down by the contribution of the combination of San Joaquin River inflow and agricultural drainage versus the contribution by the Sacramento River inflow. Figure 4.12 shows that eliminating SWP pumping in 2002 had very little if any impact on EC at Brandt Bridge. The source of water here, nearly always 100% from the San Joaquin River and agricultural drainage, only slightly changed after eliminating SWP pumping. At Old River near Middle River, a slight increase in EC in April and May was associated with a slight shift in source water from a combination of the San Joaquin River and agricultural drainage to mostly the Sacramento River (Figure 4.13). Some west Delta water may have also contributed to the increase in EC. Of the three sites, significant change in

EC due to eliminating SWP pumping was only seen at Old River at Tracy Road (Figure 4.14). A significant decrease in EC here from June through September was associated with a significant change in the source water, Sacramento River water replacing combined San Joaquin River and agricultural drainage. Interestingly, while the SWP pumping was eliminated beginning on January 6, 2002, these changes in EC and source water only became significant in June of 2002.

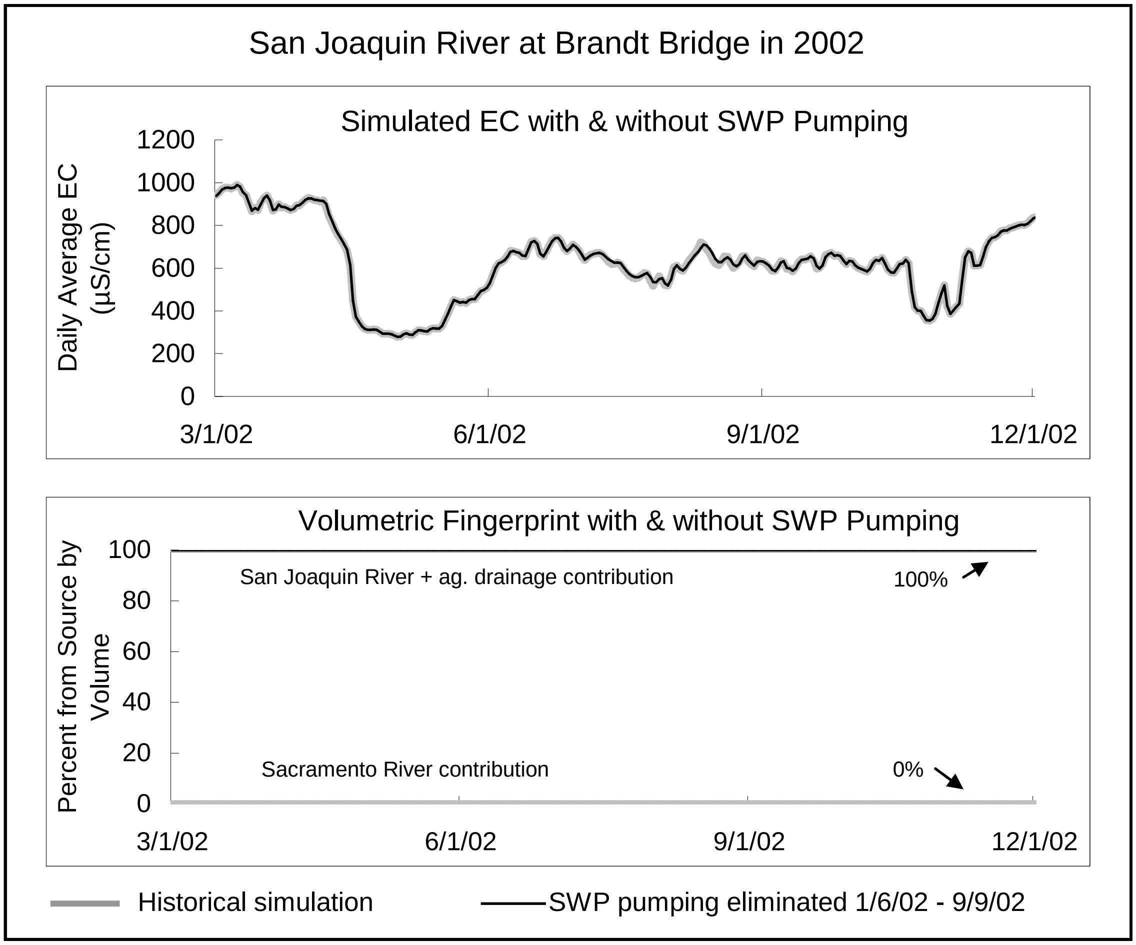

Figure 4.12: DSM2-modeled EC and volumetric fingerprint at Brandt Bridge for 2002 historical and modified conditions.

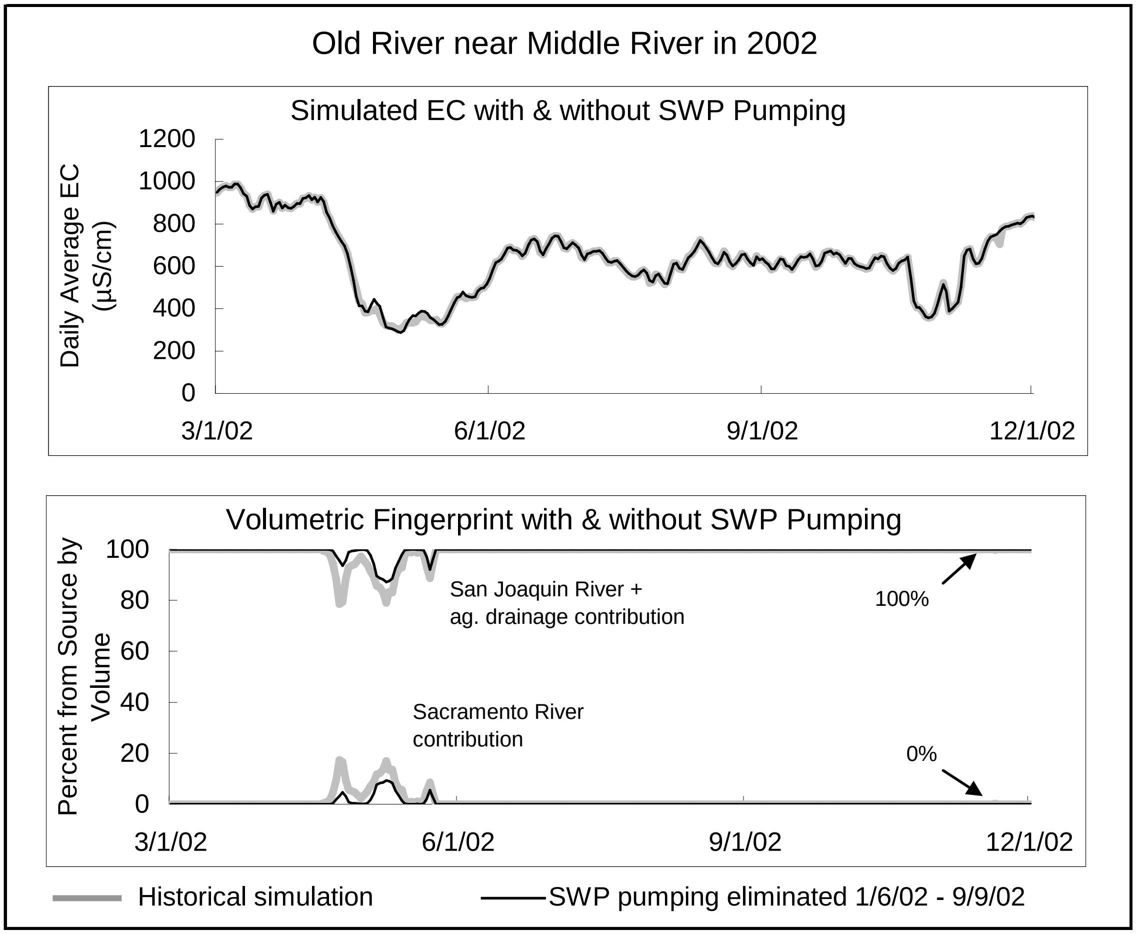

Figure 4.13: DSM2-modeled EC and volumetric fingerprint at Old River near Middle River for 2002 historical and modified conditions.

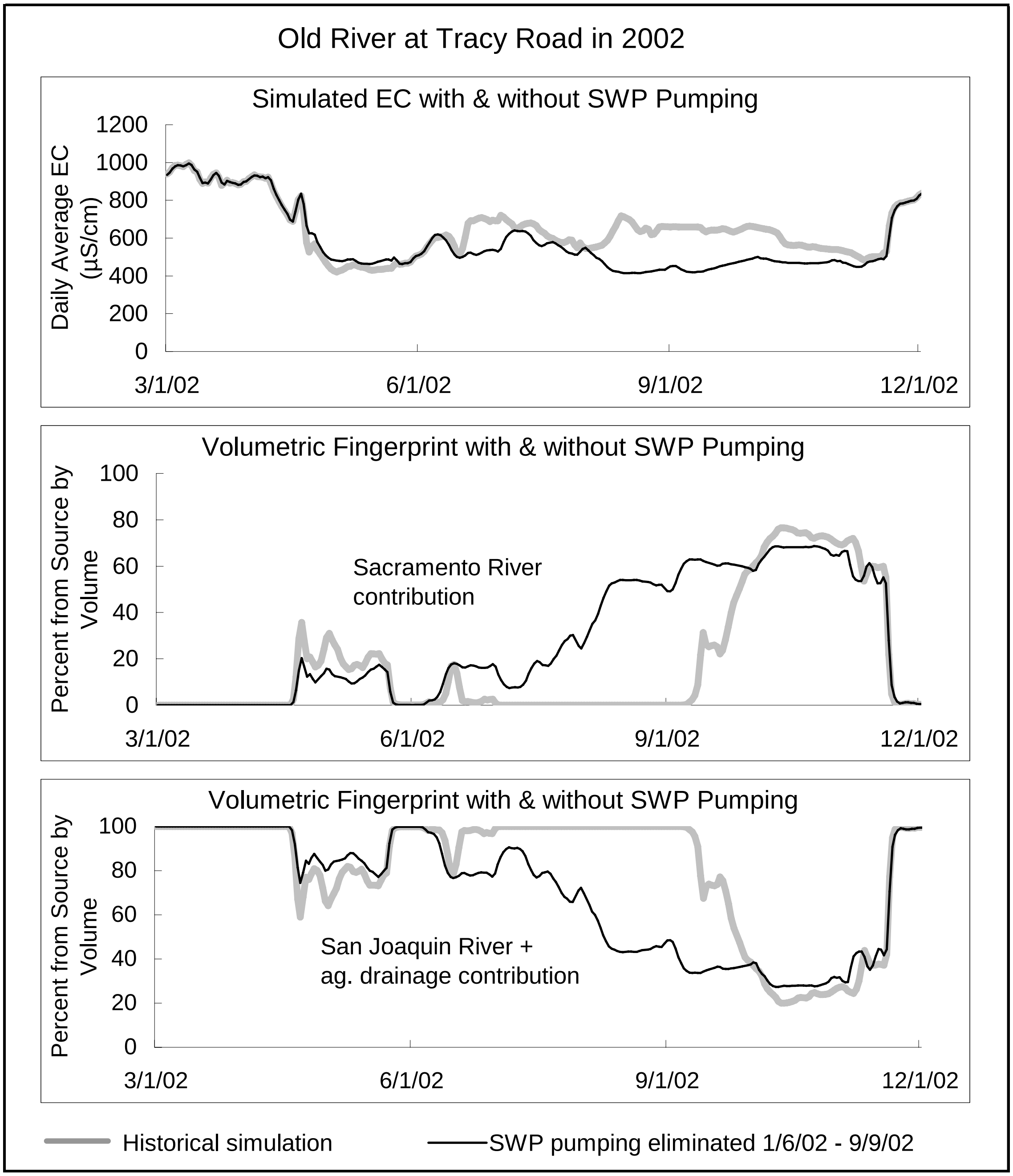

Figure 4.14: DSM2-modeled EC and volumetric fingerprint at Old River at Tracy Road for 2002 historical and modified conditions.

4.4.4 2003 Fingerprinting and EC

Figures 4.15, 4.16, and 4.17 present the EC and fingerprinting at the three locations for historical and modified 2003 conditions. At Brandt Bridge, the source of water in 2003 was again virtually entirely a combination of San Joaquin River and agricultural drainage and this did not significantly change when SWP pumping was eliminated (Figure 4.15). As a result, the EC here did not significantly change under the modified conditions. At Old River near Middle River, eliminating SWP pumping from 1/4/03 through 5/30/03 reduced the contribution of the Sacramento River as a source of water here and increased the combination of San Joaquin River and agricultural drainage (Figure 4.16). The result is a slight decrease then increase in EC here. At Old River at Tracy Road, eliminating SWP pumping shifted the source water here from Sacramento River to a combination of San Joaquin River and agricultural drainage and caused an increase in EC (Figure 4.17). As in 2002, eliminating SWP pumping did not have an effect on EC and the source of water until months later.

Comparing Figure 4.14 and Figure 4.17, eliminating SWP pumping can result in more or less Sacramento River reaching Old River at Tracy Road with the EC here either increasing or decreasing. In order to understand the conflicting results, more detailed analysis is needed of the historical hydrodynamic conditions and how these might change when SWP pumping is eliminated. In the 2002 simulation, the high SWP pumping combined with high CVP pumping induced a net downstream flow in Old River to Clifton Court Forebay despite the presence of the temporary Old River barrier. Eliminating SWP pumping allowed the Sacramento River water drawn to the south Delta by the CVP pumping and agricultural depletions to be moved upstream by the temporary barrier operation. In the 2003 simulation, eliminating SWP pumping reduced the amount of Sacramento River source water in the south Delta which meant less Sacramento River reaching Old River at Tracy Road and higher EC values here.

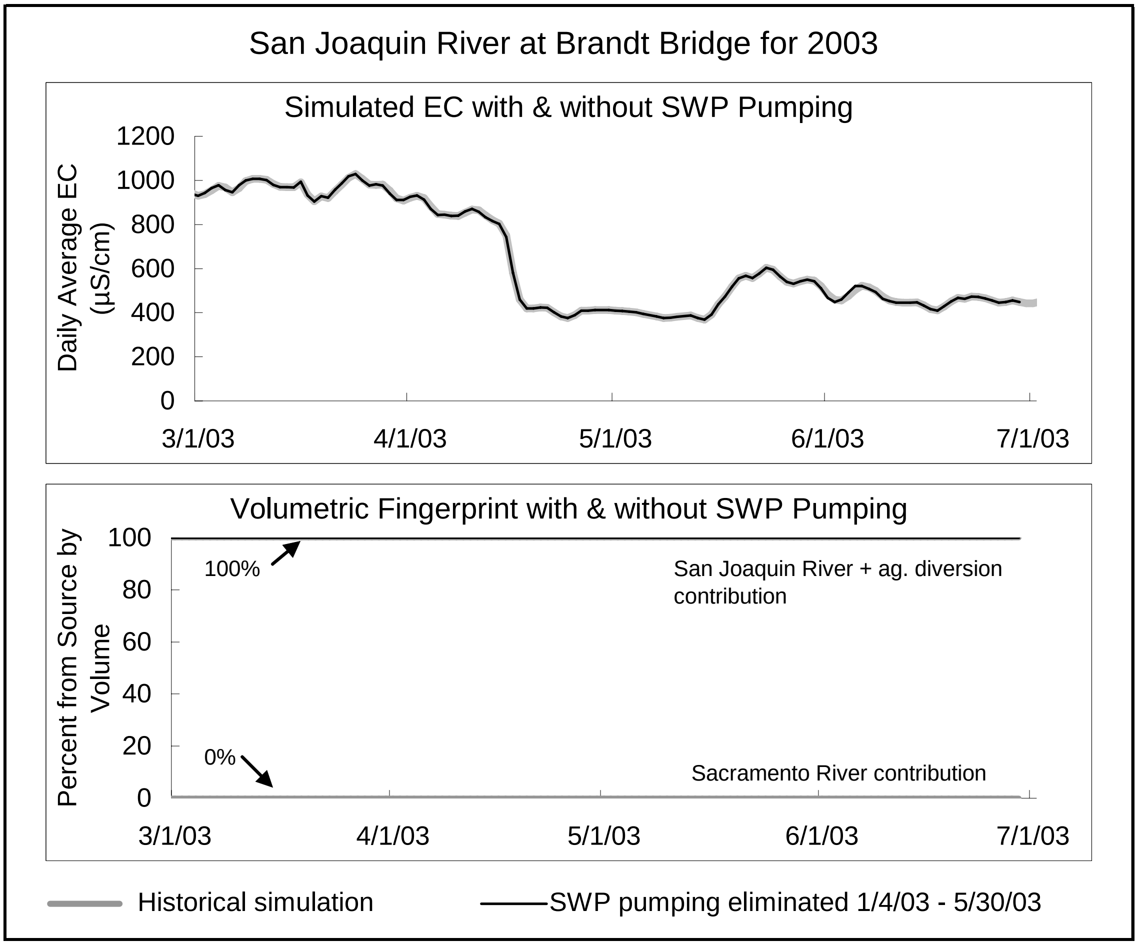

Figure 4.15: DSM2-modeled EC and volumetric fingerprint at Brandt Bridge for 2003 historical and modified conditions.

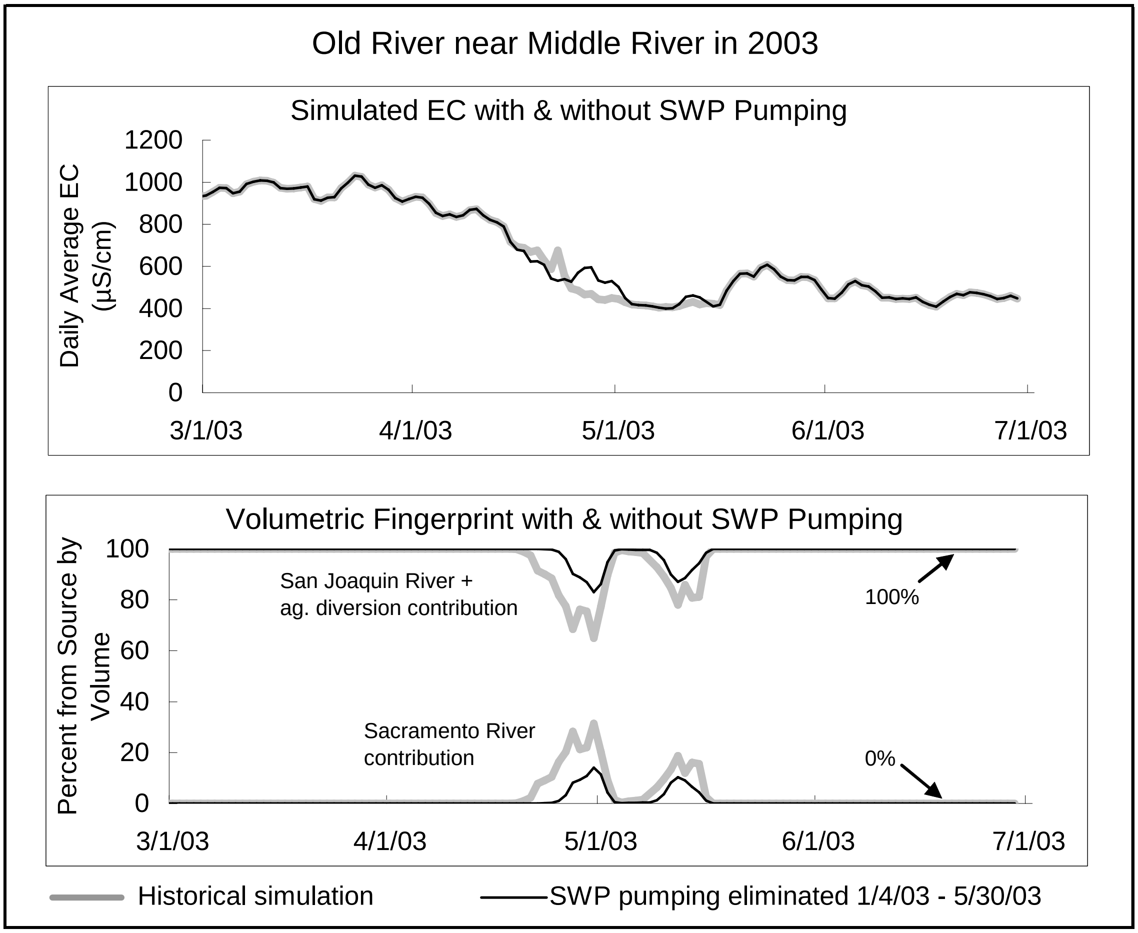

Figure 4.16: DSM2-modeled EC and volumetric fingerprint at Old River near Middle River for 2003 historical and modified conditions.

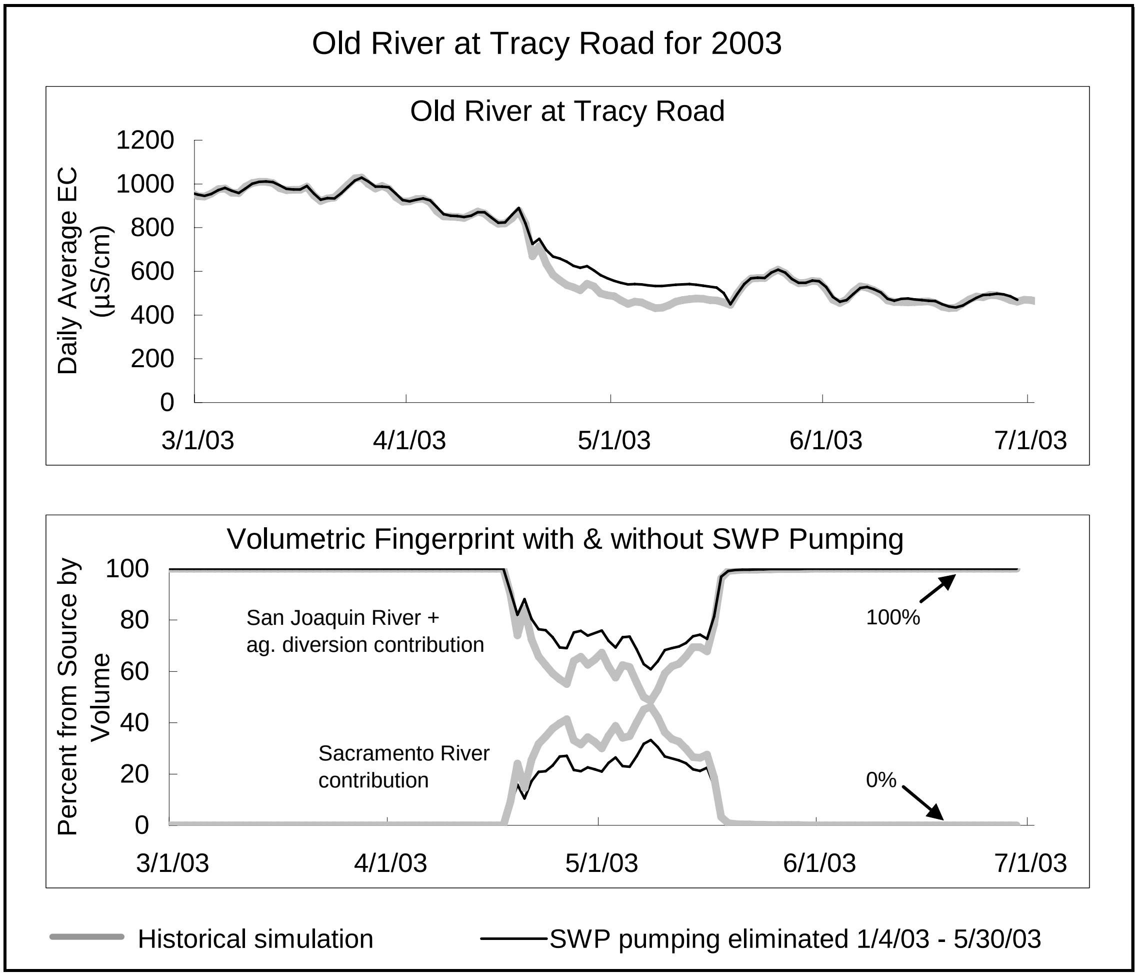

Figure 4.17: DSM2-modeled EC and volumetric fingerprint at Old River at Tracy Road for 2003 historical and modified conditions.

4.5 Summary and Conclusions

Modeled fingerprints of sources of water in the south Delta are valuable in interpreting changes in EC and explaining the movement of water due to hydrology, SWP pumping, and south Delta barrier operation. Water quality studies in the south Delta have tended to express results in terms of the extent operations of barriers or SWP pumping influence water quality. Underlying this information is an assumption that water in the Delta is being mixed differently. Fingerprinting allows direct analysis of how activities in the Delta affect mixing—in this case how SWP pumping affects the presence of water originating from the Sacramento River reaching the south Delta.

4.6 References

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Mierzwa, M. and Wilde, J. (2004). “Chapter 9: Using QUAL Fingerprinting Results to Develop DOC Constraints in CALSIM.” *Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh. 25th Annual Progress Report to the State Water Resources Control Board.* California Department of Water Resources, Bay-Delta Office, Sacramento, CA. http://modeling.water.ca.gov/delta/reports/annrpt/2004/2004Ch9.pdf

Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

27th Annual Progress Report
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Chapter 5:
A Relationship between Vernalis and Brandt Bridge Electrical Conductivity

Author: Bijaya Shrestha

5 A Relationship between Vernalis and Brandt Bridge Electrical Conductivity

5.1 Introduction

A relationship between the measured electrical conductivity in the San Joaquin River (SJR) at Vernalis and Brandt Bridge has been developed. This relationship may be used to estimate target San Joaquin River salinity, as measured and expressed by electrical conductivity (EC), at Vernalis to ensure meeting the Brandt Bridge salinity (EC) standard of 700 μS/cm during April through August and 1000 μS/cm during September through March. The relationship was based on Department of Water Resources and US Bureau of Reclamation 1994 – 2002 monthly-averaged EC data measured at Vernalis, Mossdale, and Brandt Bridge. The preliminary compilation and analysis of data from these three locations were done by Andy Chu (Project Operations Planning Branch, DWR).

5.2 Data Characteristics

For Vernalis, Mossdale, and Brandt Bridge (Figure 5.1), box plots of monthly averaged EC data were generated (Figure 5.2). Table 5.1 summarizes some of the descriptive statistics for the historical EC data at those periods.

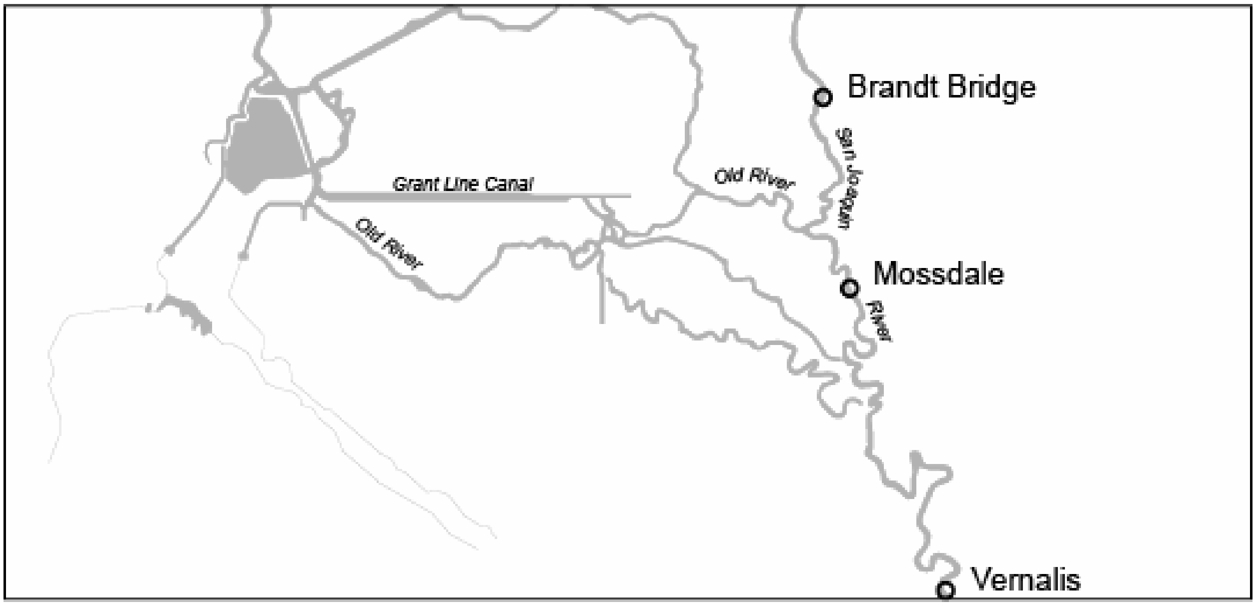

Figure 5.1: Locations of Vernalis, Mossdale, and Brandt Bridge on the San Joaquin River.

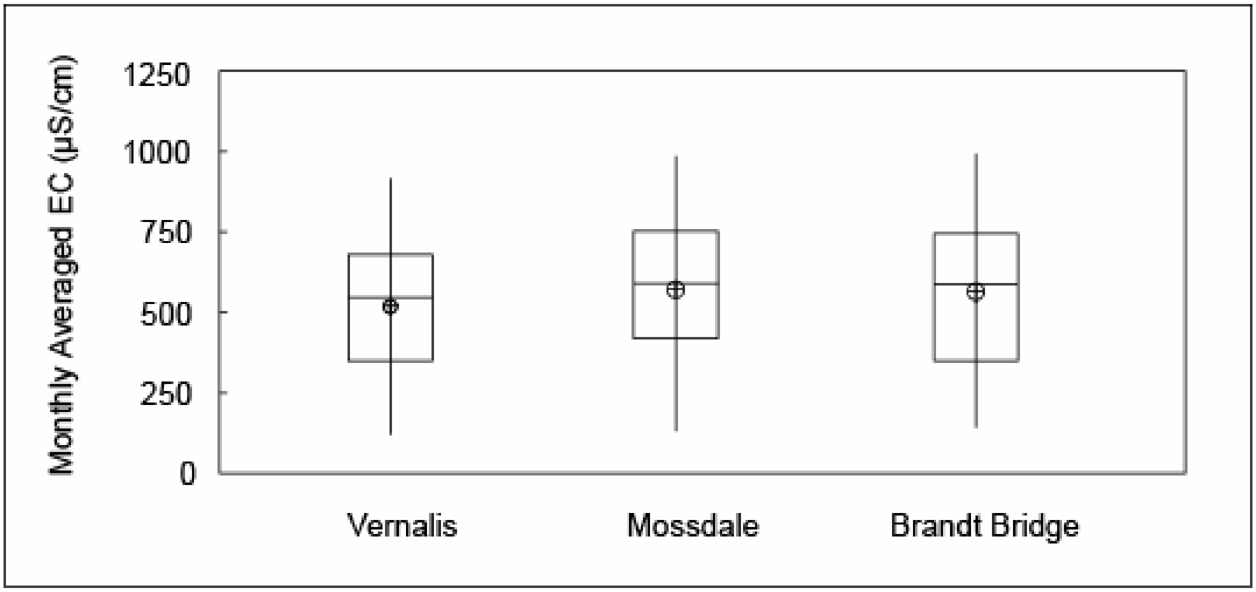

Figure 5.2: Box plots of Monthly-average EC at Vernalis, Mossdale and Brandt Bridge.

Table 5.1: Descriptive statistics of monthly EC at Vernalis, Mossdale and Brandt Bridge.

Location	Number of Data Points	Mean (µS/cm)	Standard Deviation (µS/cm)	Range (µS/cm)	
				Min	Max
Vernalis	108	518	206	121	917
Mossdale	86	570	222	133	982
Brandt Bridge	103	566	225	146	991

The monthly averaged EC from all three locations had a similar statistical distribution that was characterized by a large spread of values and an even distribution of lower and higher EC values. There were no outliers in the monthly average values.

5.3 Statistical Analysis

As shown in the scatter plot in Figure 5.3, monthly averaged EC at Vernalis and Brandt Bridge are strongly correlated, with a Pearson's correlation[1] of 0.97. A regression analysis of EC shows Brandt Bridge EC to be 1.08 times the Vernalis EC, indicating an 8% water quality degradation (as measured by EC) between Vernalis and Brandt Bridge.

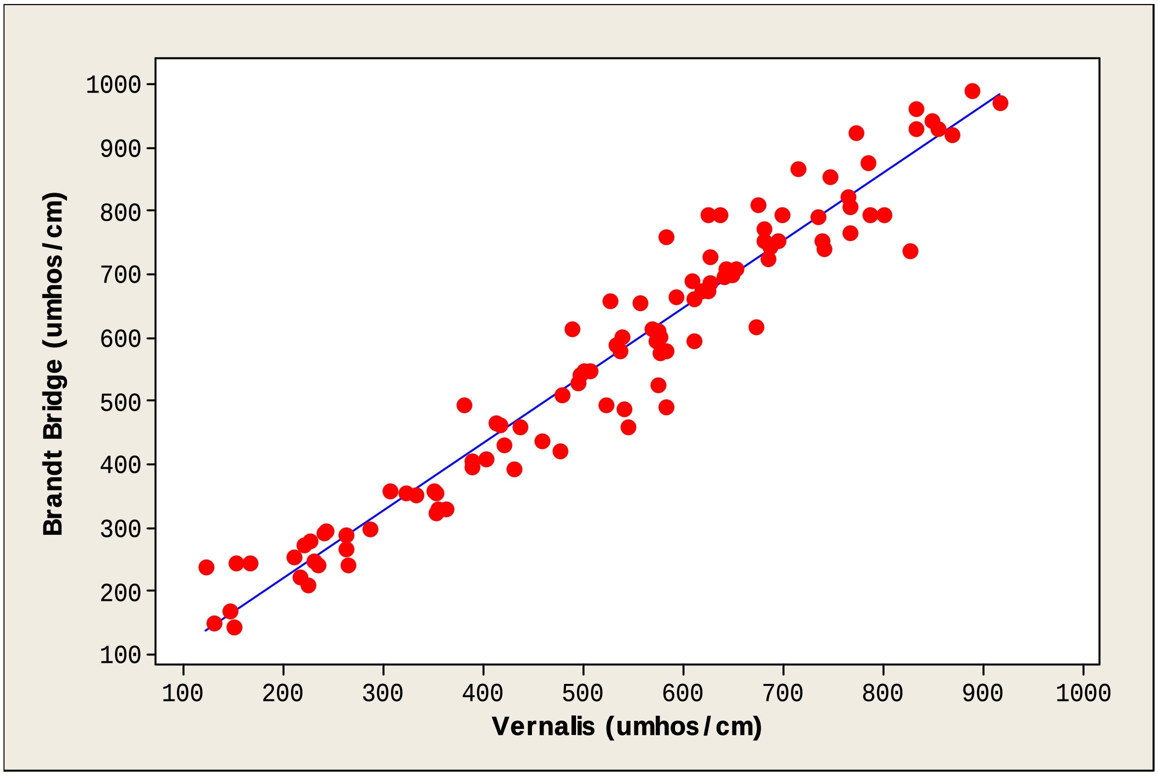

Figure 5.3: Brandt Bridge vs. Vernalis Monthly-averaged EC.

Using the standard error of regression and sum of squares, one can predict the Brandt Bridge EC as a function of Vernalis EC for a given confidence level. Figure 5.4 shows the required Vernalis EC to ensure a target Brandt Bridge EC (700 umhos/cm during Apr-Aug and 1000 EC for the rest of the months) at different confidence levels. The numerical values are provided in Table 5.2.

[1] The Pearson correlation r, measures the strength of the linear relationship between the X and Y variables. R^2, the coefficient of determination (a popular measure in regression analysis) is the fraction of the variance explained by the regression. In the least square regression, $R^2 = r^2$.

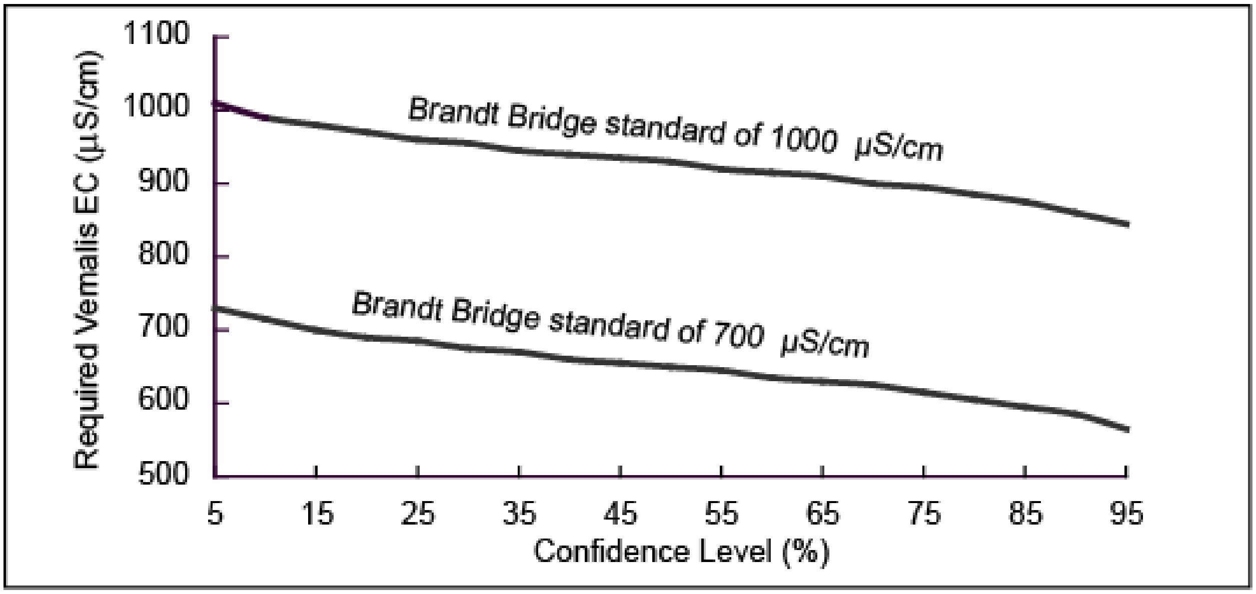

Figure 5.4: Required Vernalis EC to ensure target Brandt Bridge EC at different confidence levels.

An attempt was made to break down the salinity (EC) degradation estimate into two parts:

a) From Vernalis to Mossdale
b) From Mossdale to Brandt Bridge

Initial analysis indicates an average EC degradation of 7% between Vernalis and Mossdale and 1% between Mossdale and Brandt Bridge. Figure 5.5 shows the strong correlation between Vernalis EC and Mossdale EC, with a Pearson's correlation of 0.98.

Table 5.2: Required monthly-averaged EC at Vernalis to ensure compliance with the Brandt Bridge EC standards.

Required Vernalis EC to Ensure Brandt Bridge Standard is Met					
	Brandt Bridge Standard			Brandt Bridge Standard	
Confidence level	700 μS/cm	1000 μS/cm	Confidence level	700 μS/cm	1000 μS/cm
95	565	845	45	655	935
90	585	860	40	660	940
85	595	875	35	670	945
80	605	885	30	675	955
75	615	895	25	685	960
70	625	900	20	690	970
65	630	910	15	700	980
60	635	915	10	715	990
55	645	920	5	730	1010
50	650	930			

The EC at Brandt Bridge was at times lower than the EC at Mossdale, typically during net reverse flow conditions on the San Joaquin River between the two sites. Under these conditions, better quality water from downstream travels upstream in the San-Joaquin River as far as the head of Old River. Net reverse flows at Brandt Bridge usually occur during low San-Joaquin River flows at Vernalis (below 1,000 cfs) and high State Water Project and Central Valley Project pumping. Sometimes the EC at Brandt Bridge was lower than the EC at Mossdale even when the San-Joaquin River flow at Vernalis was 2,000 cfs or higher. This was especially noticeable for 1999 and later years.

In a separate analysis, the EC data was divided into two parts: data from prior to 1999 and data from 1999 to present. Regressional analysis from the earlier period suggested an average 4% EC degradation between Mossdale and Brandt Bridge, which is about half of the total EC degradation between Vernalis and Brandt Bridge. The second period suggested an average 1% EC improvement at Brandt Bridge relative to Mossdale. Developing an accurate estimate for the degradation of water quality in individual reaches requires a fairly accurate data set to within a few percent. Based on the analysis mentioned above, the measured EC data used may not have had the level of accuracy required for water quality analysis by separate reaches in the San Joaquin River.

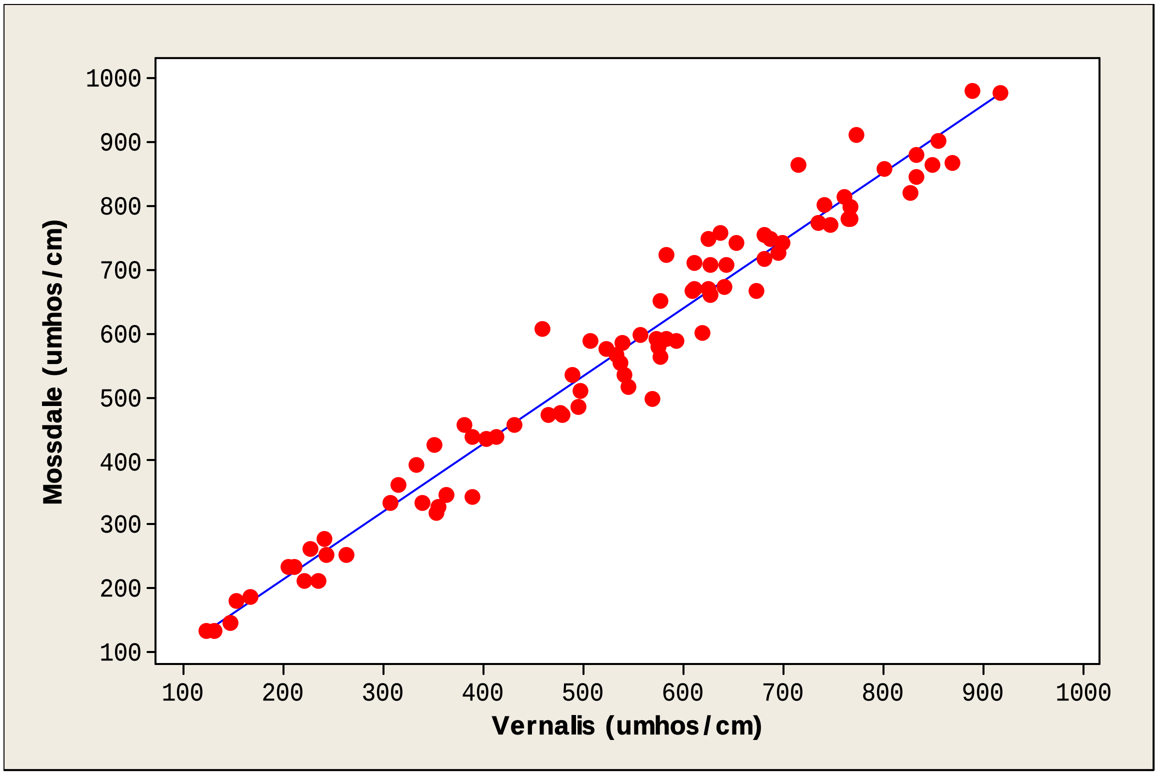

Figure 5.5: Monthly-averaged EC at Mossdale vs. Vernalis.

Since Mossdale is about 2.8 miles upstream of the confluence of Old and San Joaquin Rivers, it can be concluded the EC degradation between the head of the Old River and Brandt Bridge is less than half the total degradation between Vernalis and Brandt Bridge, and possibly much smaller. The reasons for this may be higher tidal flows in the San-Joaquin River downstream of the head of the Old River and possibly less agricultural drainage impact in the lower reach.

Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

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Chapter 6: Using DSM2 to Develop Operation Strategies for South Delta Improvements Program's Proposed Permanent Gates

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6 Using DSM2 to Develop Operation Strategies for South Delta Improvements Program's Proposed Permanent Gates

6.1 Introduction

The Department of Water Resources' (DWR) South Delta Improvements Program (SDIP) proposes the installation of four permanent operable gates in the south Delta. These gates are intended to replace the existing temporary barriers and have three primary objectives:

- minimize the number of in- and out-migrating salmon moving towards export pumps,
- maintain adequate water levels for South Delta farmers to prevent cavitation from occurring in their irrigation pumps, and
- improve water quality in the South Delta channels by providing better circulation.

One gate is proposed installed at the head of Old River (HOR) to minimize the impact of export pumps on the in- and out-migrating salmon. Periods of operation would be during the April 15 to May 15 Vernalis Adaptive Management Plan (VAMP) periods and in October and November. SDIP also proposes to install three permanent agricultural gates: in Middle River (MR) between the confluence of Victoria Canal and Tracy Road Bridge, in Old River (OR) near the confluence of Grant Line Canal and the Tracy Pumping Plant, and in Grant Line Canal (GLC) near the mouth of Grant Line Canal and toward the Clifton Court Forebay (CCF). Figure 6.1 shows the gate locations. All four South Delta permanent gates are assumed operable to provide significantly more flexibility than the existing temporary barriers. This chapter provides an overview of the problems with the water conditions in the South Delta channels and discusses using DWR's Delta Simulation Model II (DSM2) in driving the evolution of the plans for the operation of the permanent gates, plans which are included in the 2005 Draft SDIP EIR/EIS (DWR, 2005).

6.2 Overview of South Delta Channel Problems

For the last three decades, the farmers in the south Delta region have experienced problems operating the pumps and siphons used to irrigate their fields. The main problem was low water levels, but water quality has also been a concern. The South Delta Water Agency (SDWA) complained that the low water levels caused by tidal affects in the Delta had been exacerbated by the operation of the State Water Project (SWP) and Central Valley Project (CVP) pumps. After years of negotiations, the Department of Water Resources (DWR) agreed to install, when needed, seasonal temporary rock barriers in Middle River, Old River, and Grant Line Canal (referred to as agricultural barriers). It was also agreed that DWR would install a temporary rock barrier at the head of Old River during the spring and fall to help migrating salmon.

The current temporary agricultural barriers help capture water during flood tides by allowing flow through culverts with flap-gates, and then prevent flow downstream during the ebb tide once the water level drops below the weir crest elevation. When all three temporary agricultural barriers are installed, the water levels upstream of the barriers are typically adequate for the farmers to irrigate their farms. However, the water quality in the area bounded by the temporary south Delta barriers can be poor. This is because the water captured upstream of the agricultural barriers is predominantly from the San Joaquin River with some agricultural drainage added, and this drainage water is usually much saltier than the river water (see Chapter 4 for more information on sources of salinity in the South Delta). A possible exception to the poorer water quality upstream of the barriers is in the section of the rivers immediately upstream of the barriers. These regions receive a portion of the water that is moving upstream on the flood tide, water which at times is primarily of Sacramento River origin. This water is typically of better quality than that originating from San Joaquin River. Unfortunately under typical conditions the flood tide does not provide sufficient energy to transport the better quality water very far upstream of the barriers. When the San Joaquin River flow at Vernalis is below 1200 cfs, particularly during the summer irrigation season, the net tidal flows in Middle River, Old River, and Grant Line Canal upstream of the barriers are near zero. Under these conditions of little circulation, the concentration of salt in south Delta channels can significantly increase due to return flows from agricultural drainage.

The permanent operable gates proposed in the SDIP would provide much more operational flexibility than the current temporary agricultural barriers. In support of the SDIP, operating rules for the permanent gates were sought that use tides to provide improved circulation and transport more of the better quality of Sacramento River source to the channels upstream of the gates, while also improving water levels.

6.3 Development of Plan C Gate Operations

In 2003 SDIP management requested the Delta Modeling Section design an operation of South Delta gates that maintains specified minimum water levels at three locations: Middle River near Undine Road Bridge, Old River near Tracy Road Bridge, and Grant Line Canal near Tracy Road Bridge. The target minimum levels at the sites were originally 0.5 ft mean sea level (MSL), 0.0 ft MSL, and 0.0 ft MSL respectively. The more stringent 0.5 ft. MSL minimum water level at Middle River near Undine Road would be the controlling stage criteria since the three locations are hydraulically connected. That is, meeting the 0.5 ft. MSL minimum stage requirement at Middle River near Undine Road would ensure that the target minimum stages at the other two locations would be met. The Middle River location originally had higher target minimum water level due to Middle River reaches being more shallow compared to those of Grant Line Canal and Old River. SDIP negotiated with SDWA to lower the Middle River target minimum water level to 0.0 ft MSL provided DWR agreed to dredge a portion of Middle River to improve the conveyance in Middle River. Therefore, for the process of establishing strategies for permanent gate operation, the 0.0 ft. MSL minimum water level was assumed the criterion at all three locations.

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6.3.1 Plan A Operation

The first series of permanent operable gate operations developed by the Delta Modeling Section is labeled "plan A." This proposed gate operation focuses on achieving the minimum water level criteria. It was used in SDIP's 2005 Draft Environmental Impact Statement/Environment Impact Report (DWR, 2005).

The fish gate at the head of Old River (HOR) is assumed fully closed during the April 15 to May 15 VAMP period and partially closed during periods in October and November. During these fall periods, the gate is assumed to allow 10 to 15% of the flow from San Joaquin River to pass into Old River to improve water quality by reducing stagnation problems downstream of the fish gate. These gate operations are overridden anytime the San Joaquin River flow at Vernalis exceeds 18,500 cfs, at which times the gate is assumed fully opened to protect against flooding. At all other times outside these spring and fall operations, the fish gate is kept open.

When operating, the Middle River (MR) and Old River (OR) gates are assumed operated as full tidal gates. They are always open during flood tides and are simultaneously closed during the ebb tide when the minimum water level at any one of the three target locations falls below 0.0 ft MSL. When operating, the Grant Line Canal (GLC) gate is also always open during flood tides, but its closure during ebb tide is more complex. During ebb tides, the GLC gate is operated as a special weir with a 1 ft. MSL crest elevation if MR and OR gates fail to maintain the 0.0 ft MSL water level target. The GLC gate allows water to flow downstream as long as water levels at the three target locations are higher than 1ft. MSL.

The timing of the "plan A" gate operations was developed in an iterative process. The first iteration, which assumed no gates where operating (i.e. the gates were open), identified times when minimum water levels fell below 0.0 ft MSL at the target locations. In the second iteration, the MR and OR gates were simultaneously tidally operated during the times water levels in the first iteration fell below 0.0 ft MSL. A transitional period component was included for gradual opening to closing, and a buffer time was included to insure water levels do not fall below the 0.0 ft MSL threshold. In the third and final iteration, Grant Line Canal was operated when operating the other two gates failed to achieve or maintain the target minimum water levels.

6.3.2 Plan B Operation

The "plan A" gate operation strategy resulted in the gates being operated too often. Due to transitional and buffer times (in all three gates), as well as the higher weir crest elevation for the Grant Line Canal gate, the upstream water levels at the gates locations (eastward and away from project pumps) was higher than needed to achieve the target levels. While generating the higher water levels, the "plan A" gate operation failed to maintain adequate circulation, and as a result, significant improvement in water quality did not occur. The "plan A" gate operation was modified (also known as the "plan B" gate operation) by eliminating the transitional and buffer times and reducing the crest elevation for GLC weir to 0.0 ft MSL. The "plan B" gate operation showed slight improvement in circulation and water quality compared to the "plan A" gate operation.

6.3.3 Plan C Operation

"Plan C" and "modified plan C" gate operations evolved to achieve the objective of improving water quality with better flow circulation in south Delta channels in addition to maintaining adequate water levels. These gate operation strategies attempt to maintain unidirectional net flows in the Middle River, Old River, and Grant Line Canal reaches to avoid flow stagnation and subsequent increases in salt concentrations in south Delta channels. In addition to improving water quality and water levels in the south Delta, "modified plan C" improves flows and dissolved oxygen in the San Joaquin River downstream of Old River at Head.

Plan C and Modified Plan C Gate Operation Rules

Unlike the "plan A" and "plan B" operations, the "plan C" and "modified plan C" operation rules are dependent on the San Joaquin River (SJR) hydrology at Vernalis. Because the fish gate operation dictates the amount of flow into the South Delta region through Old River, the agricultural gate operation is also dependent on the operation of the fish gate. Tables 6.1 and 6.2 summarize the "plan C" gate operation rules.

Table 6.1: Operation of Head of Old River Gate (Fish Gate).

Condition	Head of Old River (HOR) Gate
SJR > 10000	Fully Open
Pre, VAMP and Post VAMP (APR- MAY)	Fully Closed
Fall (OCT – NOV)	Partial leakage of flow (about 10 to 15%, achieved in DSM2 by using flow coefficients of 0.02)
Summer (JUN – SEP) and 2500 cfs > SJR > 800 cfs	Limit flow through Head of Old River to 500 cfs.

Table 6.2: Operation of Agricultural Gates.

Condition		Middle River (MR)	Old River at Tracy (OR)	Grant Line Canal (GLC)
If HOR is operated (see Table 6.1)		Operated	Operated	Operated
If HOR is open AND Monthly Flow (cfs)	SJR < 2500	Operated	Operated	Operated
	2500 < SJR < 4000	Fully Open	Operated	Operated
	4000 < SJR < 8000	Fully Open	Fully Open	Operated
	SJR > 8000	Fully Open	Fully Open	Fully Open

When the MR and OR gates are operated, they are fully open during flood tides and fully closed during ebb tides. When the GLC gate is operated, it is fully open during flood tides and the early part of ebb tides. Once the water levels approach the target minimum water levels of 0.0 ft.

MSL, the GLC gate is partially closed to protect minimum water levels. In DSM2, during ebb tides, the GLC gate is modeled as a series of culverts with the crest elevation of -0.5 MSL.

The “modified plan C” gate operation differs from the “plan C” gate operation by limiting the flow down the head of Old River in the summer months (June – September) to 500 cfs the when San Joaquin River flow at Vernalis is between 800 and 2500 cfs. Studies have shown that for these conditions, a diversion of about 500 cfs of San Joaquin River flow down the head of Old River is sufficient to meet the minimum water level criteria at the three target locations. In addition, limiting the amount of San Joaquin River flow down Old River keeps more flow in the main stem of the San Joaquin River, which in turn improves water levels, water quality, and dissolved oxygen in the San Joaquin River. The magnitude of the tidal pumping through MR and OR gates also will increase slightly. The object-to-object feature of DSM2 was used to directly relocate water on one side of the HOR to the other, without having to change the way DSM2 simulates gate structures.

Figures 6.1 to 6.4 show the gates locations, gates operation rules, and the likely direction of net flows in South Delta channels. Figure 6.5 shows the additional rule that applies only to the “modified plan C” gate operation.

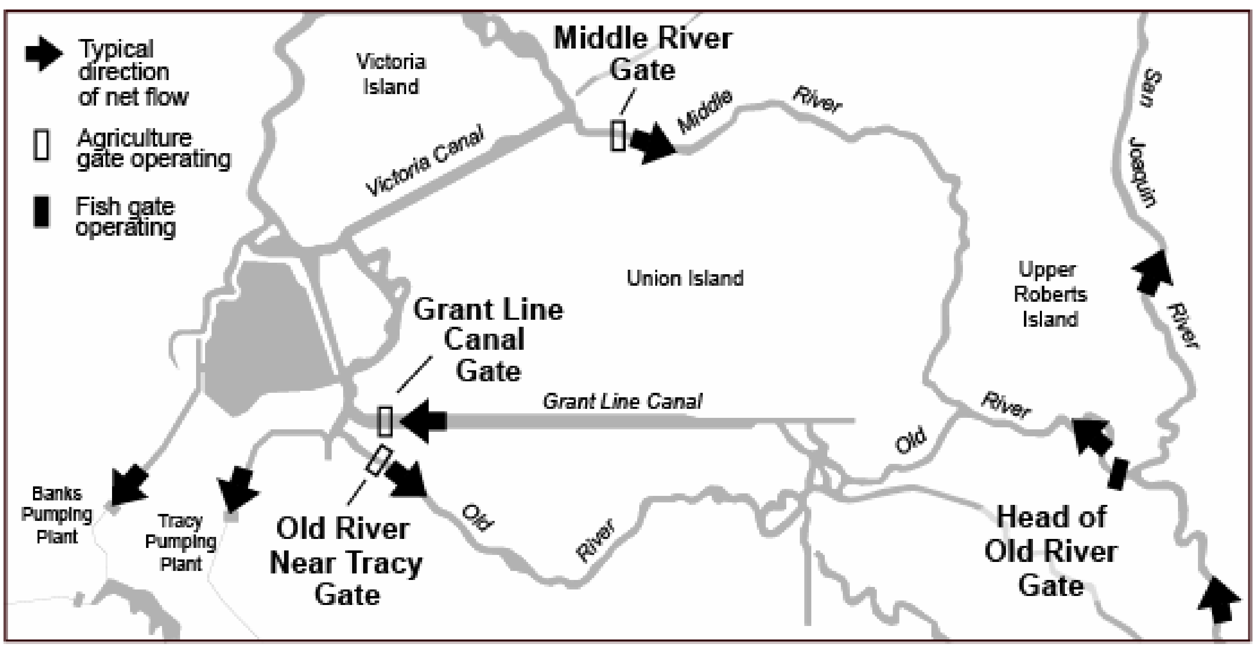

Figure 6.1: South Delta permanent gate operation for low San Joaquin River flows (SJR< 2500 cfs) or Old River at head gate closed.

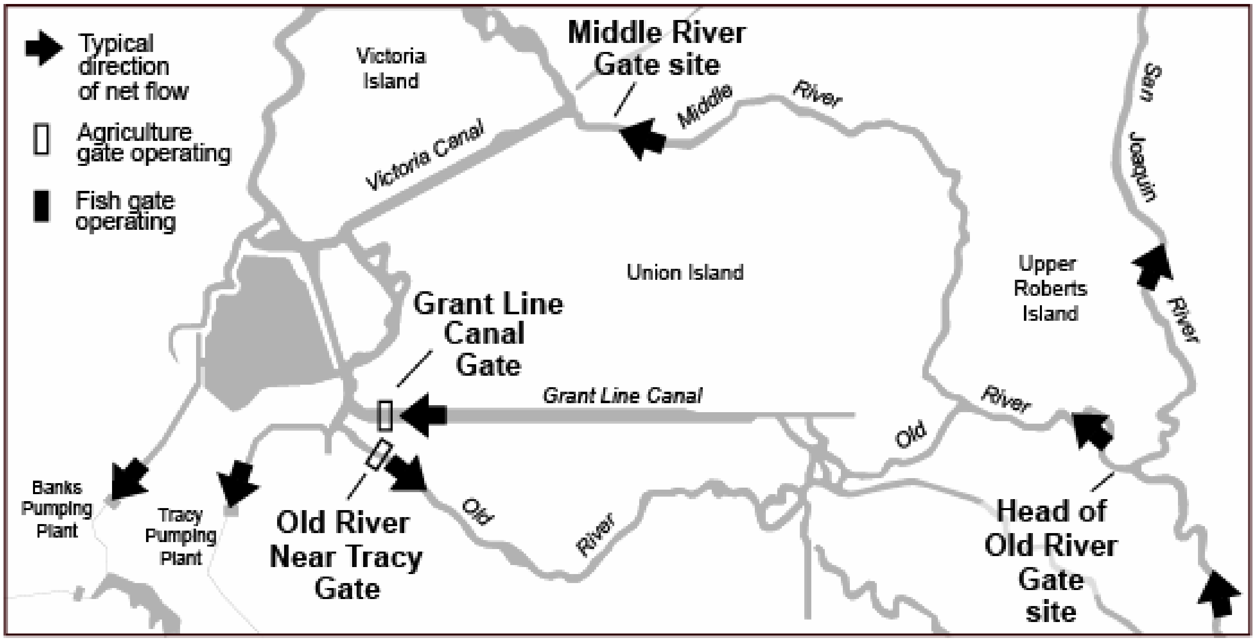

Figure 6.2: South Delta permanent gate operation for intermediate San Joaquin River flows (2500 < SJR < 4000 cfs) and head of Old River gate open.

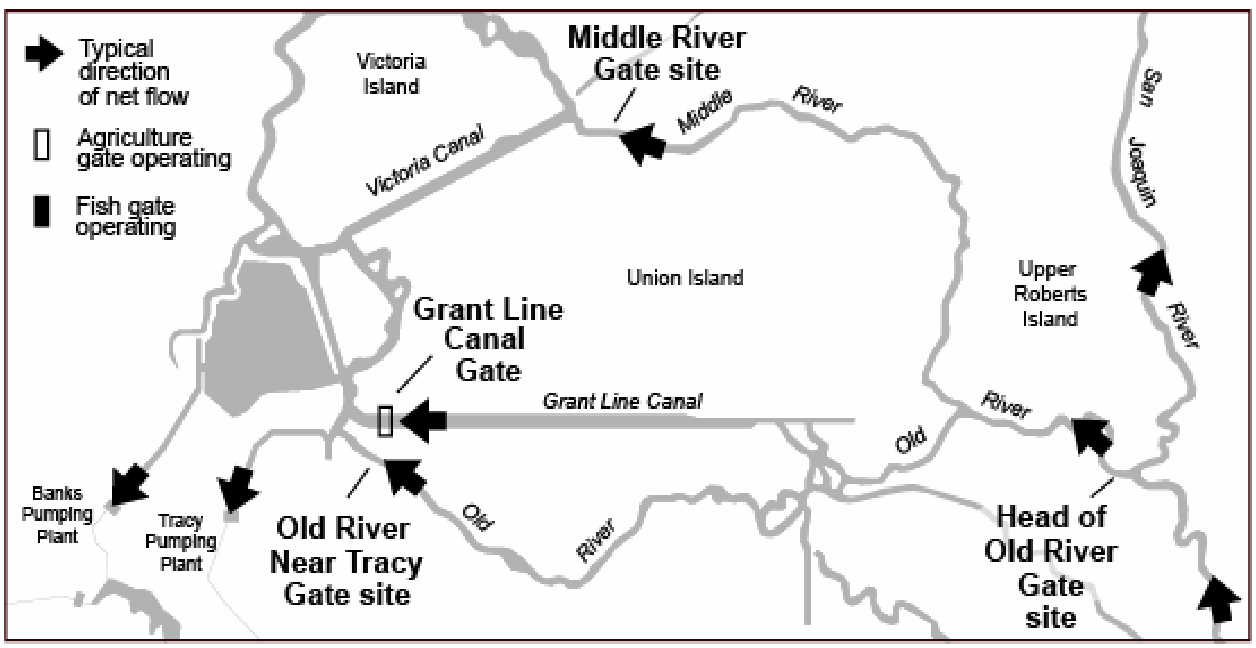

Figure 6.3: South Delta permanent gate operation for high San Joaquin River flows (4000 < SJR < 8000 cfs) and HOR open.

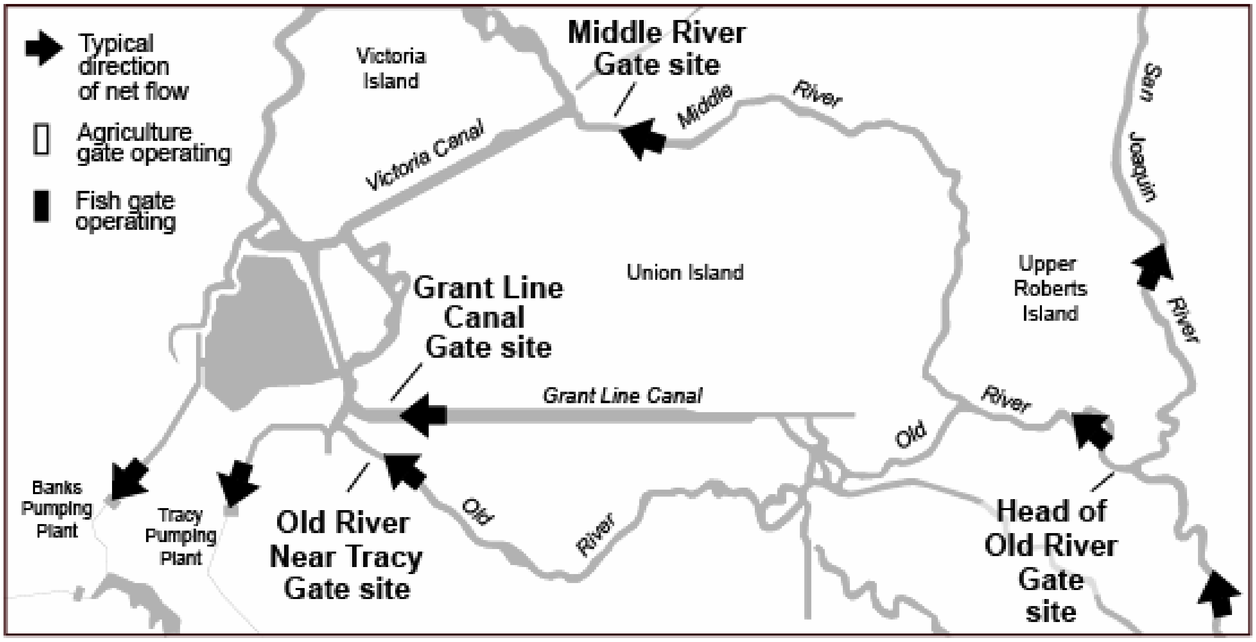

Figure 6.4: South Delta permanent gate operation for very high San Joaquin River flows (SJR > 8000 cfs).

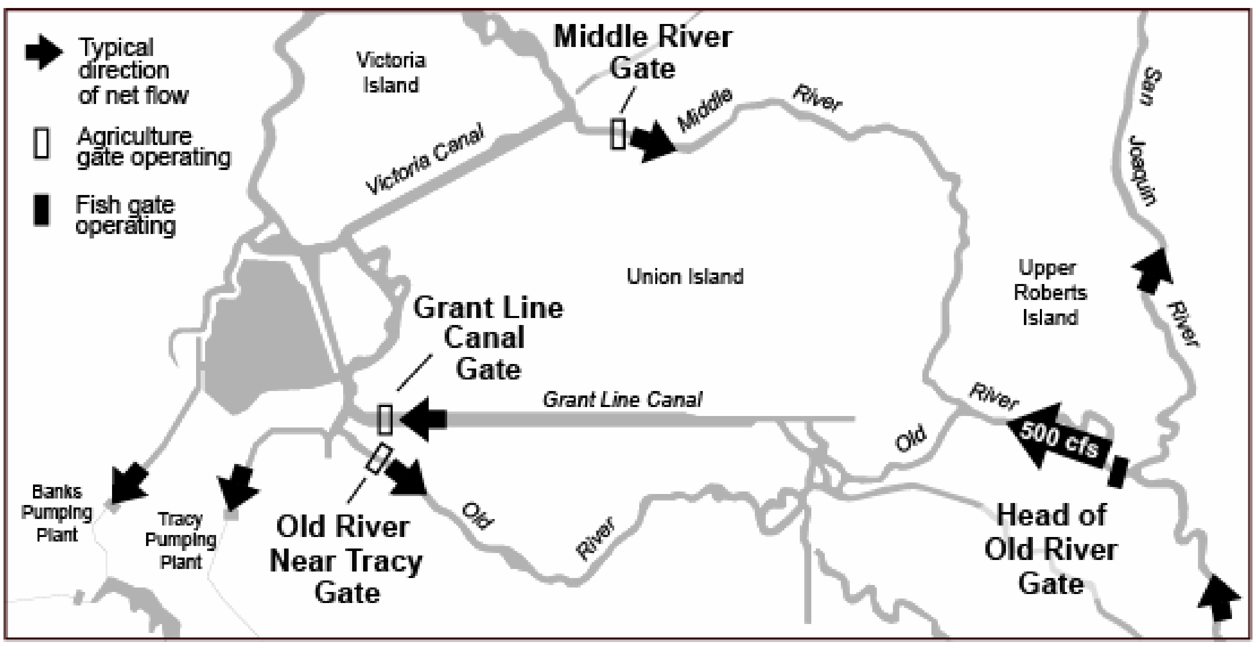

Figure 6.5: South Delta permanent gate operation for Modified Plan C (Jun-Sep) San Joaquin River (800 < SJR < 2500 cfs) and head of Old River gate closed.

6.4 Summary and Recommendations

The south Delta gate operation methodologies ("plan C" and "modified plan C") described here are general operation rules that are simple and easy to implement. The number of agricultural gates operated depends solely on the anticipated San Joaquin River flow at Vernalis and whether the fish gate at the head of Old River is operated. In general, the "modified plan C" (or "plan C") operation rule is sufficient to maintain adequate minimum water levels and water quality in the south Delta reaches most of the time. However, there are still a few times in the simulations when minimum water levels fall below 0.0 ft MSL at the target locations. These violations occur mostly during high San Joaquin flows when either the Middle River gate or both Middle and Old River gates are assumed not needed under the general rule; hence, these violations were artifacts of the simple operating rules. In reality, such violations can easily be prevented by more refined operating rules that call for either the Old River or both Middle and Old River gates operated during such conditions.

In the proposed general gate operation rules, the Grant Line Canal gate is usually operated differently from the Middle River and Old River gates. The Middle River and Old River gates, when operated, allow flow only in the upstream direction during flood tide. The Grant Line Canal gate serves as the main outlet for stored water, allowing water to leave south Delta channels during the ebb tide and inducing unidirectional flow in the three channels. As discussed earlier, unidirectional flow provides better circulation and helps to improve water quality. Under certain conditions, especially during neap tide, the flood tide lacks sufficient upstream energy to create unidirectional flow in Middle and Old rivers. This in turn may cause stagnation and an increase in salinity concentration. Studies have shown that during these times, which typically last about 3 to 4 days, changing the gate operations by having some combination of the Old River or Middle River gates act as outlets may induce the desired circulation. The flexibility of permanent operable gates allows such alternate operations which can resolve specific problems that are inadequately addressed with using standard operations.

6.5 Reference

California Department of Water Resources. (2005). *South Delta Improvements Program Draft Environmental Impact Statement/Environmental Impact Draft Report, 2005.* Sacramento, CA: California Department of Water Resources, Bay-Delta Office.

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Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

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Chapter 7: Estimates for Consumptive Water Demands in the Delta using DETAW

Author: Tariq Kadir

7 Estimates for Consumptive Water Demands in the Delta Using DETAW

7.1 Introduction

A new model, Delta Evapotranspiration of Applied Water (DETAW), is being developed to enable consistency between the Department of Water Resources' models CalSim-II and DSM2 and to improve the estimation of consumptive water demands in the Delta for the two models spatially and temporally. DETAW is based on the Simulation of Evapotranspiration of Applied Water (SIMETAW) model (DWR, 2006a,b) with modifications to account for Delta-specific conditions such as seepage from channels. DETAW estimates daily consumptive water demands for 168 subareas within the Delta Service Area at both historical (time varying) and projected (fixed) levels of land use development for the 1922-2003 simulation period. DETAW is driven by a graphical user interface (GUI) that allows for both input data modifications and graphical viewing of a wide array of computed results.

7.2 Background

The CalSim-II model used for planning studies of both the State Water Project (SWP) and Central Valley Project (CVP) systems uses projected land use level based estimates of monthly evapotranspiration of applied water (ETAW) for the lowlands and uplands of the Delta for the simulation period currently 1922-2003. These estimates are computed using the Consumptive Use model (Barnes, 1979). DSM2 uses estimates of monthly ETAW for 142 subareas in the Delta which are computed using the Delta Island Consumptive Use (DICU) model (DWR, 1995). These estimates are then processed to develop the node-specific diversions and return flows for DSM2. Due to differences in the spatial resolutions and computational procedures of the CU and DICU models and differences in the types and sources of input data, results for these two models are not completely consistent. To address these issues a new model called DETAW was developed by UC Davis in cooperation with DWR's Division of Planning and Local Assistance and funded by the Modeling Support Branch of the Bay-Delta Office.

7.3 Description of DETAW

DETAW is a GUI-driven C^{++} computer application for estimating ETAW. DETAW estimates daily soil water balances for subareas within the Sacramento-San Joaquin River Delta region by accounting for evapotranspiration losses and water contributions from rainfall, seepage, and irrigation. This water balance model is similar to that used in the SIMETAW model developed cooperatively by DWR and UC Davis. DETAW calculates daily ETAW for both historical and projected land use development levels. Land and water use categories include eleven crop categories, urban land use, riparian areas, and open water surfaces. For DETAW, historical daily precipitation for 1922-2003 is used for both historical and projected level computations. However, the precipitation (as well as other parameters such land use, etc) can be modified in

DETAW for alternative scenarios, including climate change studies. At the historical level, the crop and urban acreages vary from year to year reflecting actual changes in land use and shifts in crop acreages. At the projected level two land use types are used: one GIS pattern for years that are classified according to the Sacramento Valley Water Year as dry or critical, and another pattern for years that are classified as wet, above normal, or below normal. In either case, total acreages by category (e.g., crop type or urban use) are established through estimation at the Delta Uplands and Delta Lowlands aggregate level; they are then disaggregated to 168 subareas based on two GIS-based land use distributions. For wet, above normal, and below normal years, a GIS composite from the 1992-2002 land use surveys is used (Figure 7.1). For dry and critical years, the 1976 survey GIS layer for the Delta is used (Figure 7.2).

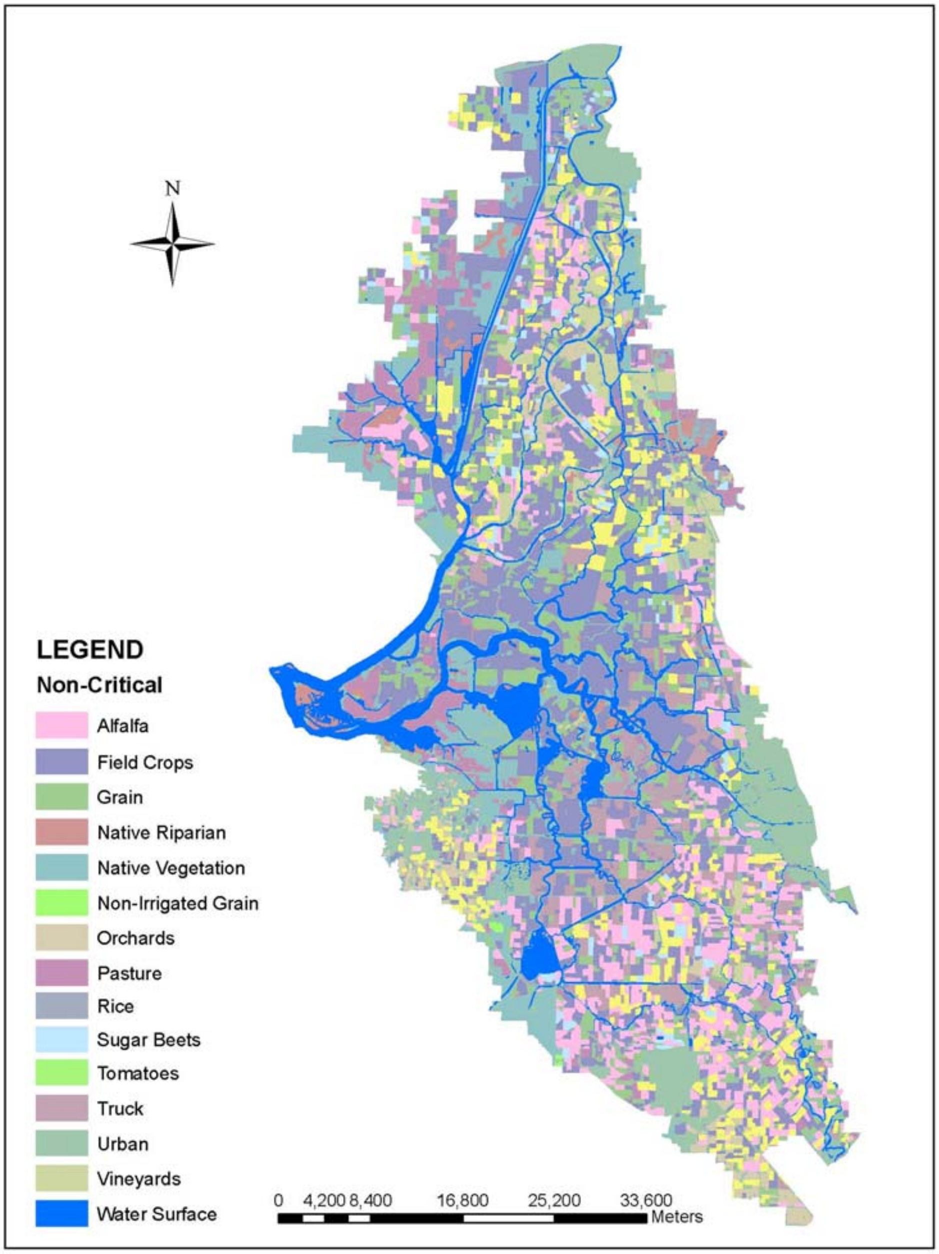

Figure 7.1: Delta land use in non-critical or non-dry water years.

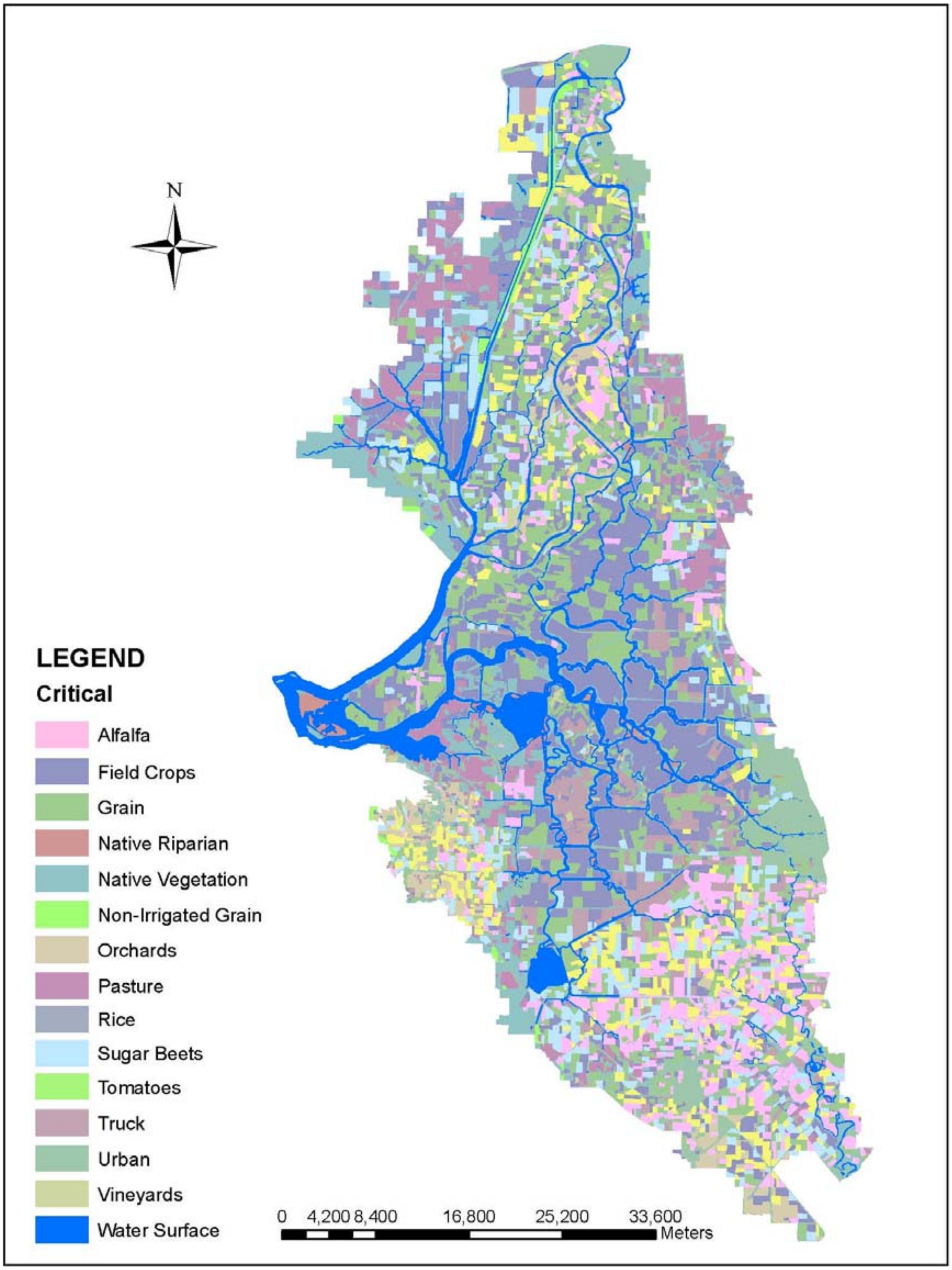

Figure 7.2: Delta land use in critical and dry water years.

Daily estimates of ETAW can be aggregated by DETAW temporally (monthly and annual) and spatially (e.g., by uplands and lowlands) to meet any modeling data needs.

7.4 DETAW's 168 Subareas

The original 142 subareas for the DICU model (Figure 7.3) were digitized from a printed schematic since no CAD schematic or GIS layer could be located. The digitized map was rectified into a GIS layer (Figure 7.4). For spatial analysis computational reasons, the areas were further disaggregated into the168 subareas (Figure 7.5) to eliminate any "satellite" or disjointed areas as represented in the 142 subarea configuration.

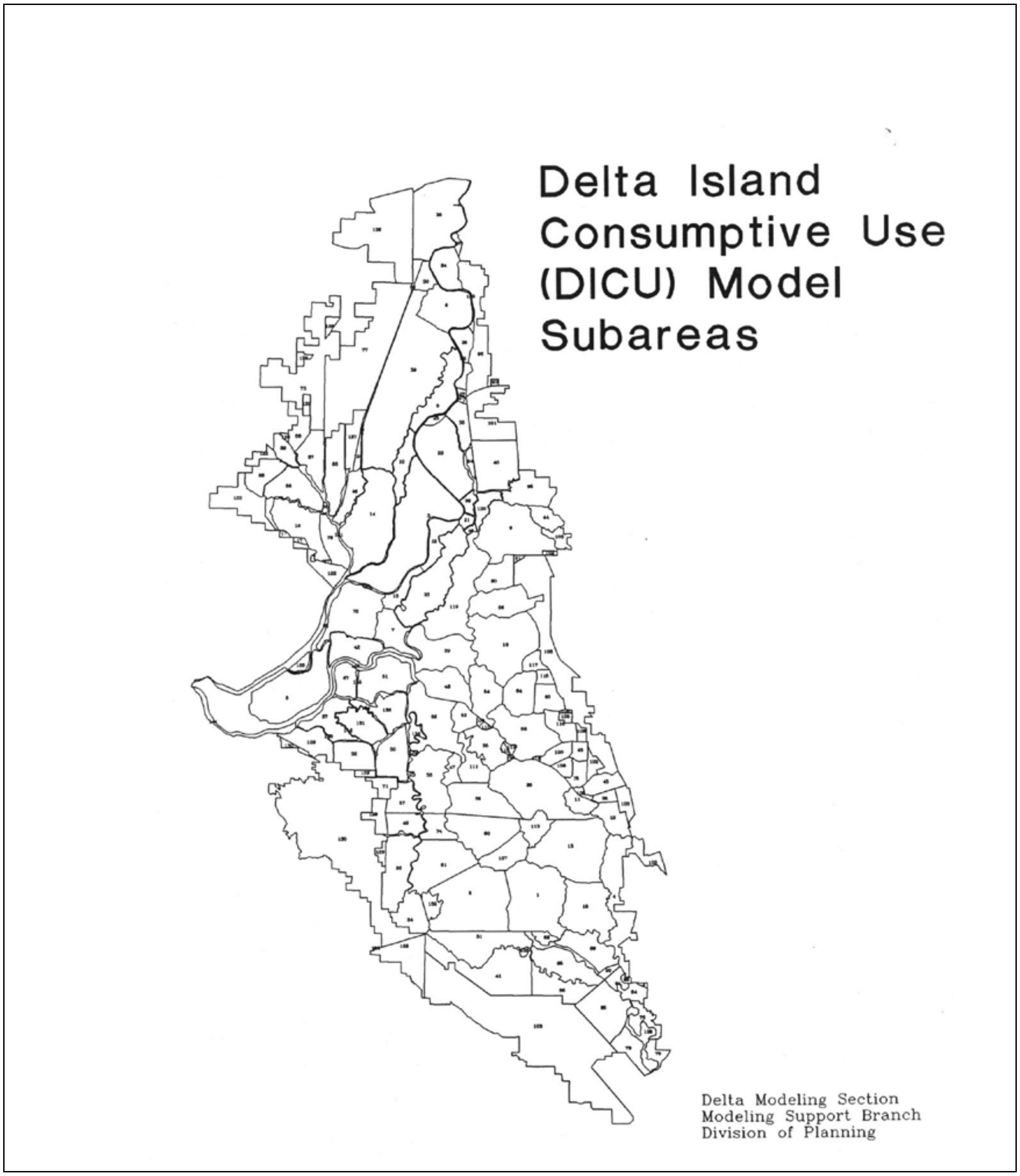

Figure 7.3: Base map for the 142 Delta subareas in DICU.

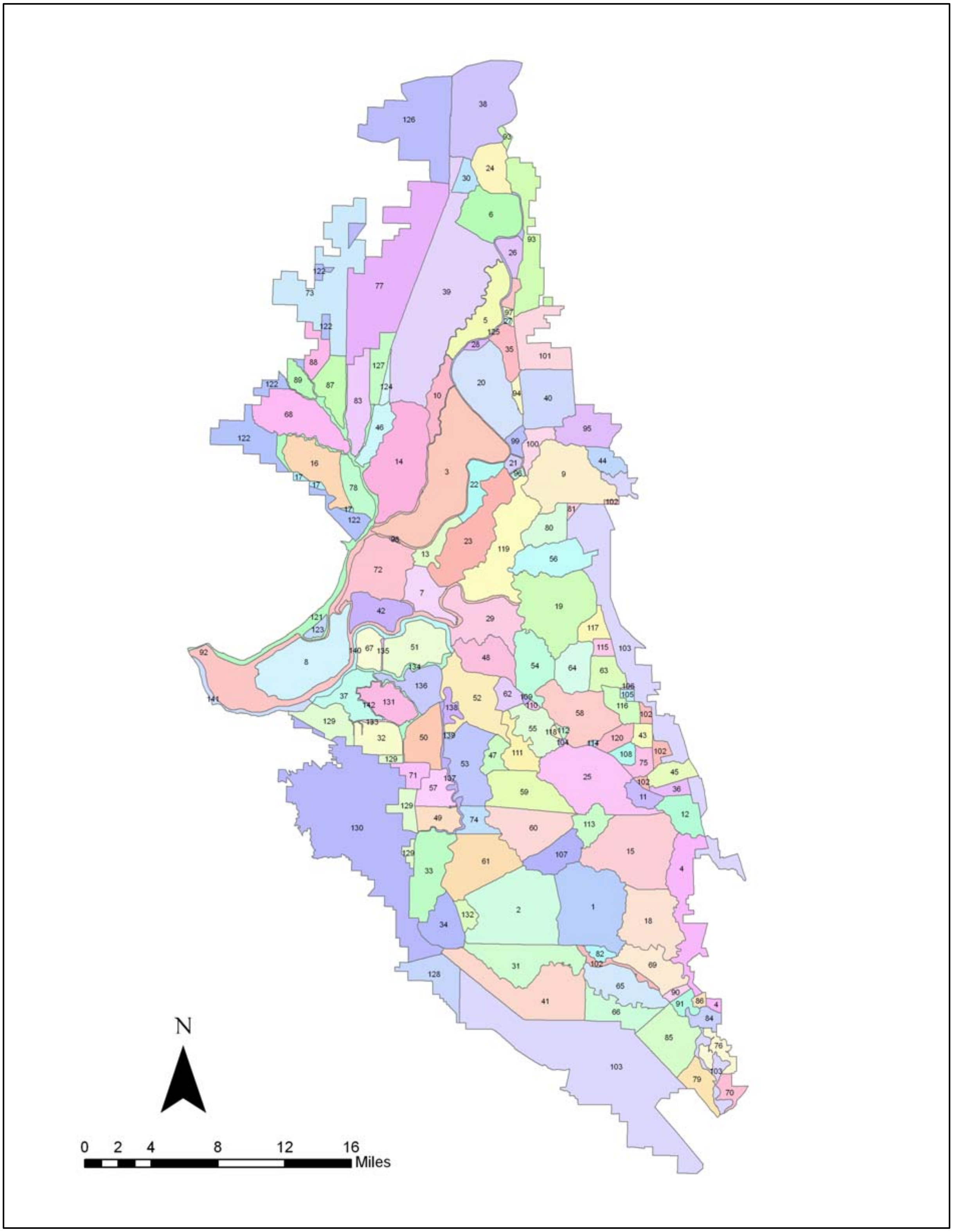

Figure 7.4: Digitized map of the 142 Delta subareas in DICU.

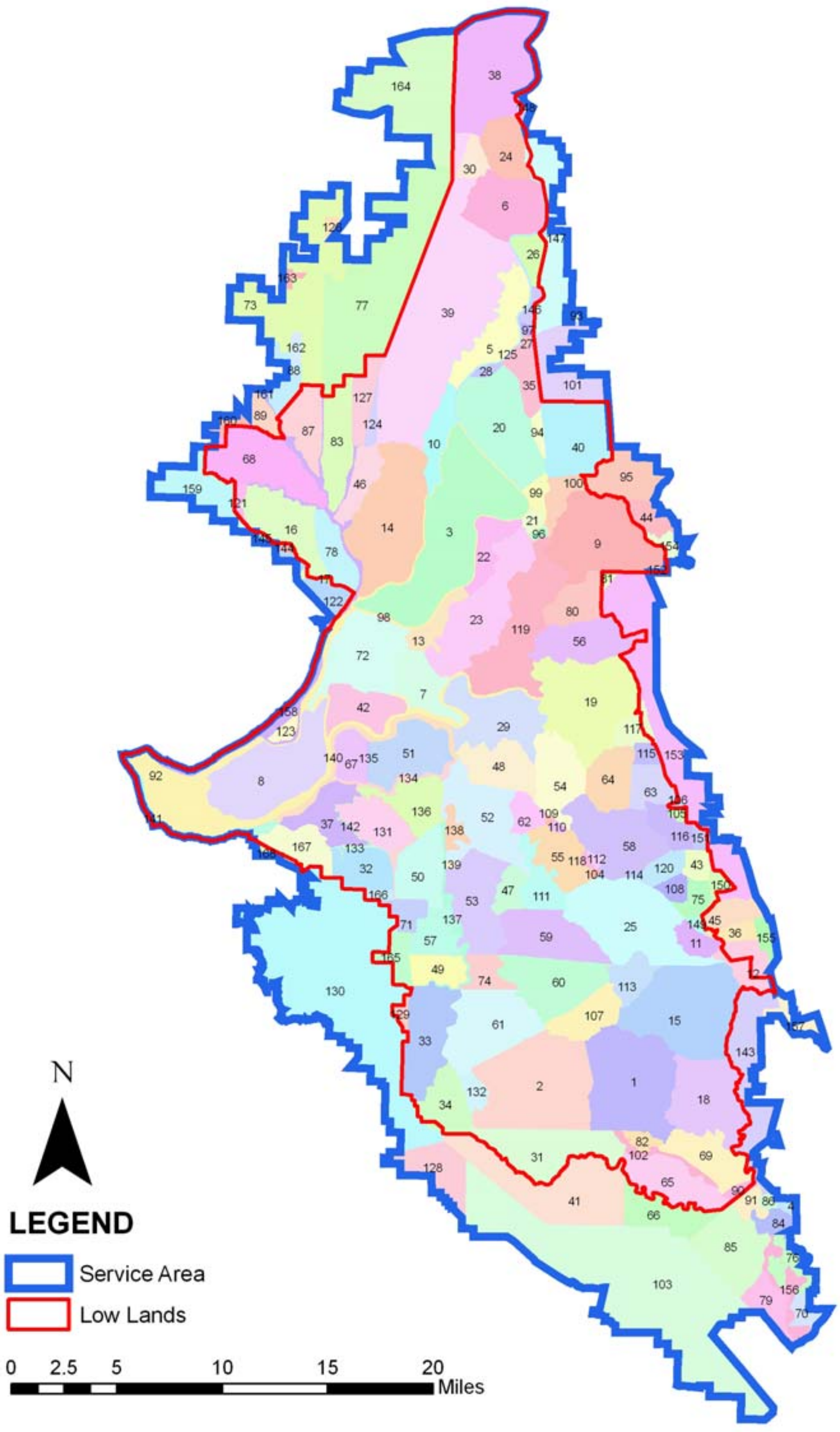

Figure 7.5: DETAW's 168 Subareas.

7.5 Calculating Daily Precipitation by DETAW Subarea

Daily precipitation for each subarea was estimated by Thiessen polygons based on seven precipitation gaging stations located in and around the Delta (Figure 7.6). Some of the daily precipitation data had to be estimated by correlations with other stations. Areal-weighted averages were used for subareas located in more than one Thiessen polygon.

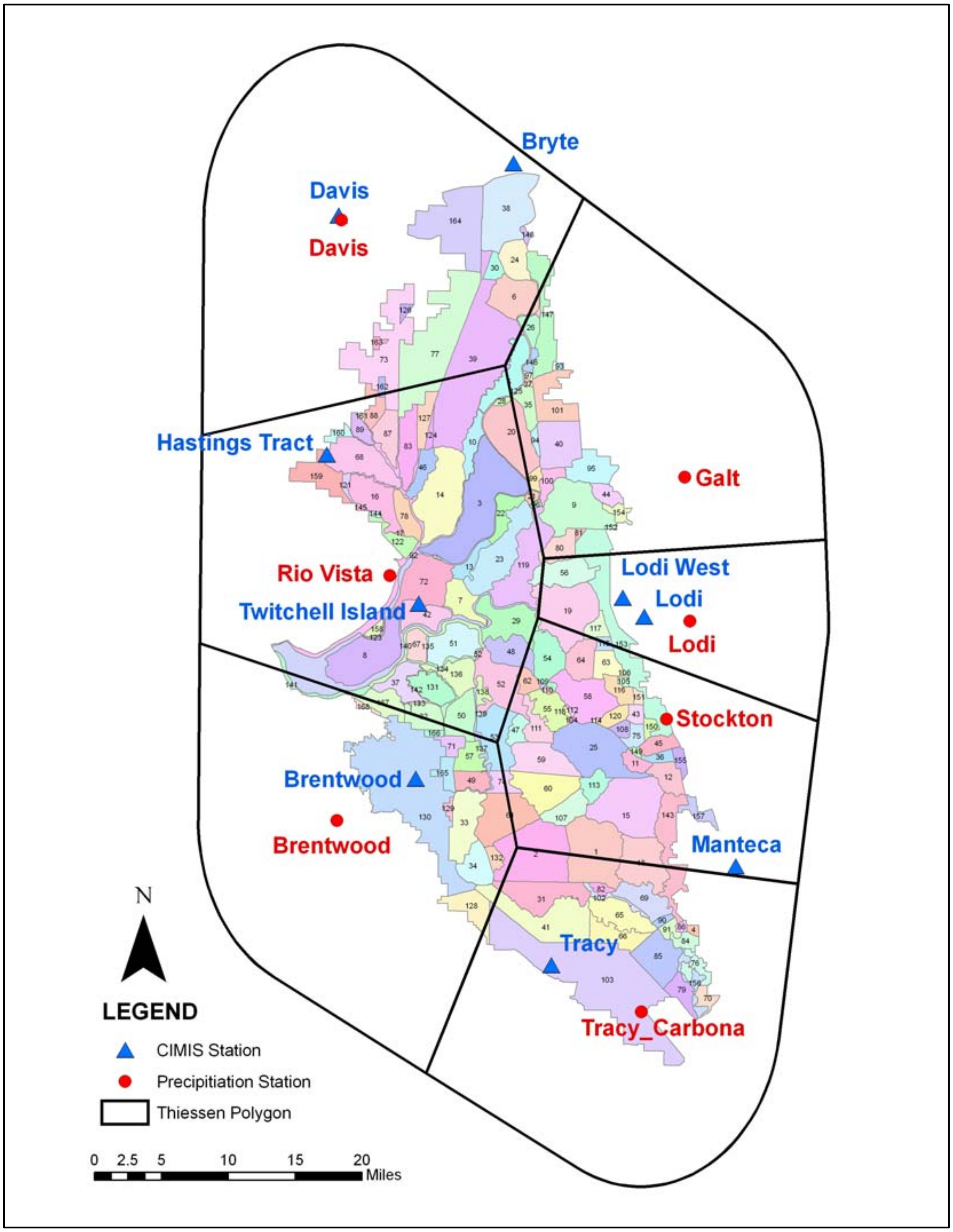

Figure 7.6: Thiessen polygons delineating the association of subareas with precipitation stations.

7.6 Calculating Daily ETo by DETAW Subarea

A key component to calculating ETAW is crop potential evapotranspiration rate, ETo. ETo is calculated by DETAW by using the Hargreaves-Samani equation calibrated to the Pennman-Montieth equation as calculated by the California Irrigation Management Information System (CIMIS) stations located around the Delta (Figure 7.7). The Pennman-Montieth equation could not be used explicitly because long-term climate data input is not available, whereas the Hargreaves-Samani equation is mainly temperature-based and temperature is more readily available than climate data. To account for the spatial variability across the Delta, lines of equal ETo using the CIMIS results were developed and then factors for each subarea were computed. This allows computing daily ETo for each subarea for the entire period of 1922-2003.

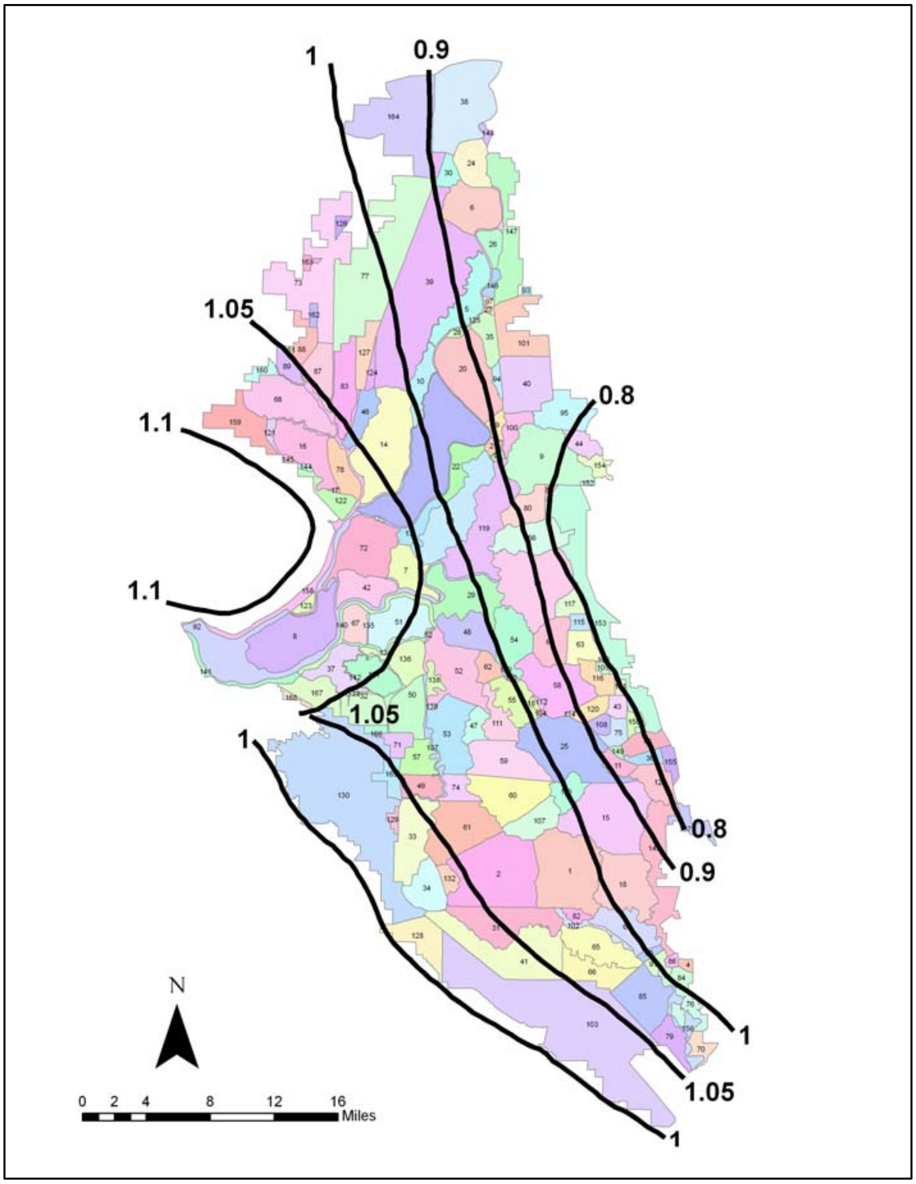

Figure 7.7: Correction factor isolines for the Harvey-Samani and the Pennman-Montieth equations.

7.7 Calculating Daily ETAW

Daily water balances of ETAW are computed for each subarea for each crop category (Figure 7.8). Seasonal crop coefficient curves Kc's are used to estimate the daily crop ETc from the ETo's. Irrigations (diversions from islands) are triggered when the soil water content drops below the yield threshold (allowable depletion multiplied by plant available water) after taking precipitation and seepage into account.

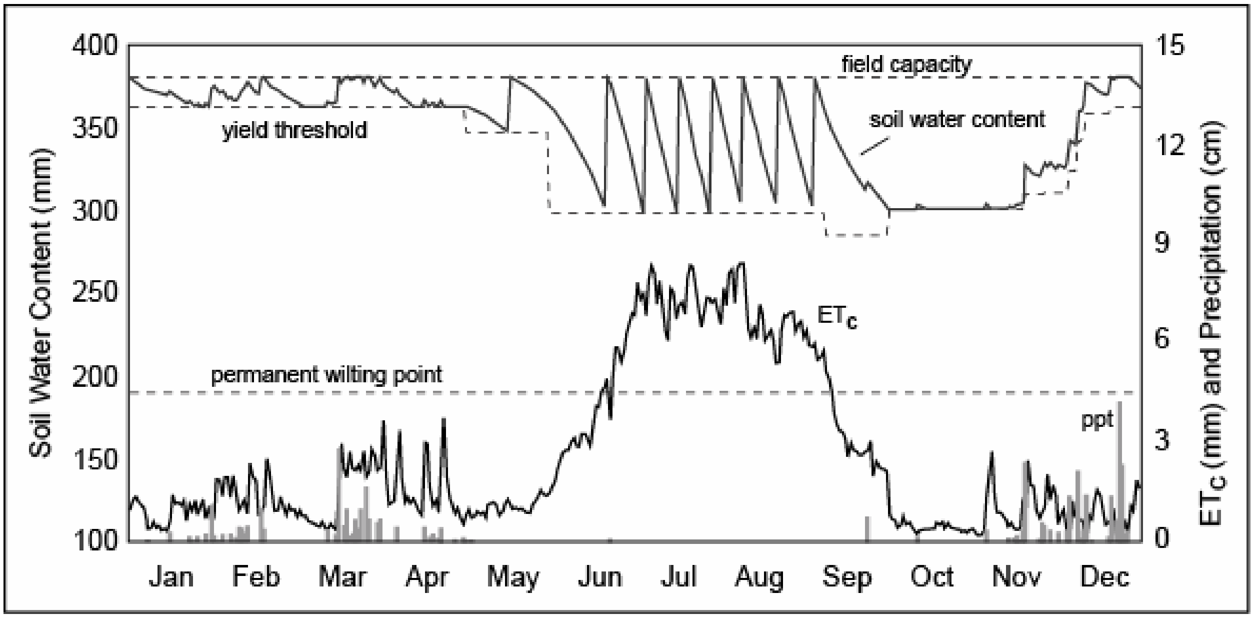

Figure 7.8: Typical daily-varying water balance for a crop.

7.8 Summary

A new model, DETAW, is being developed to calculate consumptive water demands in the Delta. The Delta is divided into 168 subareas. Daily precipitation for each subarea is estimated using Thiessen polygons from seven precipitation gaging stations. Daily potential evapotranspiration rates, ETo, are computed using the Hargreaves-Samani equation and are correlated to the modified Pennman-Montieth equation. Daily crop evapotranspiration unit rates, ETc, are computed using seasonal crop coefficients. Daily water balances taking estimated channel seepage are used to estimate daily ETAW by subarea for the period 1922-2003. These values can then be used to develop daily nodal diversions and return flows for the DSM2 model and estimates of Delta Uplands and Delta Lowlands consumptive demands for the CalSim-II model.

7.9 References

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Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

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Chapter 8:
Priority 3 Clifton Court Forebay Gate Operations for Extended Planning Studies

Author: Jim Wilde

8 Priority 3 Clifton Court Forebay Gate Operations for Extended Planning Studies

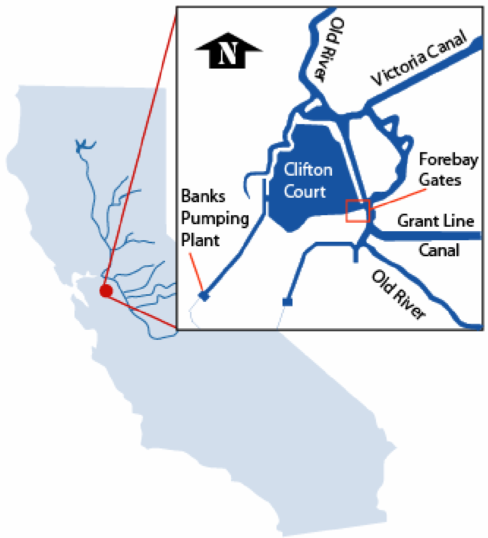
8.1 Introduction

The CALFED Common Assumptions Modeling Team is using the Delta Simulation Model Version 2 (DSM2) model to simulate Delta conditions over 82-year planning studies. In order to conduct these studies, the existing Forebay intake operation under Priority 3 for 16-year planning studies needs to be extended. A time series of Clifton Court Forebay intake gate operation for use in DSM2 planning simulations has been constructed to account for operation of the intake gates under the "Priority 3" criteria. This operation is based on the channel stage immediately outside the Forebay and is intended to reduce impacts of State Water Project diversions on local water levels.

8.2 Background

The Clifton Court Forebay intake structure is composed of 5 control gates (Figures 8.1 and 8.2). At times the gates are operated separately to provide better control of inflow. Normally, however, the gates can be considered to operate in unison (Le, 2004). Typically the gates are opened and closed several times a day to reduce any impacts on levels in the south Delta due to State Water Project (SWP) exports at Banks Pumping Plant.

CLIFTON COURT FOREBAY GATES



LOCATION: Byron, Contra Costa County California

WATERWAY(S): Sacramento-San Joaquin Delta, Clifton Court Forebay

COORDINATES: 37°49' 48" N - 121°33'26" W

DATE OF CONSTRUCTION: ~1969

CONSTRUCTED BY: California Department of Water Resources

OWNER: California Department of Water Resources

STATUS: Active

STRUCTURE TYPE: 5 Radial Gates

SIZE: ~20' height x ~20' width (per gate)

PURPOSE: To minimize SWP impacts on water levels in channels near Clifton Court Forebay and to reduce entrainment of fish in the Forebay

Figure 8.1: View of the Forebay gates from across Old River on Coney Island. *(photograph taken by Mike Burns)*

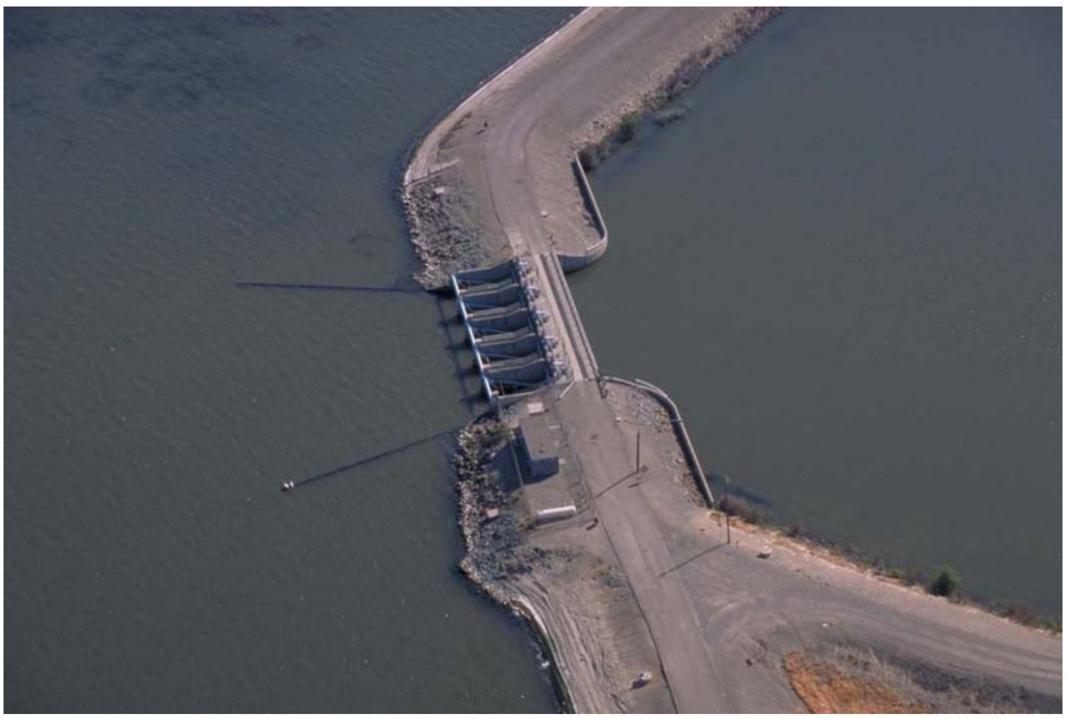


Figure 8.2: Aerial view of the Clifton Court Forebay inlet.

The criteria for the gate operation is defined in the 1989 "STANDING OPERATING ORDER PC 200.7-A" (O&M, 1989). Operation of the Clifton Court Forebay intake gates by what is commonly termed "Priority 3" is such that:

> "Intake gates open 1 hour after the low-low tide; close 2 hours after the high-low tide; reopen 1 hour before the high-high tide; and close 2 hours before the low-low tide."

For a spring tide, the intake gate operation schedule is as shown in Figure 8.3.

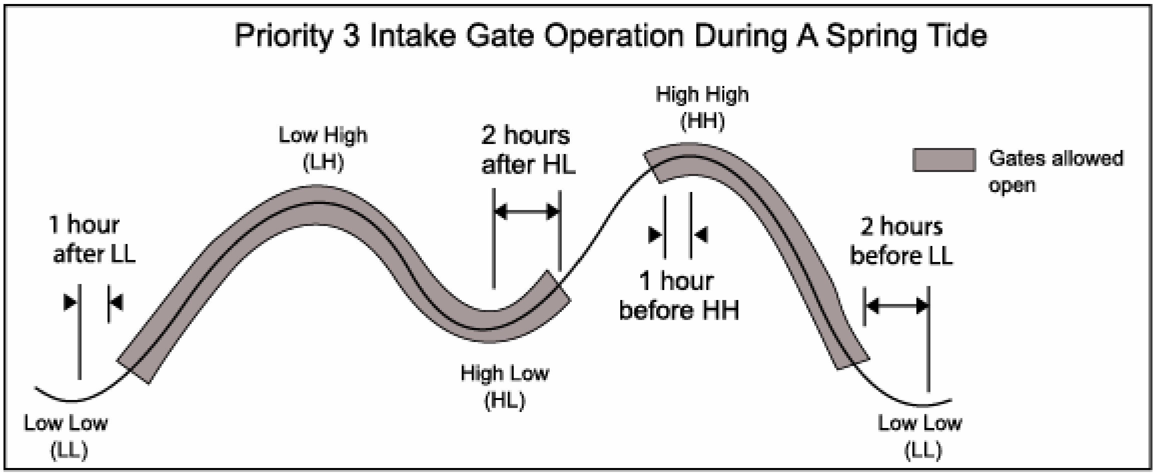


Figure 8.3: Priority 3 Clifton Court Forebay gate operation during spring tide.

Because DWR Operations and Maintenance (O&M) operating guidelines assume a synchronized gate operation and in order to simplify the modeling of the gates, DSM2 treats the five gates as a single device. It is desirable that DSM2 planning simulations assume an intake gate operation according to the Priority 3 operating guidelines in order to simulate more realistic water levels in the south Delta.

8.3 General Methodology

Developing forebay intake gate operation timing involves three steps: simulating channel stage levels adjacent to the forebay; determining the times of higher-high (HH), lower-low (LL), lower-high (LH), and higher-low (HL) water levels; and establishing the gate timing according to Priority 3 criteria. Because the intake gate timing is based on the water levels outside the forebay intake gates, a preliminary base planning simulation is first run to generate a 15-minute time series of stage just outside the intake gates. Constructing the gate operation time series then is done through an analysis of this preliminary stage time series using a Jython script which identifies the times of the HH, LL, LH, and HL values. Based on these times and the Priority 3 criteria, the script constructs an irregular time series of timing of the intake gates' operation. The time series for a Priority 3 gate operation for an 82-year planning simulation is then converted to DSS format for use by DSM2. Figure 8.4 shows an example of the stage just outside the forebay gate as simulated by DSM2 and the generated intake gate operation criteria under Priority 3.

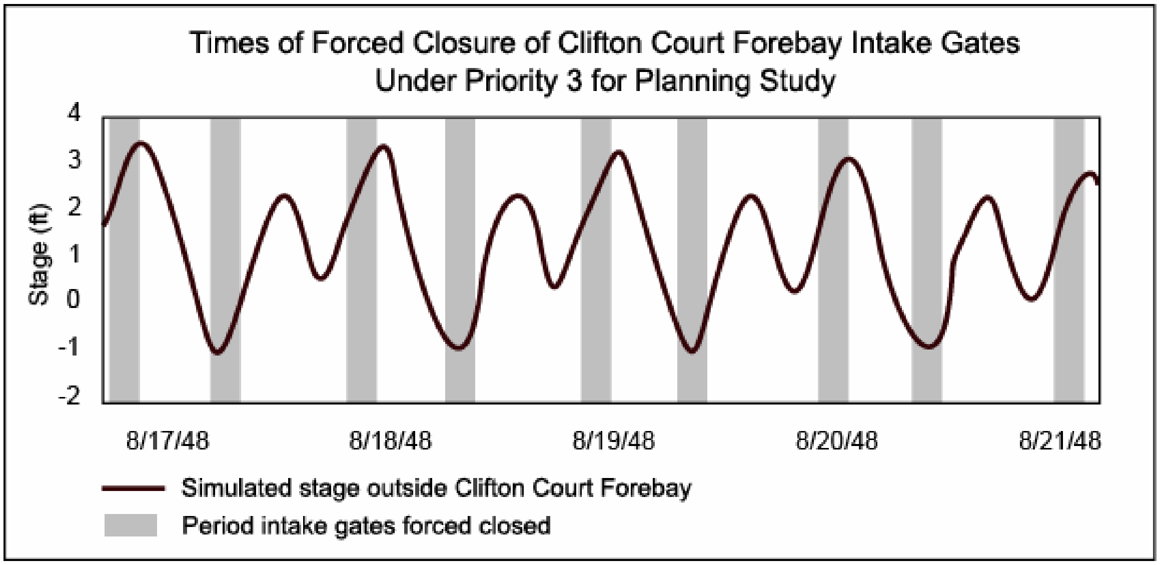


Figure 8.4: Example of Clifton Court Forebay gate timing for a planning study under a Priority 3 criteria.

8.4 Impact of Priority 3 Forebay Intake Gate Operation on DSM2-Generated Water Levels

In this section, water levels under Priority 3 are compared to levels under what has been called 'Priority 4'operation of the intake gates in order to demonstrate the effect on south Delta water levels of strategically restricting flow into the forebay. Priority 4 operation allows water to flow into Clifton Court Forebay any time the water level inside the forebay is lower than the level outside. However, water inside the forebay is never allowed to flow back out. Under Priority 4 much of the water diversion into the forebay occurs during each rising tide. As shown in Figure 8.3, under Priority 3 the intake gates are kept closed on the rising tide before the high-high tide. This allows the tide to better propagate upstream. The south Delta rock barriers, when installed, do suppress some of the upstream movement of tidal energy. For a comparison of the two intake operations, water levels are presented at three locations in the Delta: outside the Clifton Court Forebay intake gate, outside Tom Paine Slough, and inside Tom Paine Slough (Figure 8.5).

The water levels in the south Delta under Priority 3 and 4 for March through September of 1991 from a planning study are shown in Figure 8.6. In 1991 the Grant Line Canal barrier was assumed installed from May 16 to October 1, the Middle River barrier and the Old River near DMC barrier were assumed installed from April 15 to October 1, and the head of Old River barrier was assumed installed from April 14 to May 16 and from September 17 to November 30. The relatively large differences in daily maximum stage (up to one foot) just outside the forebay in July occurred during high SWP and Central Valley Project (CVP) pumping. This shows the potential effectiveness of Priority 3 under high pumping. However, for this same time period, the difference in daily maximum stage outside of Tom Paine Slough, which is upstream of the Old River barrier, is much smaller. This indicates that the barriers reduce the benefits to maximum water levels.

Under high pumping but without the barriers installed, as in March, the difference in maximum water levels under the two intake gate operations is large all along Old River from near the forebay intake to near the mouth of Tom Paine Slough.

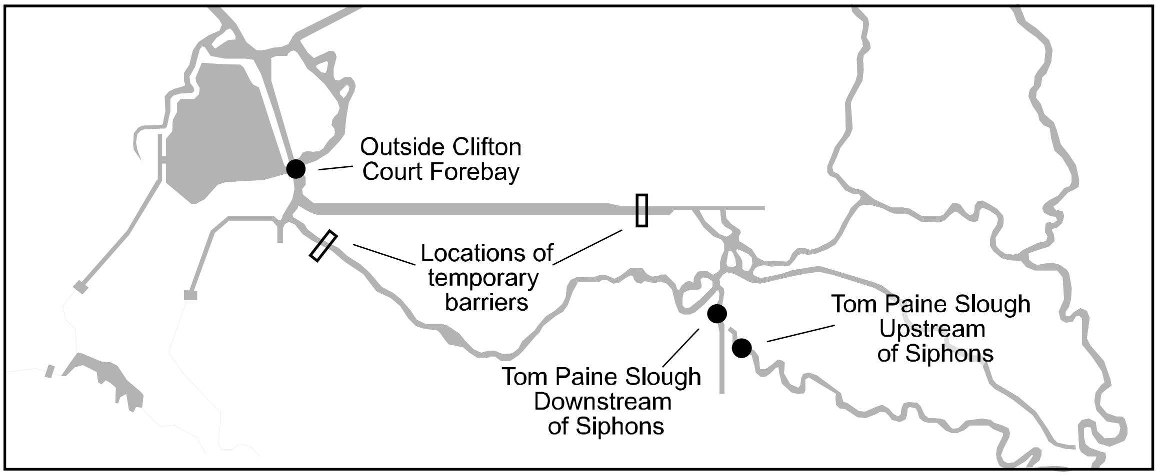


Figure 8.5: Locations water levels are presented to show the impact of operating Clifton Court Forebay intake gates according to Priority 3.

Figures 8.7, 8.8, and 8.9 compare water levels at the three sites over an extended planning simulation of 1975 through 1989. Thirty-day running averages of daily maximum and minimum levels show that the patterns in water levels discussed above are persistent. Operating Clifton Court Forebay intake gates according to Priority 3, as established by the methodology presented in this chapter, significantly affects the maximum water levels near the forebay, but this effect diminishes upstream approaching the siphons on Tom Paine Slough. To show the impact of Priority 3 intake gate operation on the movement of water upstream of Clifton Court Forebay, tidal flows can also be examined.

The impact of operating under Priority 3 can also be seen in the south Delta flows. Figure 8.10 shows the 30-day running average of daily maximum and minimum flows in Old River just upstream of the temporary barrier site near the DMC intake. Positive flows are flows in the downstream direction while negative flows are upstream flows associated with an incoming tide. Diverting water into Clifton Court Forebay under Priority 3 as compared to Priority 4 doesn’t significantly change downstream flows, but causes higher peak upstream flows. This is consistent with the goal of Priority 3 preserving the momentum of incoming tides which results in increased movement of water upstream Old River.

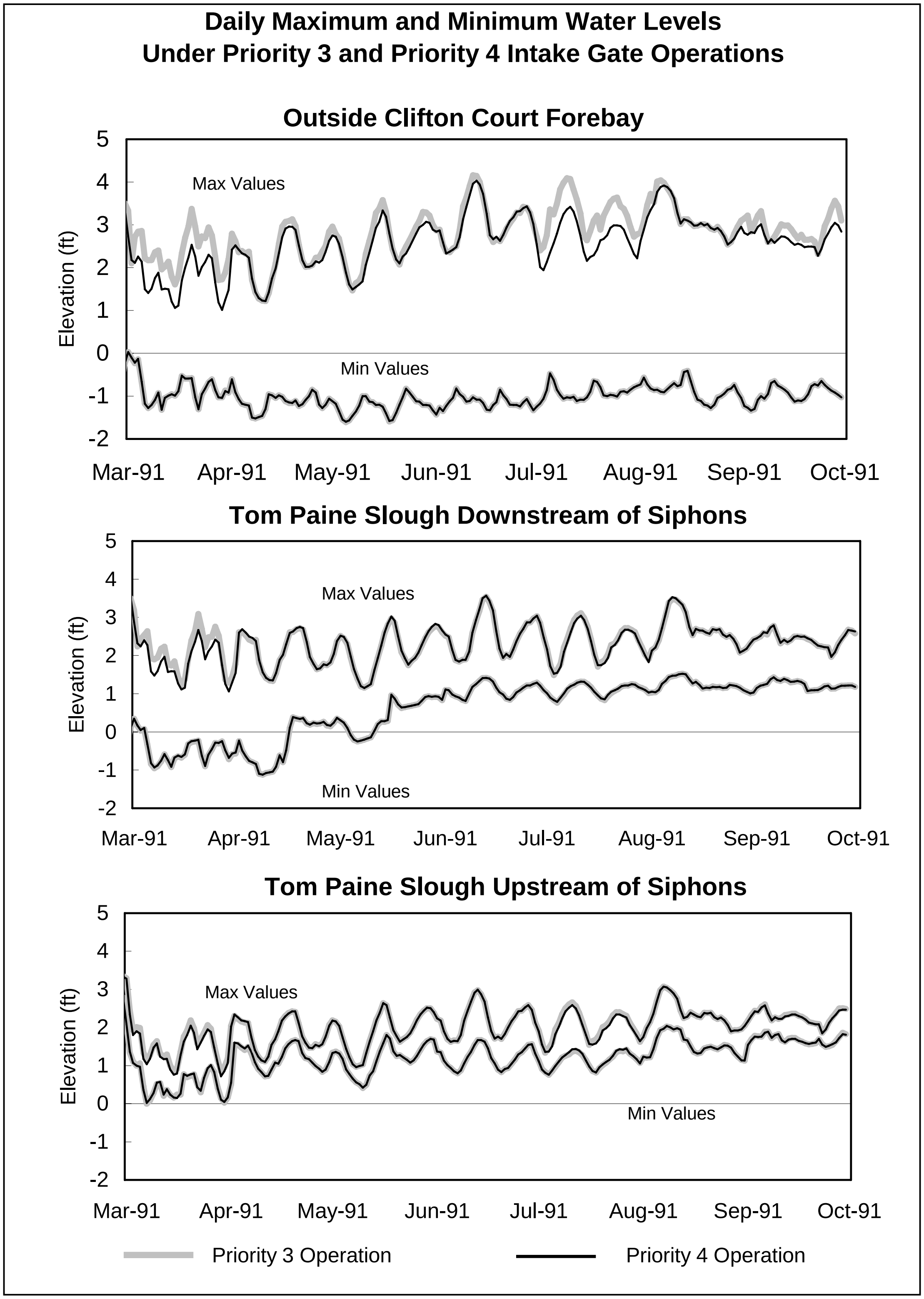


Figure 8.6: Water levels at three locations in the south Delta under Priority 3 and Priority 4 forebay intake gate operation, 1991 planning conditions.

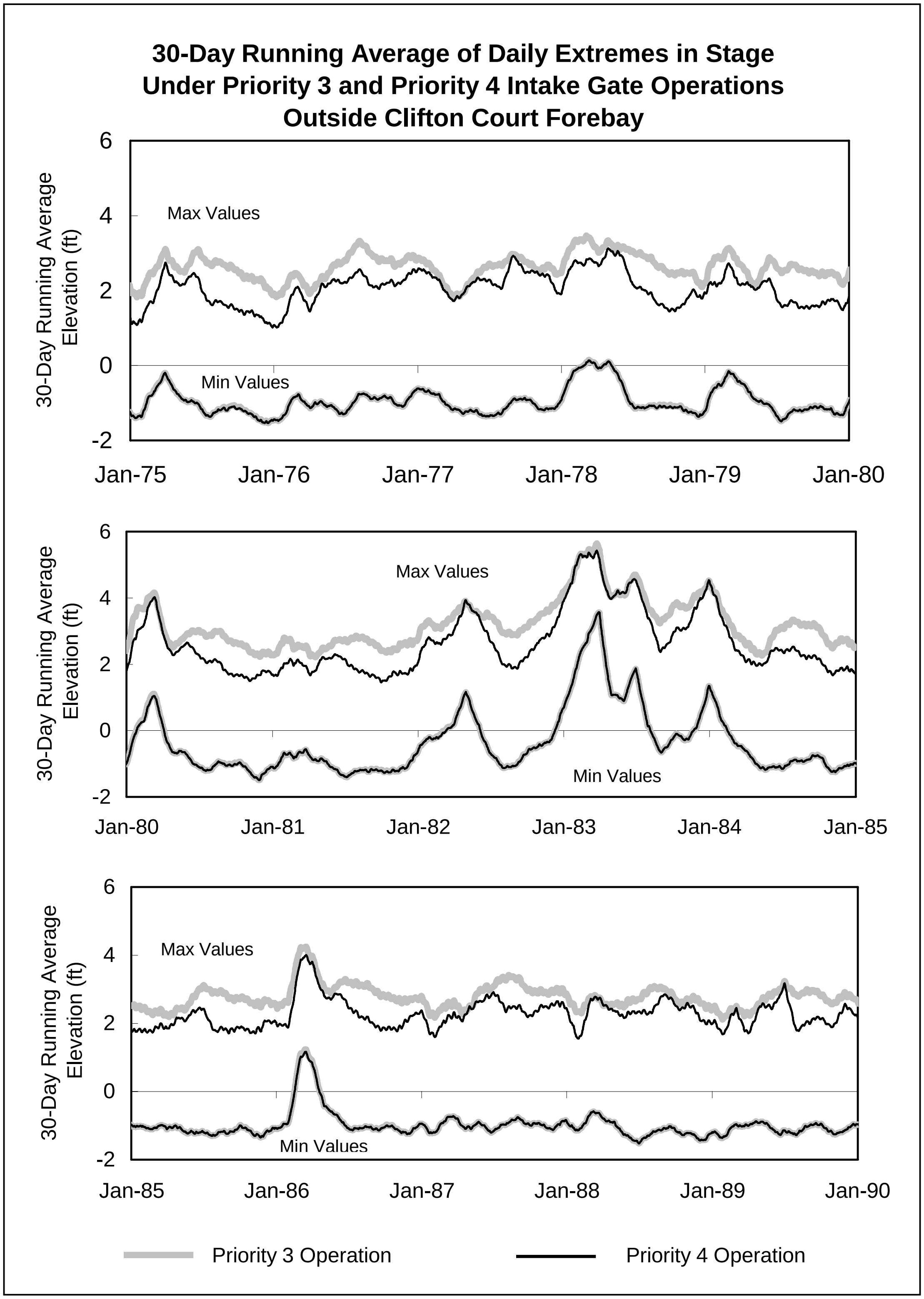


Figure 8.7: Outside Clifton Court Forebay 30-Day running average daily of minimum and maximum water levels under Priority 3 and Priority 4 Clifton Court Forebay intake gate operations.

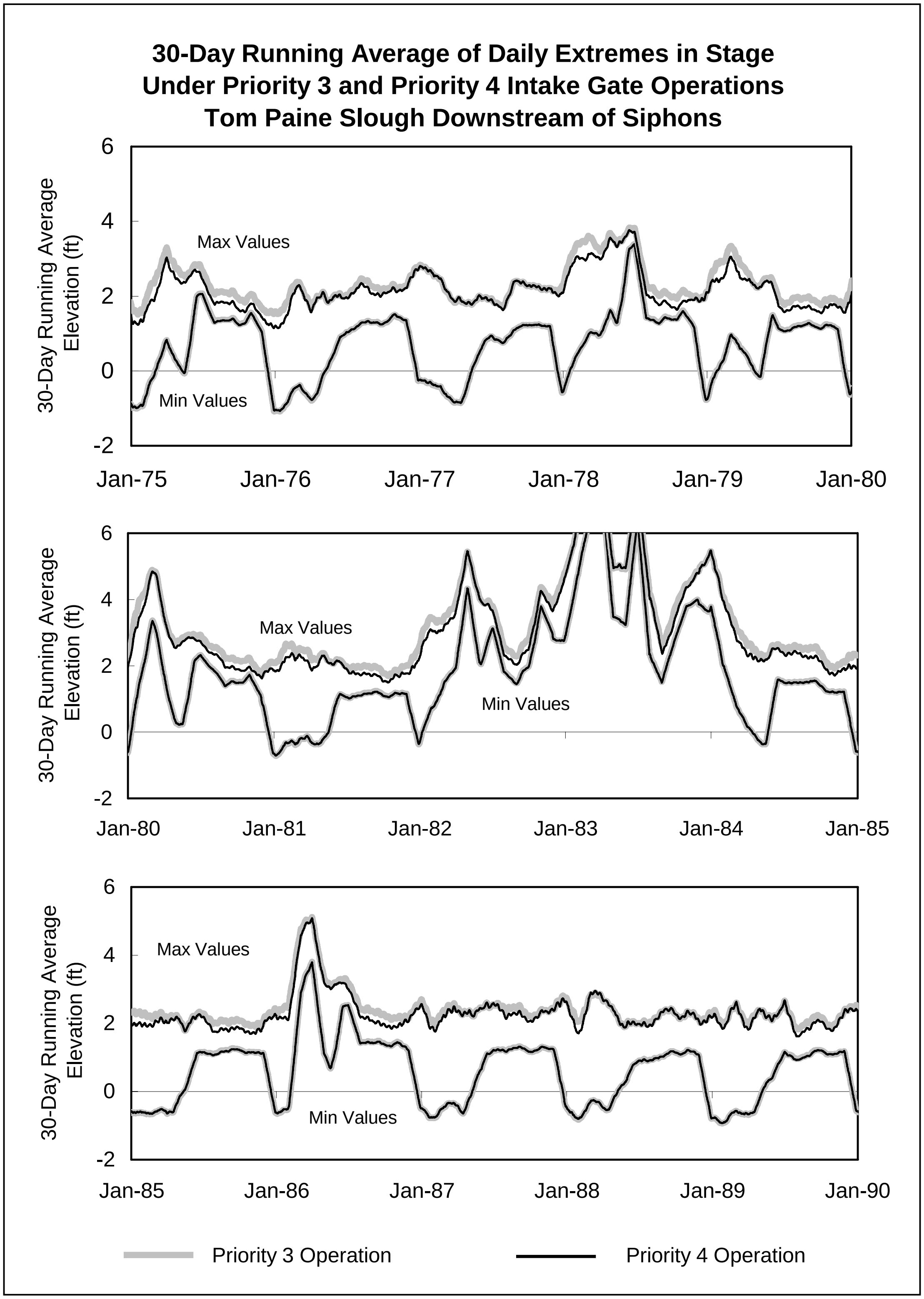


Figure 8.8: Outside Tom Paine Slough 30-Day running average daily of minimum and maximum water levels under Priority 3 and Priority 4 Clifton Court Forebay intake gate operations.

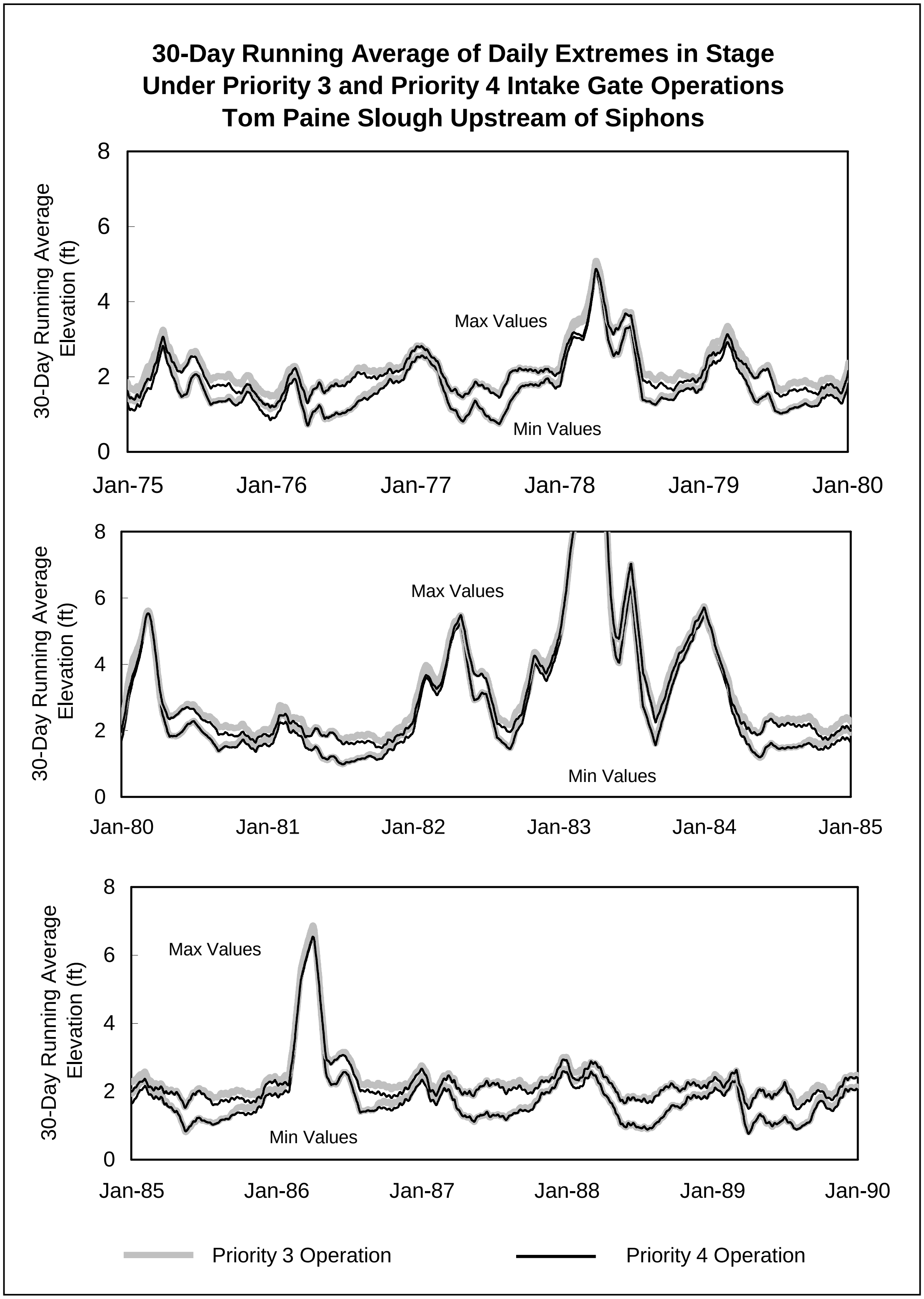


Figure 8.9: Inside Tom Paine Slough 30-Day running average daily of minimum and maximum water levels under Priority 3 and Priority 4 Clifton Court Forebay intake gate operations.

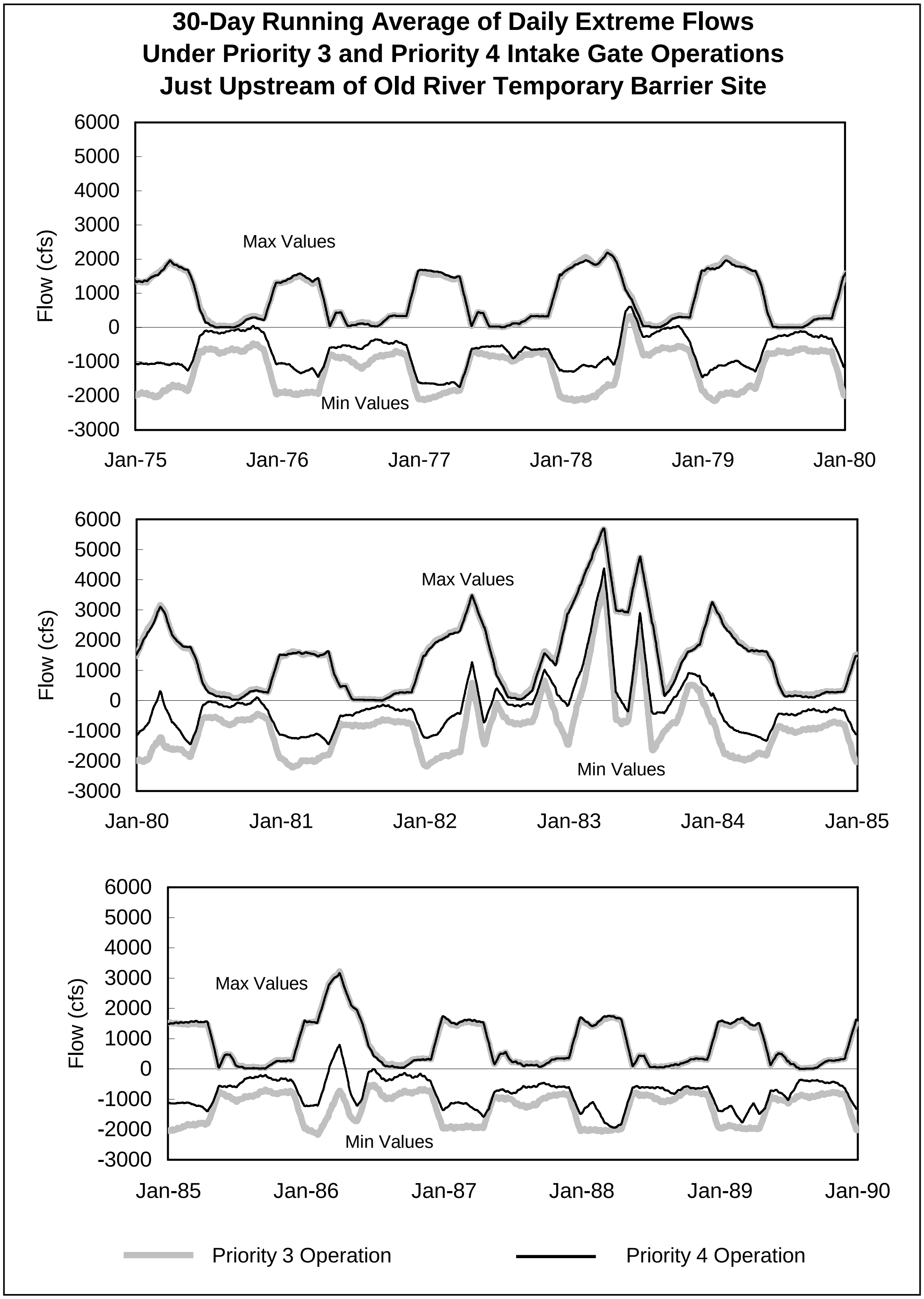


Figure 8.10: Just upstream of Old River temporary barrier 30-day running average daily of minimum and maximum flows under Priority 3 and Priority 4 Clifton Court Forebay intake gate operations.

8.5 References

Le, K. (2004). "Chap. 12: Calculating Clifton Court Forebay Inflow." *Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh. 22nd Annual Progress Report to the State Water Resources Control Board.* Bay-Delta Office, California Department of Water Resources. Sacramento, CA. http://modeling.water.ca.gov/delta/reports/annrpt/2004/2004Ch12.pdf

O&M (1989). *Standing Operating Order PC 200.7-A.* Division of Operation and Maintenance, California Department of Water Resources. Sacramento, CA.

Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

27th Annual Progress Report
October 2006

Chapter 9:
DSM2 Simulation of Historical Delta Conditions over the 1975 – 1990 Period

Author: Myint Thein and Parviz Nader-Tehrani

9 DSM2 Simulation of Historical Delta Conditions over the 1975 – 1990 Period

9.1 Introduction

The Delta Simulation Model II (DSM2) is a one-dimensional mathematical model for simulating Sacramento-San Joaquin Delta hydrodynamics, water quality, and particle tracking though the modules HYDRO, QUAL, and PTM respectively. DSM2 was first calibrated and validated in 1997. In 1999 the Environmental Services Office (ESO) modified the representation of Delta bathymetry that DSM2 uses. The Interagency Ecological Program's (IEP) DSM2 Project Work Team (PWT) adopted this new representation for DSM2 in its recalibration and validation of the model in 2000 (Nader-Tehrani and Shrestha, 2000). This effort used four periods to calibrate HYDRO (May 1988, April 1997, April 1998, and September-October 1998) and one three-year period to calibrate QUAL (October 1991 – September 1994). HYDRO and QUAL were then both validated by simulating historical hydrodynamics and electrical conductivity from 1990 through 1999. This calibration and validation process resulted in an overall good fit with the field data for stage, flow, and water quality (Nader-Tehrani, 2001). Recently, the historical simulation by DSM2 has been extended to include the 1975 -1990 period. This chapter discusses some of the key issues in this work and summarizes model results.

9.2 Input Data

A simulation of historical Delta conditions by DSM2-HYDRO and QUAL requires recorded or estimated key historical Delta inflows and exports, the stage at Martinez, Delta islands consumptive use (DICU), and operational information of gates and barriers in the Delta. Required input data were retrieved from the Interagency Ecological Program (IEP). The IEP data vault has limited information on the operation of gates and barriers prior to 1986. For operational information before 1986, two DWR publications were consulted:

- DWR Bulletin 132 (1976 to 1982), The California State Water Project, Appendix E, Water Operations in the Sacramento-San Joaquin Delta.

- DWR Bulletin 69 (1975 to 1985), California High Water.

As part of trial measures to improve water quality in the south Delta and west Delta during the drought of 1976 and 1977, several temporary-barriers were installed and later removed. Using the information from these DWR publications, gates input files for DSM2 were updated for the period before 1986.

9.3 Discussion

DSM2-HYDRO simulated flow and stage in Delta channels and then DSM2-QUAL simulated electrical conductivity (EC). Discussions on the comparisons of DSM2 simulation results to the recorded historical data will be presented in three parts: stage simulation, flow simulation, and EC simulation. The locations in the Delta where measured and simulated results are discussed in this report are shown in Figure 9.1.

9.3.1 Stage Simulation

Most of the available measured stage began to be collected in late 1985. Stage data which covers the entire 1975 – 1990 simulation period is available at only a few locations in the Delta.

For the simulation period of 1975 – 1990, California experienced all five types of water-years: Wet, Above Normal, Below Normal, Dry, and Critical. At times during this period, extreme high and low stages were monitored in the Delta. DSM2 simulated stages generally matched the observed field data well, including during times of extreme stages. As examples, for the San Joaquin River at Brandt Bridge, Figure 9.2 compares simulated and observed stages during the flood of February 1986 and Figure 9.3 compares observed and simulated stages for the low stages of June 1988.

At a few sites the stage data recordings before October 1, 1987 were not referenced to mean sea level. On October 1, 1987 the reference datum for stage data recordings was shifted to 0.0 NGVD (National Geodetic Vertical Datum) mean sea level (IEP, 2006). DSM2 simulated stages, which are entirely referenced to mean sea level, were compared to the recorded stages at these sites and substantial discrepancies were exposed. To demonstrate this phenomenon, Figures 9.4 and 9.5 show recorded and simulated stages for RSAC123 (Sacramento River at Georgiana Slough) and RMKL005 (Mokelumne River N. Fork at Georgiana Slough). As shown in these figures, the recorded stages before the reference-datum change of October 1, 1987 widely deviated from the simulated stages, but after this date the recorded and simulated data agreed well.

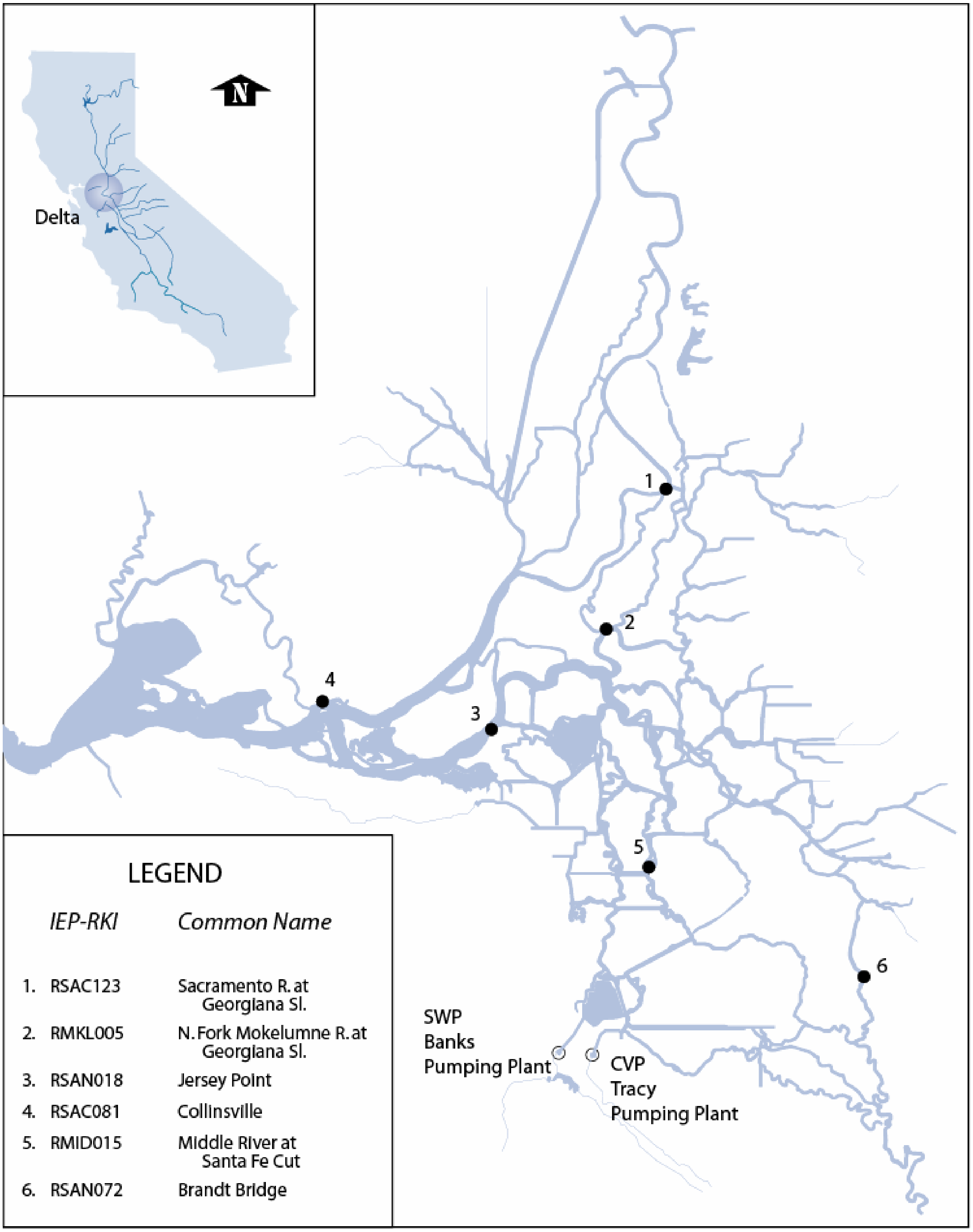


Figure 9.1: Locations that the DSM2 simulation results are compared to observed data.

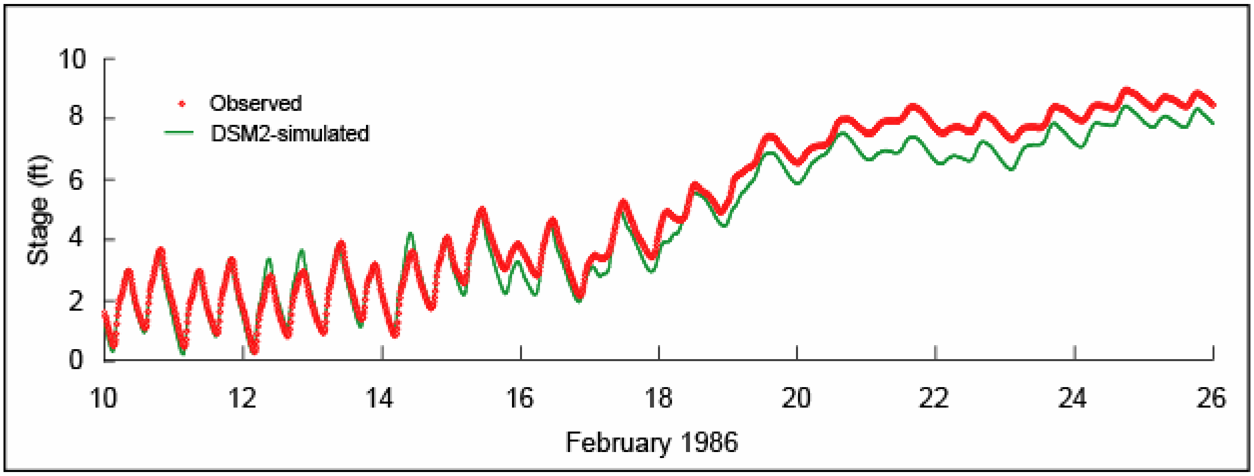


Figure 9.2: Observed and DSM2-simulated 15-minute stage at RSAN072 (San Joaquin River at Brandt Bridge) during the February 1986 flood.

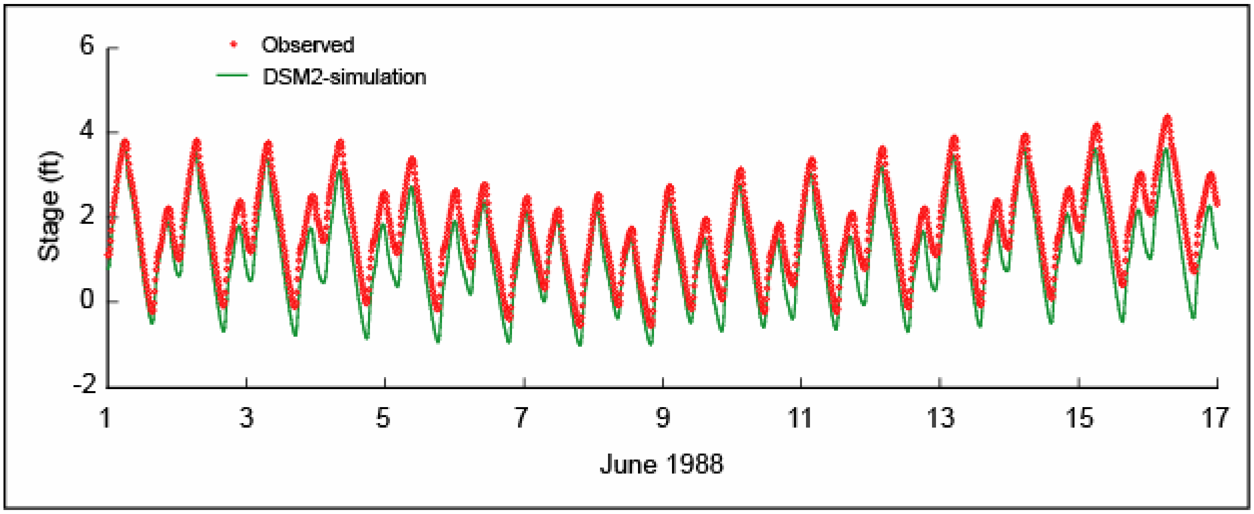


Figure 9.3: Observed and DSM2-simulated 15-minute stage at RSAN072 (San Joaquin River at Brandt Bridge) during the summer of 1988.

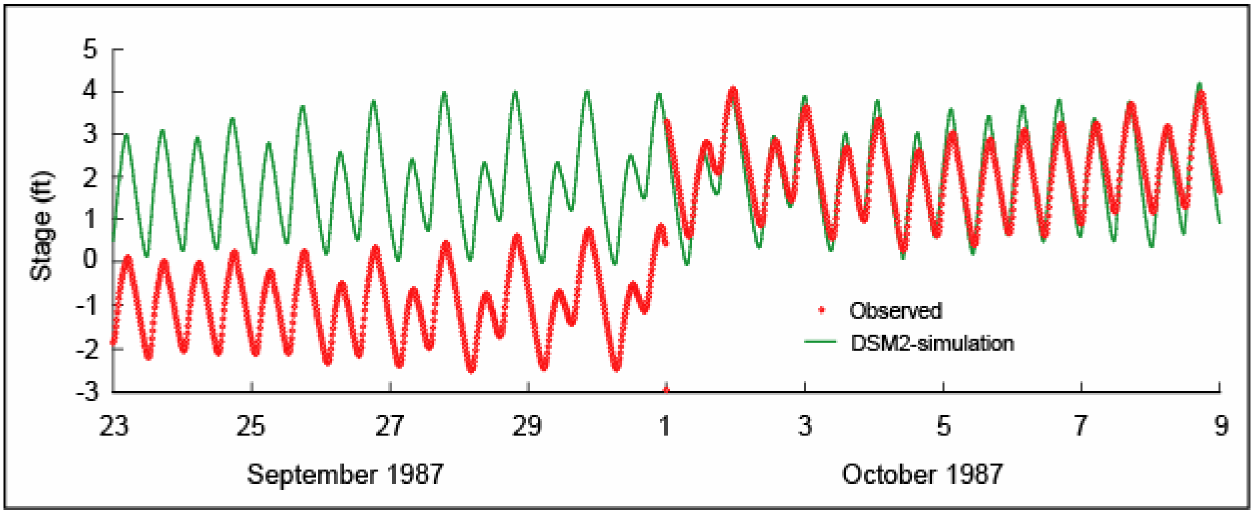


Figure 9.4: Observed and DSM2-simulaed 15-minute stage at RSAC123 (Sacramento River at Georgiana Slough) before and after the stage reference-datum for was changed on October 1, 1987.

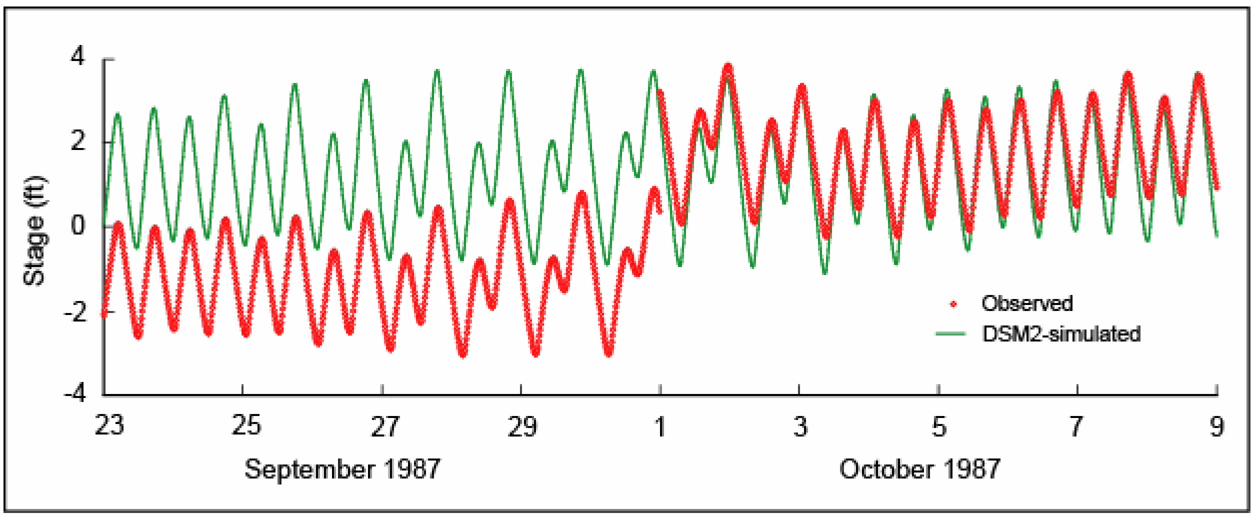


Figure 9.5: Obseved and DSM2-simulated 15-minute stage at RMKL005 (North Fork of the Mokelumne River at Georgiana Slough) before and after the stage reference-datum was changed on October 1, 1987.

9.3.2 Flow Simulation

Prior to 1990 there were very few sites in the Delta where flow data were recorded. Only two IEP sites have a sizeable amount of recorded 15-minute flow data prior to1990 available to verify the DSM2 simulated results. These two sites are RMID015 (Middle River at South East of Bacon Island) and ROLD024 (Old River at Bacon Island). At these sites, 15-minute flow data started to be recorded in January 1987. SWP and CVP pumping stations draw water primarily from Middle River and Old River. RMID015 and ROLD024 are located upstream of the pumping stations (Figure 9.1) so that the effects of pumping on flow are at times distinctly noticed at these sites.

A comparison plot of typical 15-minute flow data between DSM2 simulations and monitored field data is shown in Figure 9.6. In this figure, negative values signify water moving upstream. Tidally-varying DSM2-simulated flows closely match observed flows including flow reversals and tidal fluctuations.

To assess the general pattern of net flows at RMID015, daily-averaged DSM2-simulated flows are compared with averaged observed flows in Figure 9.7. Negative values indicate net flow in the upstream direction. The higher negative values reflect larger export rates and lower San Joaquin River inflows, and higher positive values reflect higher San Joaquin River inflows and lower export rates. During low San Joaquin River inflows, the net flows at RMID015 tend to be upstream towards the SWP and CVP pumps, indicating the movement of water originating from Sacramento River and eastside streams towards the pumping stations. During high San Joaquin River inflows, the net flows at RMID015 towards the pumps are significantly reduced indicating that a larger part of the export water is coming from the San Joaquin River.

9.3.3 EC Simulation

Beginning in 1964, daily-averaged electrical conductivity (EC) data were recorded at a number of sites throughout the Delta. An analysis of DSM2's EC simulation was performed at 17 sites in the Delta where adequate EC data were available. DSM2's EC-simulation results agreed well with the monitored field data at most of the sites. Yearly peak EC values in the Delta generally occurred during the fall or early winter periods. For the majority of comparisons, DSM2 captured the peak values fairly well; however, as a general trend, DSM2 tended to overestimate EC in most summers of dry periods. In fact, at times DSM2 predicted higher EC during the summer than in the fall when observed EC values were higher. Figures 9.8 and 9.9 compare measured EC to DSM2-simulated EC at RSAC081 (Sacramento River at Collinsville) and RSAN018 (San Joaquin River at Jersey Point), respectively.

Large discrepancies between observed EC and DSM2-simulated EC during the summers of dry periods were studied in detail. During the preprocessing of input data for DSM2 simulations, the Delta Islands Consumptive Use (DICU) model was used to estimate the irrigation and agricultural drainage flows throughout the Delta. The principal cause of the EC discrepancies between observed and simulated EC during critical and dry summers was hypothesized to be the inaccuracy in the DICU model's estimates of consumptive use. According to the DSM2 input, Delta outflow was lower in the summers of 1976, 1981, 1985, 1987, 1988, and 1989 than in the subsequent fall periods and DSM2 responded as expected by simulating relatively high salinity intrusion during those summers. However, field data showed no evidence of extreme salinity intrusion during those same summer periods. Assuming EC measurements are accurate, one can conclude that, for the summer periods mentioned above, net Delta outflow must have been higher than that reflected in DSM2 input. This would be consistent with the hypothesis that DICU values might cause the discrepancies between observed and simulated EC.

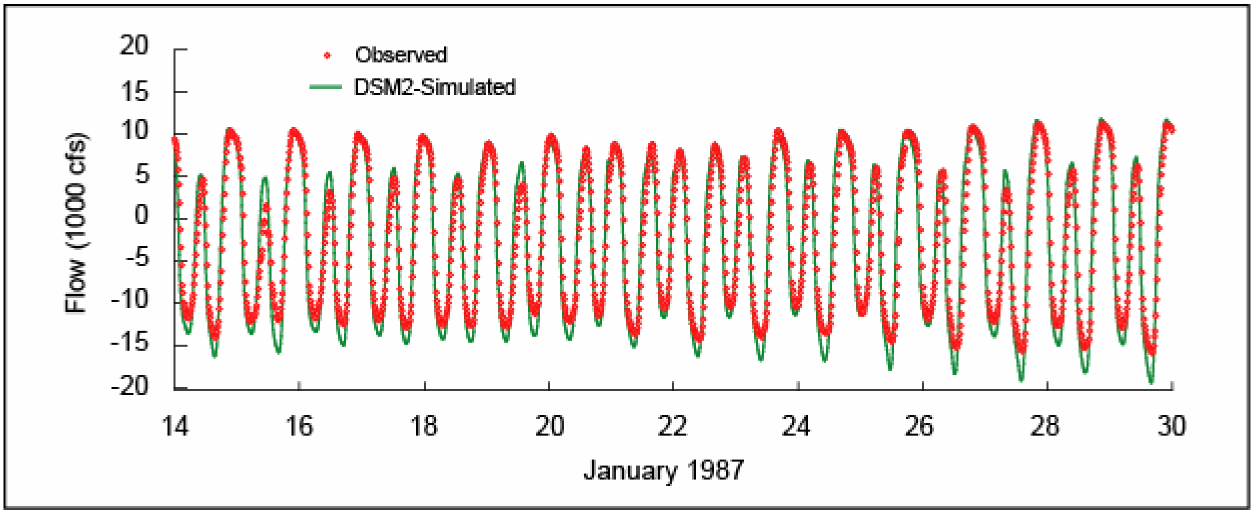


Figure 9.6: 15-minute observed flows and DSM2-Simulated flows at RMID015.

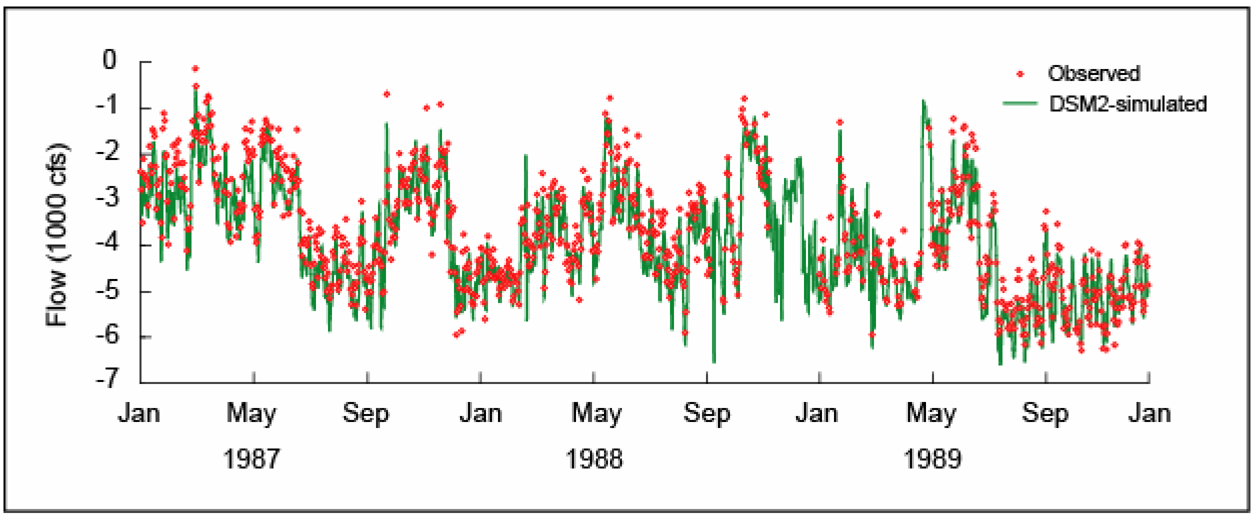


Figure 9.7: Daily-averaged observed flows and DSM2-simulated flows at RMID015.

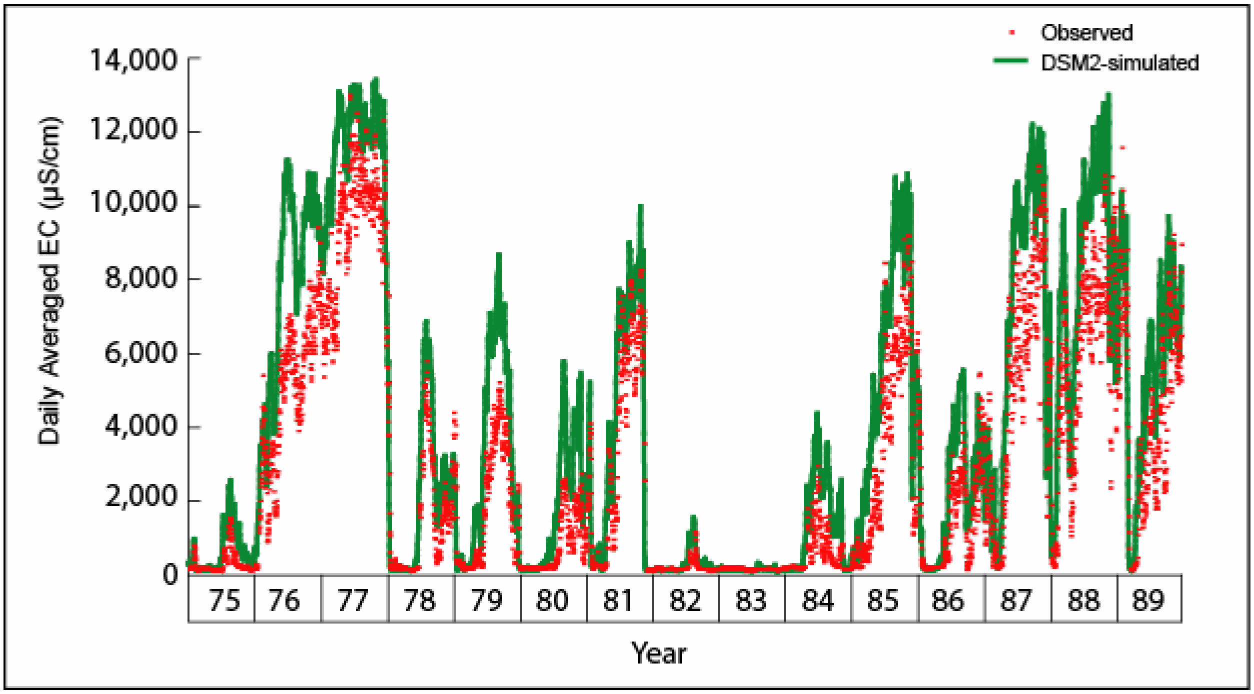


Figure 9.8: Daily-averaged observed flows and DSM2-simulated EC at RSAC081 (Sacramento River at Collinsville), 1975 to 1989.

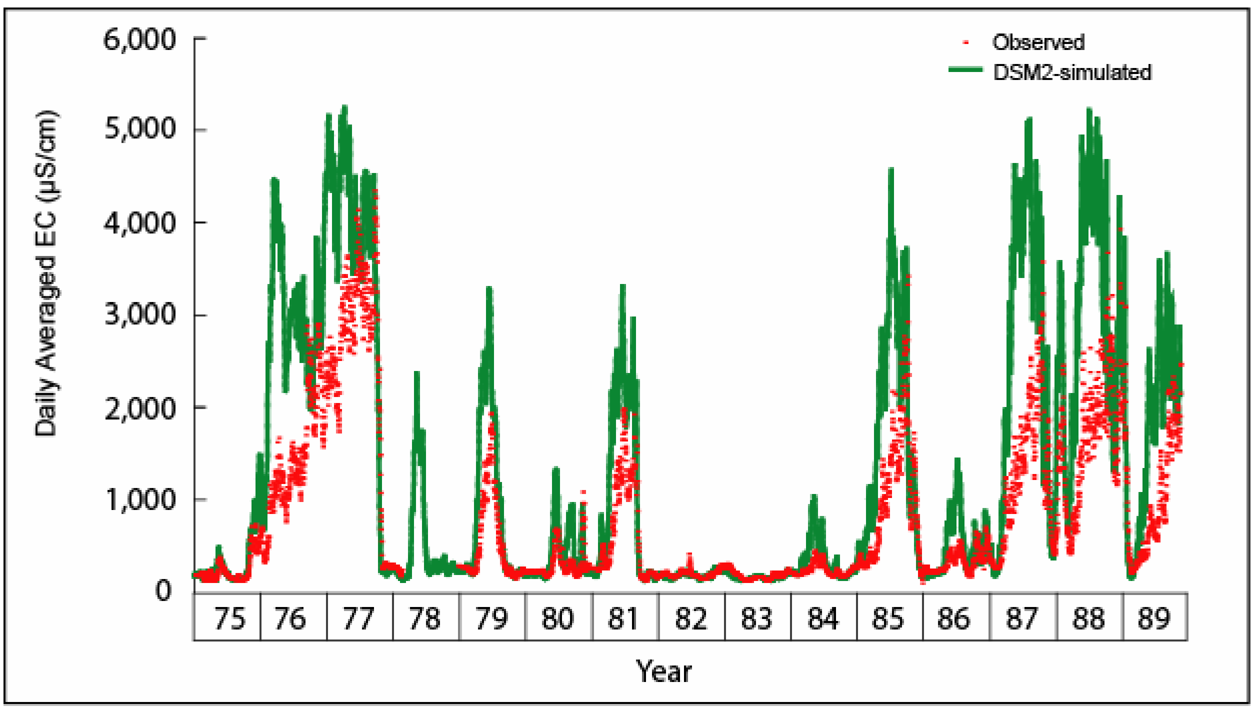


Figure 9.9: Daily-averaged observed flows and DSM2-Simulated EC at RSAN018 (San Joaquin River at Jersey Point) 1975 to 1989.

9.4 Impacts of DICU Estimates on DSM2-simulated EC

To investigate the hypothesis that DICU estimates may be the cause of error in DSM2-simulated EC, additional DSM2-HYDRO and QUAL simulations were conducted in which all DICU inputs, including the agricultural diversions, agricultural drainage returns, and seepage, were removed. Three-way comparisons were made between the output from the two DSM2 runs and the field data.

The results at RSAC 081 (Sacramento River at Collinsville) and RSAN018 (San Joaquin River at Jersey Point) are shown in Figures 9.10, 9.11, 9.12, and 9.13. The two DSM2 runs are referred to as Run A (with DICU input) and Run B (excluding DICU input). Any difference between the two DSM2 runs can be directly attributed to the effect of the DICU input. The following observations apply to locations affected by sea water intrusion.

The difference in EC between Run A and Run B is larger during summer months when the magnitude of the net Delta consumptive use is higher. At times, especially during the summers of dry periods, the difference in EC between the two model runs is very wide, suggesting that the EC results can be very sensitive to changes in DICU values. This illustrates the importance of having accurate estimates for the net Delta consumptive use.

In contrast, the model output for Run B matched the field data better during most dry summer periods. This is especially true for years 1976, 1979, 1980, 1984, 1985, 1987, and 1988. This may indicate that DICU significantly overestimates the Delta consumptive use, at least during the summer of dry periods when the net Delta outflow is particularly low. DICU is a water demand model and assumes that in lieu of rain, irrigation water is available in plentiful supply from adjacent channels.

An exception to the observation noted above is for 1977. For most locations, the simulated EC from Run A is closer to the field data than that from Run B. This is due to 1977 being a critically dry year that was preceded by another critical dry year. The salt intrusion in 1977, contrary to what typically happens for yearly dry periods, never subsided in the winter time because Delta inflows continued to be low throughout the winter. The field data suggests that the majority of the high salt intrusion occurred during the fall and winter seasons of dry periods, times when the net Delta consumptive use is usually low. As a result, the difference in EC between the two DSM2 model runs is much narrower in the fall and winter, suggesting that any error in net Delta consumptive use estimates in the fall and winter does not have a significant impact on the model output. DSM2 simulated EC for both DSM2 runs matches the field data fairly closely during these periods, raising the confidence for DSM2's ability to simulate salt intrusion.

Judging from these observations, the most likely reason for the differences between the observed EC data and DSM2-simulated EC in Run A is the inaccuracy of the DICU estimates during the summers of dry periods. DSM2 successfully recreates the high salinity intrusion that typically occurs during the fall and spring, times of low net Delta consumptive use.

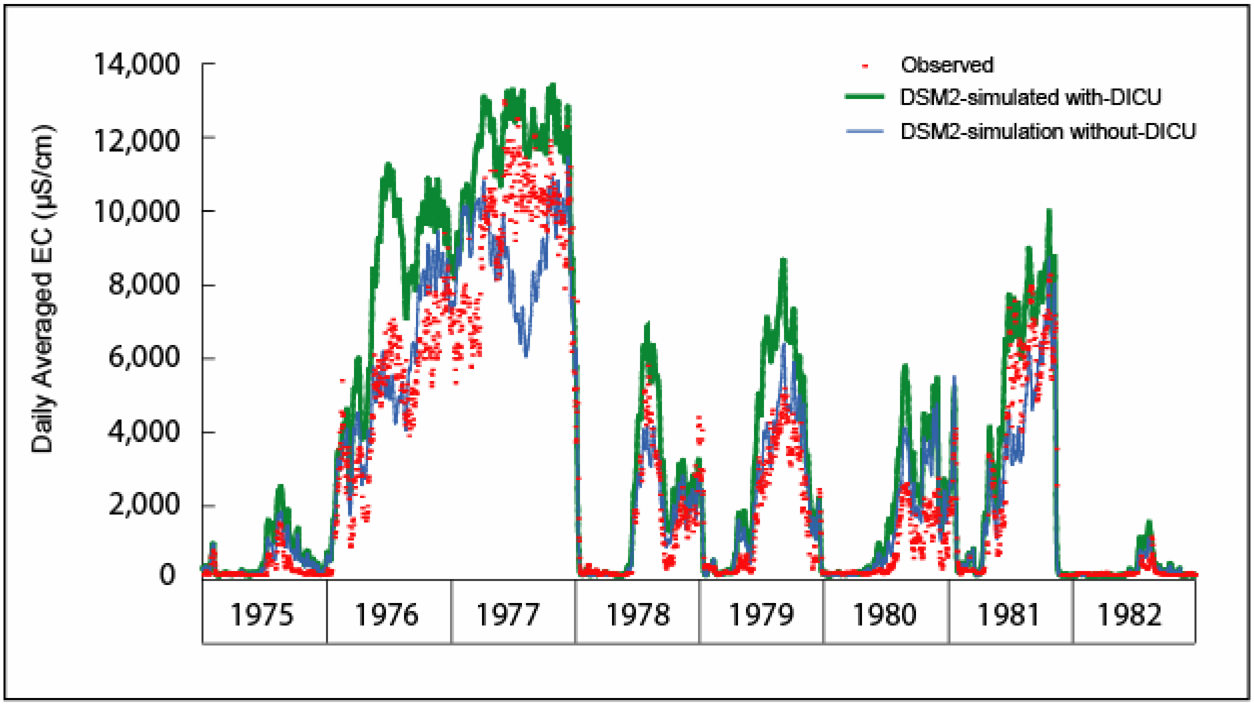


Figure 9.10: Daily-averaged observed and DSM2-simulated EC at RSAC081 (Sacramento River at Collinsville), 1975 to 1982.

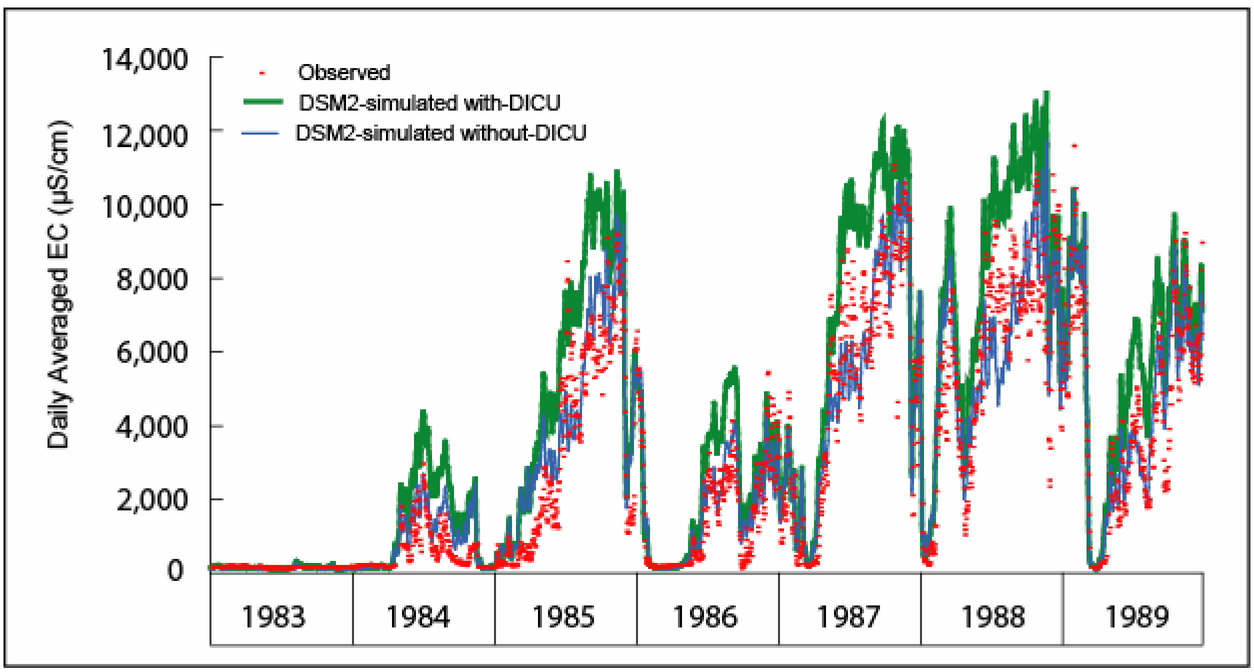


Figure 9.11: Daily-averaged observed and DSM2-simulated EC at RSAC081 (Sacramento River at Collinsville), 1983 to 1989.

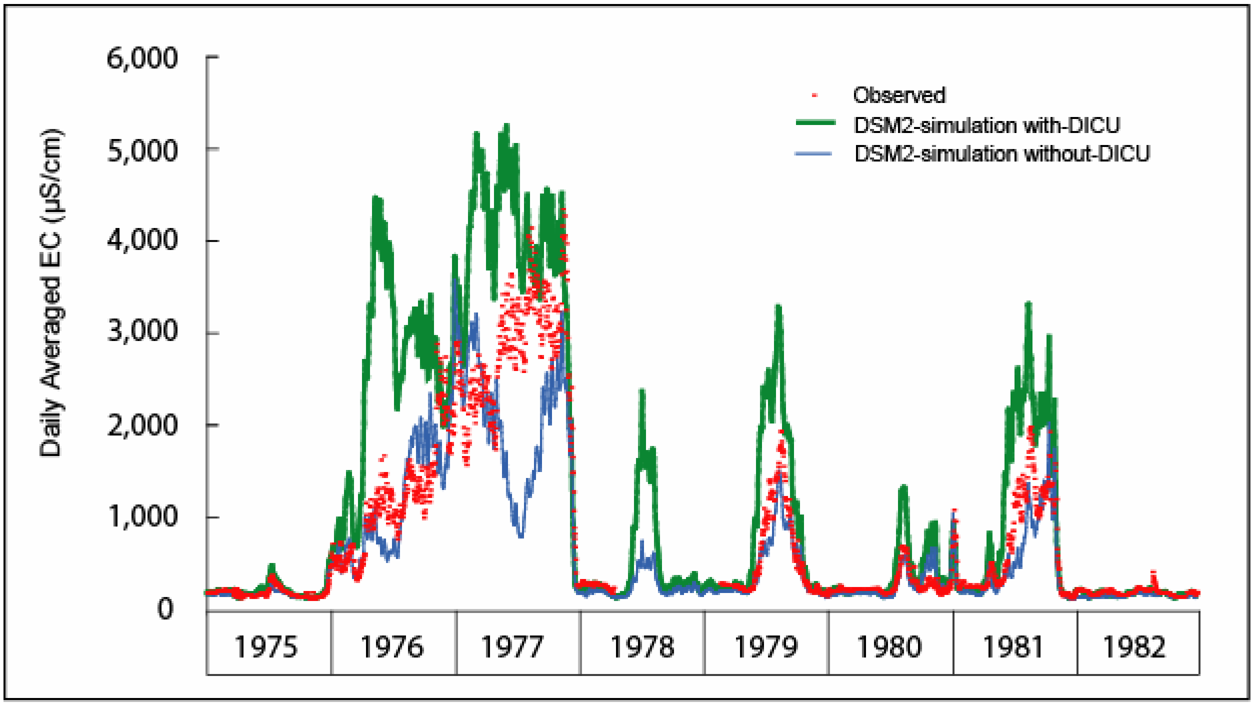


Figure 9.12: Daily-averaged observed EC and DSM2-simulated EC at RSAN018 (San Joaquin River at Jersey Point), 1975 to 1982.

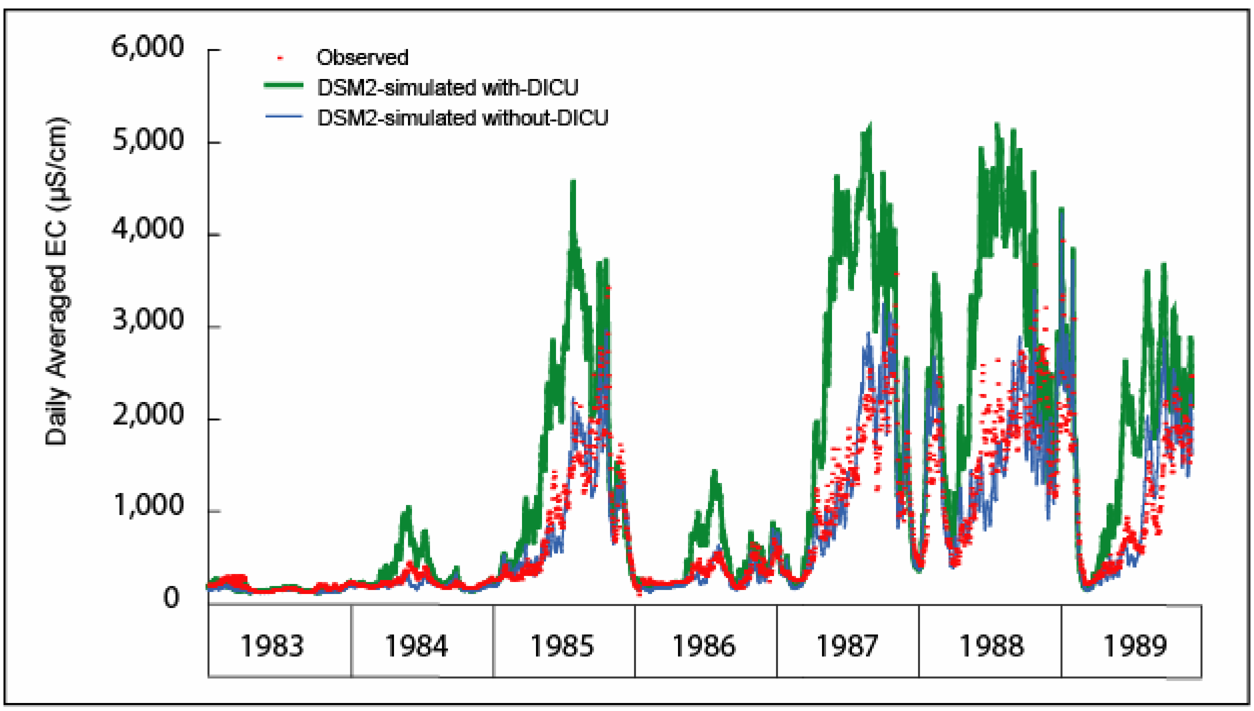


Figure 9.13: Daily-averaged observed EC and DSM2-simulated EC at RSAN018 (San Joaquin River at Jersey Point), 1983 to 1989.

9.5 Summary and Conclusions

DSM2-simulated stage and flow match well with the field data that is available for the historical 1975-1990 period. For the water-years of wet, above-normal, and below-normal, simulated EC generally agrees with the monitored EC data. DSM2 captures peak EC values that typically occur during fall or early winter months; however, DSM2 tends to overestimate EC during the summer of dry periods. Evidence indicates the reason for this overestimation of EC is that the DICU model may be overestimating the net Delta consumptive use at these times.

9.6 Recommendations

Inaccuracies in DICU estimated consumptive use may occasionally significantly impact simulated EC. At times, these inaccuracies may be the primary source of the discrepancies between simulated and field-measured EC. Modifying the existing DICU model or using an alternative DICU model may be essential for DSM2 to better match field measured EC during the summers of the critical and dry water-years, especially at the sites located in the vicinity of the confluence of the Sacramento and San Joaquin rivers. This may be challenging since no direct measurements of net Delta consumptive use is available. Indirect calculation of net Delta consumptive use by utilizing a flow balance approach on certain isolated regions might be considered. Another approach may be to develop Artificial Neural Networks that are trained to estimate net Delta outflow (NDO) based on measured EC values at Martinez and nearby areas. Once estimates for the NDO are available, the values for net Delta consumptive use could be calculated.

9.7 References

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http://modeling.water.ca.gov/delta/reports/annrpt/2001/2001Ch2.pdf

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27th Annual Progress Report
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Chapter 10: Using Particle Tracking to Generate Indexes of Fish Entrainment Potential

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10 Using Particle Tracking to Generate Indexes of Fish Entrainment Potential

10.1 Introduction

Using the Particle Tracking module of DWR's Delta Simulation Model II (DSM2), daily indexes of the potential for fish entrainment in Clifton Court Forebay were generated for historical and modified 2005 Delta conditions. Particles were continuously injected at eight locations in the central and south Delta and the total portion of particles by fate after 90 days was reported. Fate was broken down into six components: moving out of the Delta channels past Chipps Island, remaining in Delta Channels, removal by the State Water Project (SWP) and Central Valley Project (CVP) exports, removal by Contra Costa Canal diversions, and removal by Delta agricultural diversions. Results show that location of particle injection, San Joaquin River inflow, barrier operation, and SWP and CVP pumping all affect entrainment potential. Removing the historically installed temporary agricultural barriers in the south Delta had mixed results on entrainment potential depending upon the location of an injection.

10.2 Background

In the past, scientists studying Delta fish populations have attempted to relate fish salvage counts to the movement of water in Delta channels. This movement of water has mostly been accounted for only indirectly through such parameters as Delta inflow, cross-Delta flow, and Delta exports. These flows are either boundary flows that are measured or are internal flows that are calculated based upon empirical relationships developed from boundary Delta flows. Recently the United States Geological Survey (Armor, 2006) compared winter time (January through February) historical fish salvage to combined SWP and CVP pumping and to combined measured historical flows at Old River at Bacon Island (ROLD024) and Middle River at Lower Jones Tract (RMID015) (see Figure 10.1). The improvement in the regression by using measured internal flows instead of using combined SWP and CVP exports indicates that information describing Delta hydrodynamics may be important in understanding fish salvage.

The Particle Tracking Model (PTM) is a module of DSM2 and simulates the transport and fate of individual particles traveling in the channels of the Sacramento-San Joaquin Delta. It has been used to indirectly describe Delta hydrodynamics. The model utilizes velocity, flow, and stage output from DSM2-HYDRO in simulating longitudinal movement while transverse and vertical movements are accounted for by assuming a relationship between movement and water depth and velocity. PTM has been described in detail elsewhere (see Smith, 1998; Miller, 2000; Miller, 2002). PTM results of historical simulations have recently been used to create indexes of Delta residence time (see Chapter 3; Sommer et al., 2006) and to estimate the portion of San Joaquin River inflow water diverted by SWP and CVP exports (Sommer et al., 2006). In a similar fashion, PTM simulations with multiple injection locations have been conducted under historical conditions to track variations in potential for fish entrainment by SWP and CVP pumping. Below are a description of this work and a summary of the results.

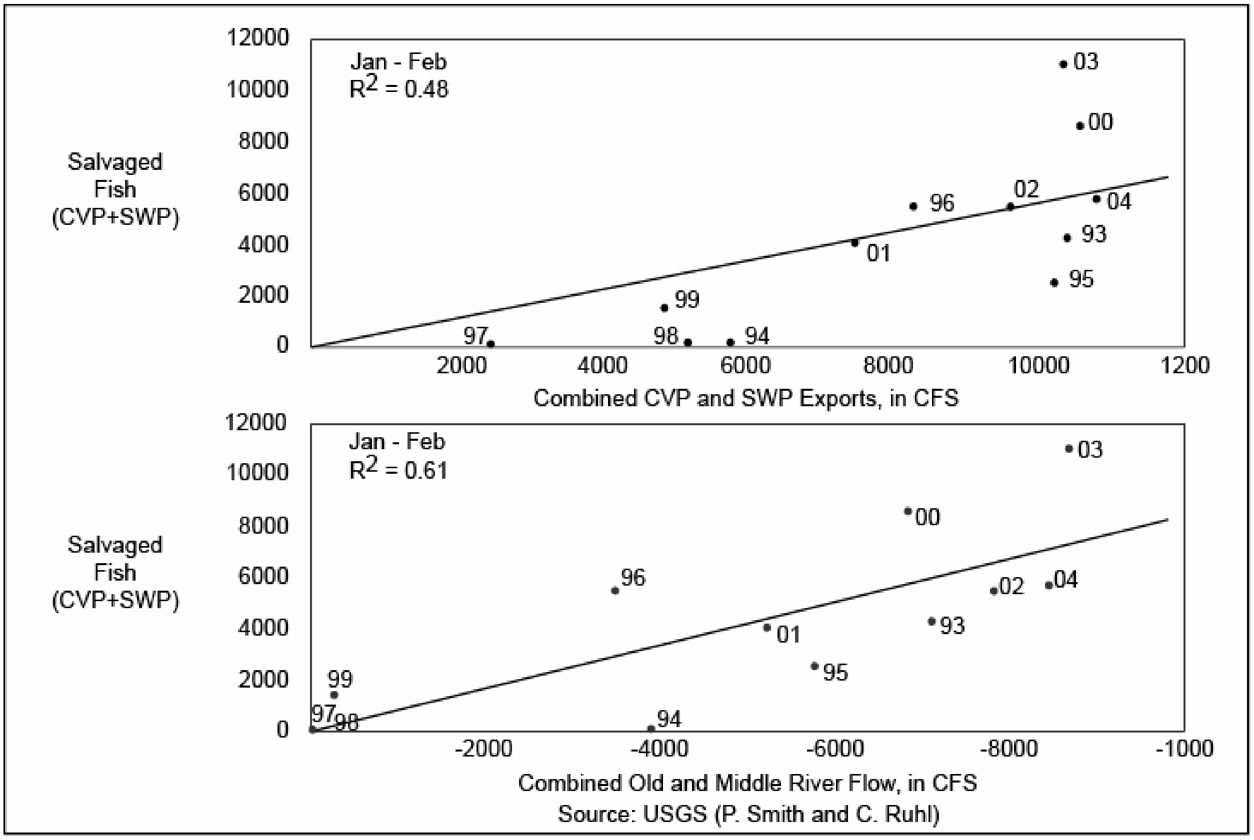

Figure 10.1: Comparison of average winter salvage to average winter exports and in-Delta flows (USGS).

10.3 PTM Setup for Historical 2005 Delta Conditions

Historical 2005 Delta conditions were used in order to test using PTM to generate an index of the potential for fish entrainment. Historical 2005 Delta hydrodynamics were first simulated using DSM2-HYDRO with historical Delta inflows and exports (Figures 10.2 and 10.3) along with historical operations of Delta structures (Table 10.1). PTM was then run by daily injecting particles at nine locations (Figure 10.4). The particles injected on any given day were separately tracked for 90 days and the fate of these particles was noted. Fate was broken down into six categories: moving out of the Delta channels past Chipps Island, remaining in Delta Channels, removal by the State Water Project (SWP) and Central Valley Project (CVP) exports, removal by Contra Costa Canal diversions, and removal by Delta agricultural diversions. The fates of injected particles after 90 days were assigned to the date of injection. In this way the portion of particles injected that are removed by SWP and CVP pumping within 90 days of the injection can be used to create an index of the potential entrainment. Such an index then is associated with the date and location of the injection and accounts for changes in Delta inflows, exports, and barrier operations and indirectly reflects the Delta hydrodynamics which might contribute to fish entrainment.

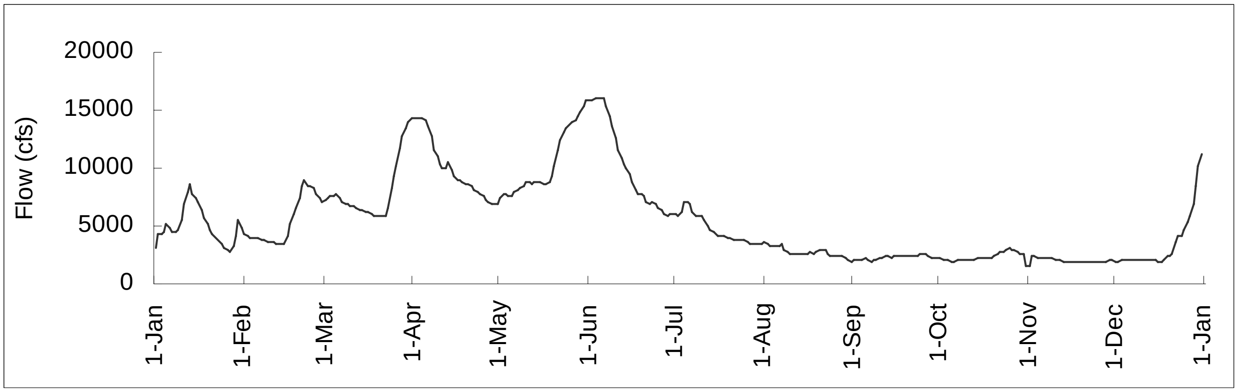

Figure 10.2: Historical San Joaquin River inflow at Vernalis, 2005.

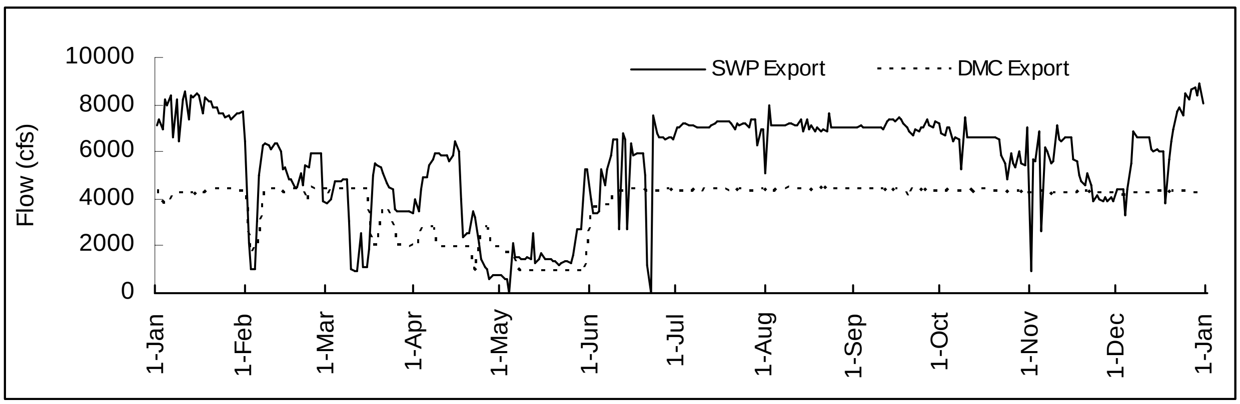

Figure 10.3: Historical State Water Project and Central Valley Project pumping from the Delta, 2005.

Table 10.1: Timing of temporary barrier installation and removal for 2005.

Barrier	Installation	Removal
Middle River	5/12/05	11/8/05
Old River near Delta Mendota Canal	5/31/05	11/10/05
Grant Line Canal	7/14/05	11/15/05
Old River @ Head (spring)	--	--
Old River @ Head (fall)	9/29/05	11/8/05

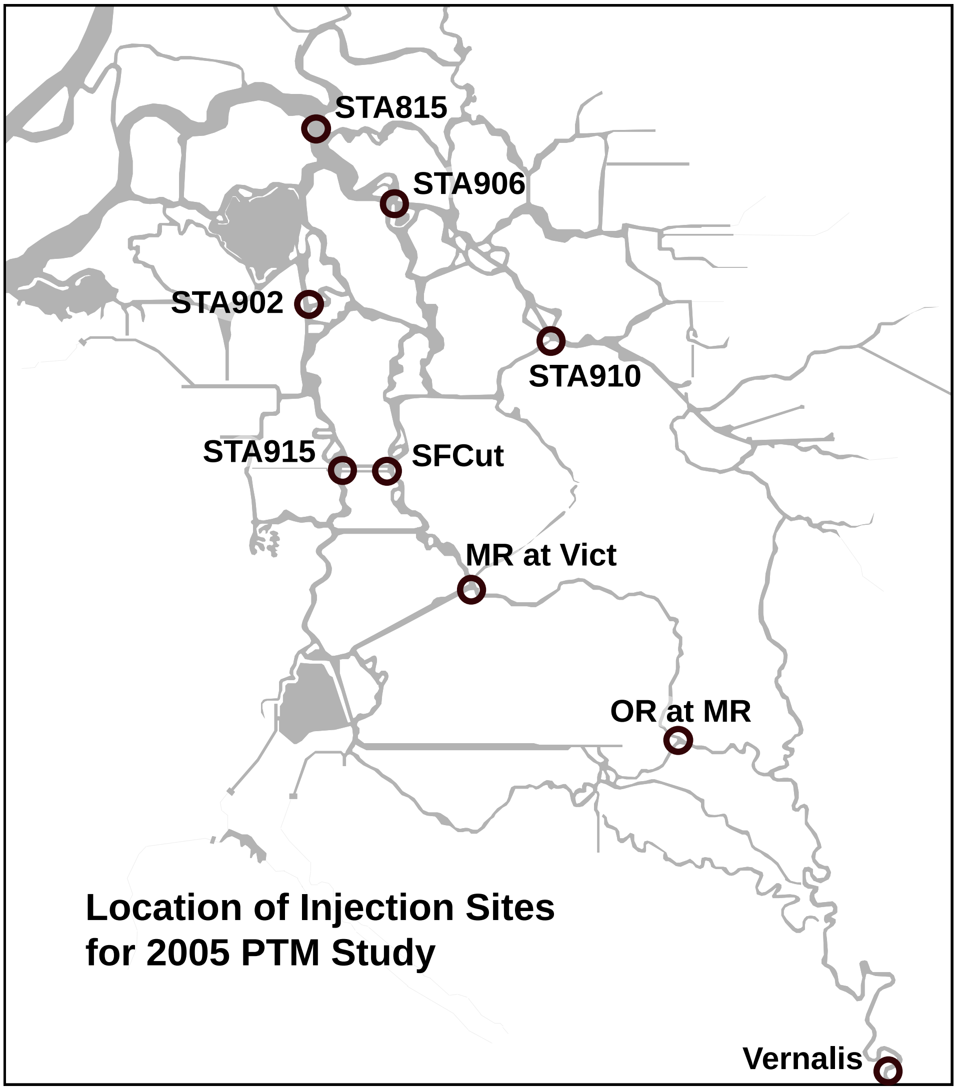

Figure 10.4: Locations particles injected for PTM study of historical 2005 Delta conditions.

10.4 PTM Results for Historical and Modified 2005 Delta Conditions

Figure 10.5 shows the fate of daily injected particles after 90 days of tracking for the nine locations of injection for historical 2005 conditions and the change in particle fate if the temporary barriers in the south Delta are assumed not installed. Highlighted are the contributions to fate of SWP and CVP pumping compared to having a fate of moving past Chipps Island. Figure 10.6 shows the PTM results for just the historical 2005 conditions as averaged over monthly or semi-monthly periods. For simplicity, only the portion of particles lost to SWP and CVP pumping and lost to agriculture diversions are presented. The balance of the particles were nearly always those particles moving out of the Delta past Chipps Island.

10.4.1 PTM Results for Historical Conditions

Figure 10.5 indicates that particle fate can vary widely from one day of injection to the next, depending upon Delta hydrodynamics. Figure 10.2 shows that significant increases in San Joaquin River inflow occurred in the periods of approximately March 20 through April 7 and from May 15 through June 15. Also, historical SWP pumping was significantly lower from mid April through May (Figure 10.3). Thus, one might predict that entrainment potential would have decreased during these periods. Figure 10.5 supports this hypothesis with generally decreased portions of particles pumped by SWP; however, interpreting results beyond this is tenuous. The brief decrease in particles lost to SWP in March is made up by an increase in particles lost to the CVP when the injection is at Middle River at Victoria Canal, Old River at Middle River, SFCut, and STA915. However, at injection locations STA815, STA902, STA906, and STA910, the decrease in particles removed by SWP translated to increased particles moving past Chipps Island. Particles injected at the locations which are further downstream on Old River or on the San Joaquin River responded to decreased SWP pumping and/or increased San Joaquin River inflows quite differently than particles injected nearer the south Delta.

The lower pumping and higher San Joaquin River inflows during the mid April through May period nearly uniformly resulted in sharply less particles being lost to the SWP and more particles moving past Chipps Island. The one exception was for the particles injected upstream of the south Delta barriers in Old River at Middle River. These particles did not significantly respond to the change in hydrology.

10.4.2 PTM Results for Modified Conditions (No Temporary Barriers)

Running the PTM simulation without the temporary agricultural barriers in Old River, Middle River and Grant Line Canal tended to shift some of the particle fate between the SWP pumping and CVP pumping. For Vernalis and Old River at Middle River injection locations, both of which are upstream of the SWP and CVP exports, removing the barriers shifted some particle fate from the SWP to the CVP with a net small change in overall particle fate. For the other injection locations, all of which are downstream of the barriers and the SWP and CVP exports, removing the barriers shifted some particle fate from the CVP to the SWP, again with a relatively small net change in combined portions of particles lost to CVP and SWP exports.

10.4.3 Period Average PTM Results for Historical Conditions

The interaction between location of particle injection, SWP pumping, San Joaquin River inflow, and the portion of injection particles entrainment by SWP and CVP exports, diverted by Delta agriculture, and moving out of the Delta past Chipps Island can be better seen in Figure 10.6. Particles injected in Old River at STA915 have approximately the same fate as those injected in Middle River at SFCut. The same holds for the fate of particles injected in the San Joaquin River at STA910 compared to Old River at STA902 and the fate of particles injected in the San Joaquin River at STA815 and STA906. Compared to the fate of particles injected elsewhere, the fate of the particles injected at Old River at Middle River is fairly insensitive to Delta hydrology. At this injection location, few particles move past Chipps and only shift somewhat from CVP entrainment to SWP entrainment when exports decreased and San Joaquin River inflow increased.

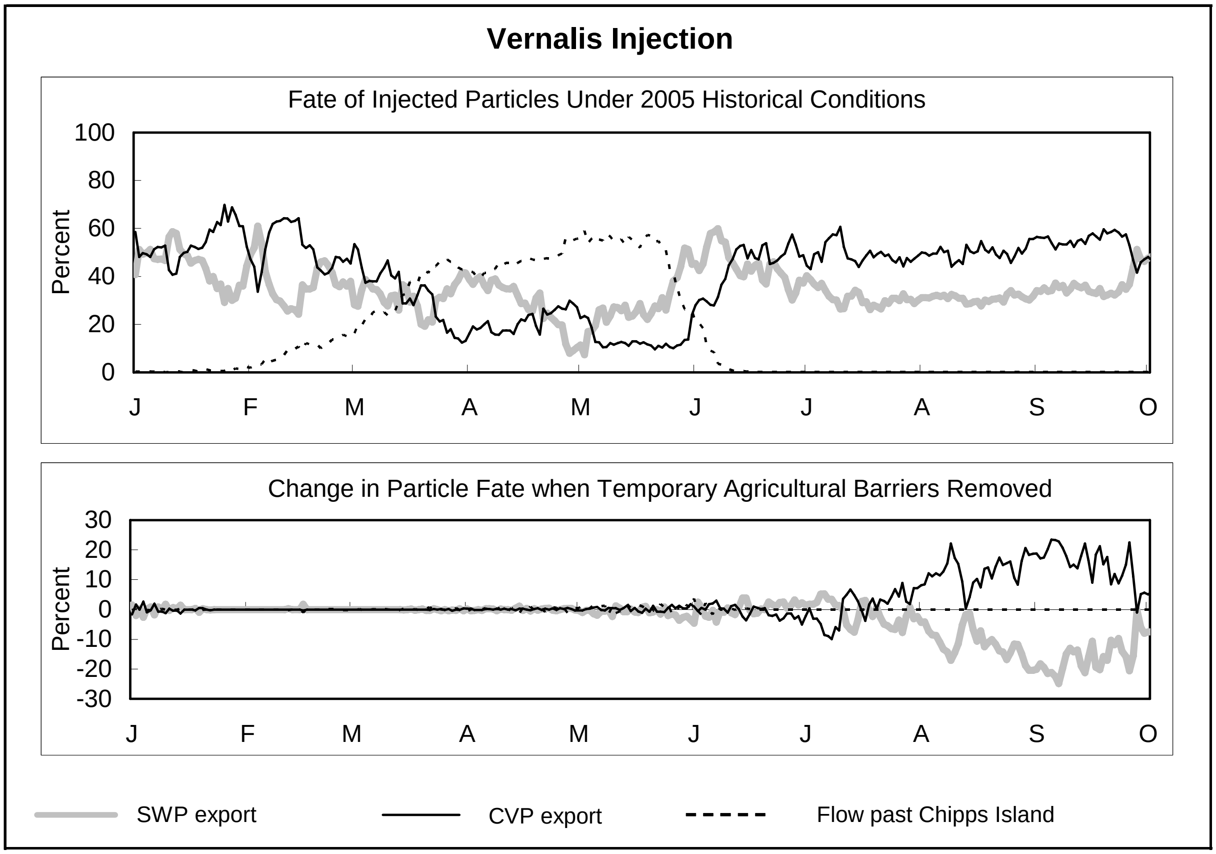

Figure 10.5: Daily PTM results for historical and modified 2005 conditions, variable locations of injections.

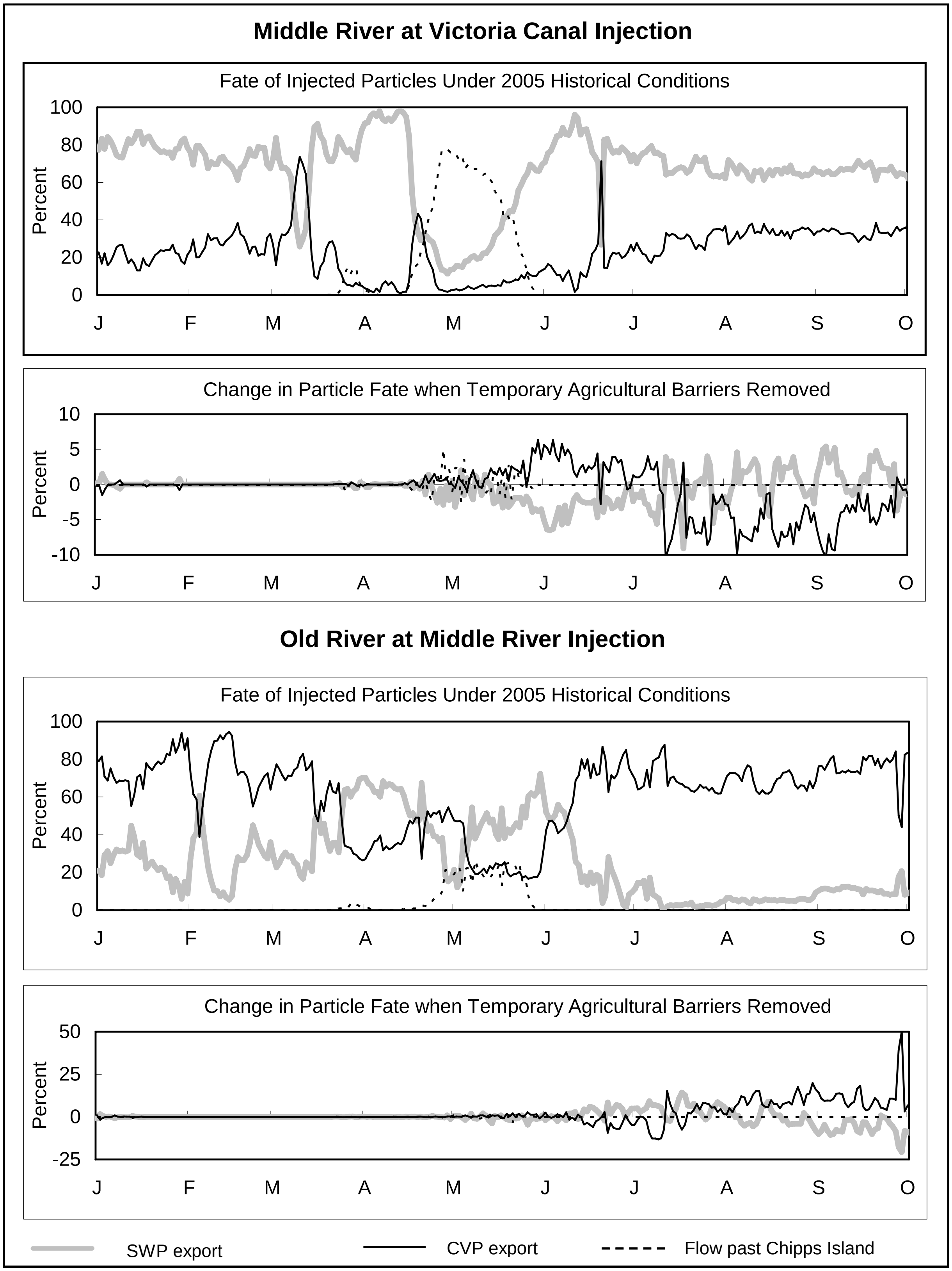

Figure 10.5 (cont.): Daily PTM results for historical and modified 2005 conditions, variable locations of injections.

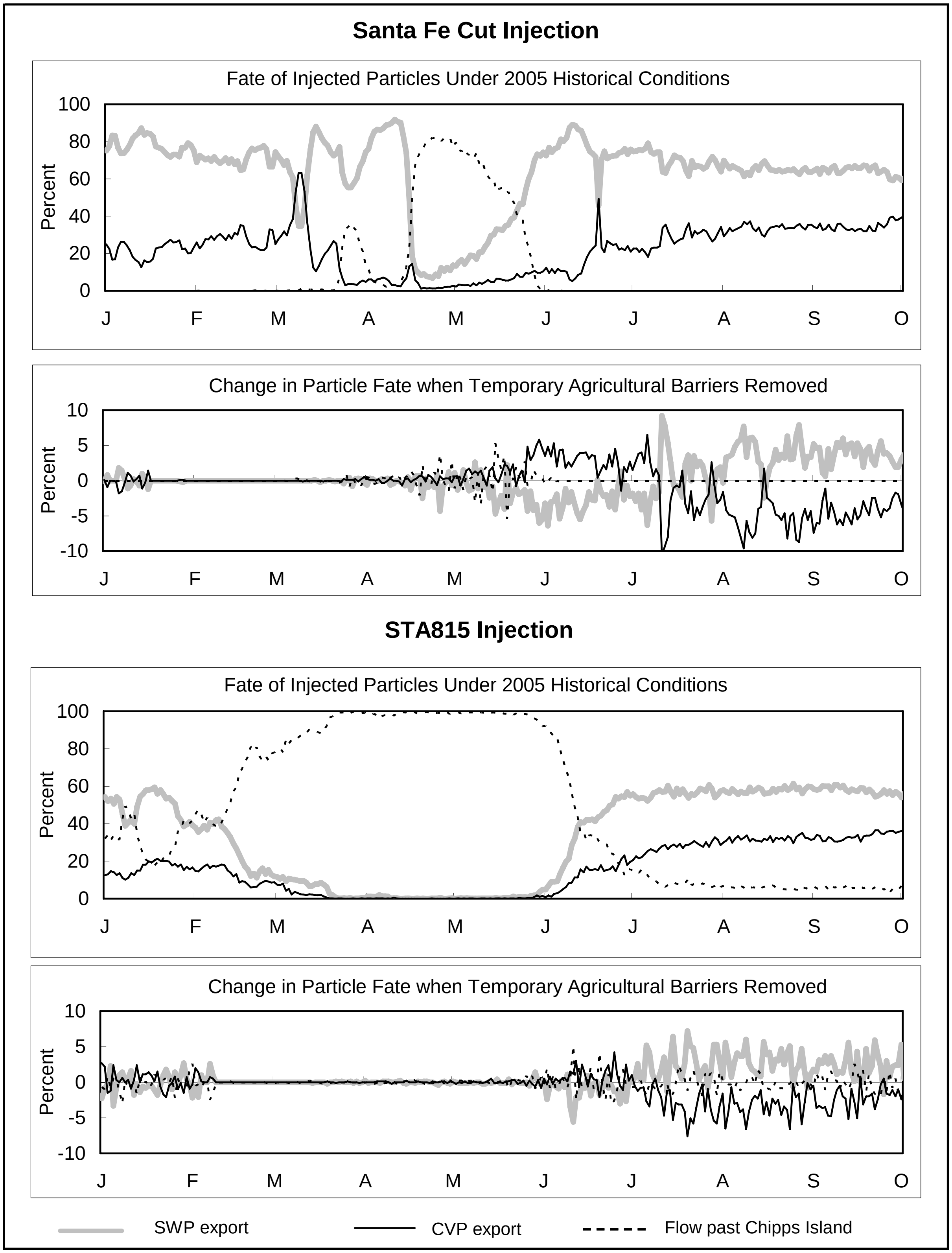

Figure 10.5 (cont.): Daily PTM results for historical and modified 2005 conditions, variable locations of injections.

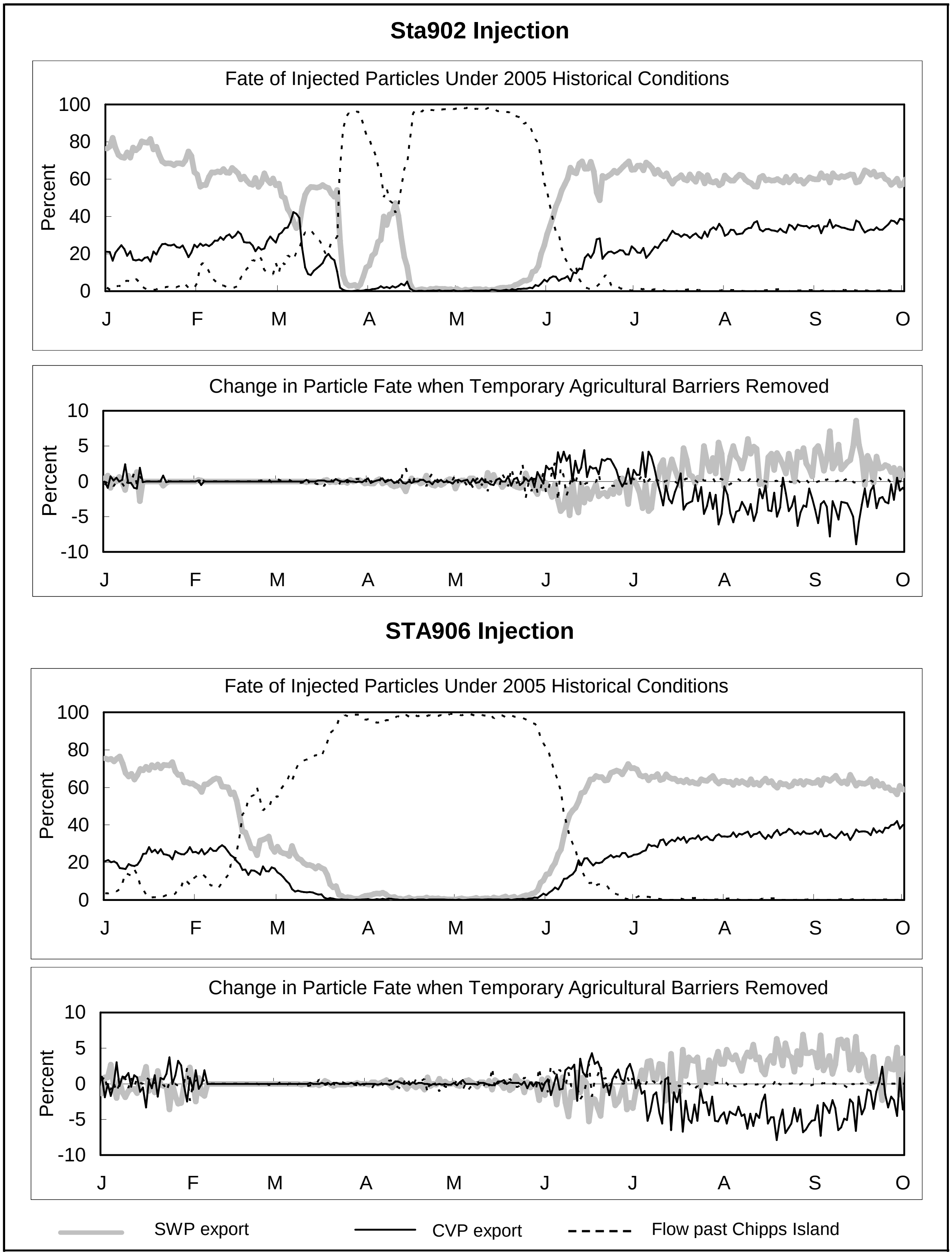

Figure 10.5 (cont.): Daily PTM results for historical and modified 2005 conditions, variable locations of injections.

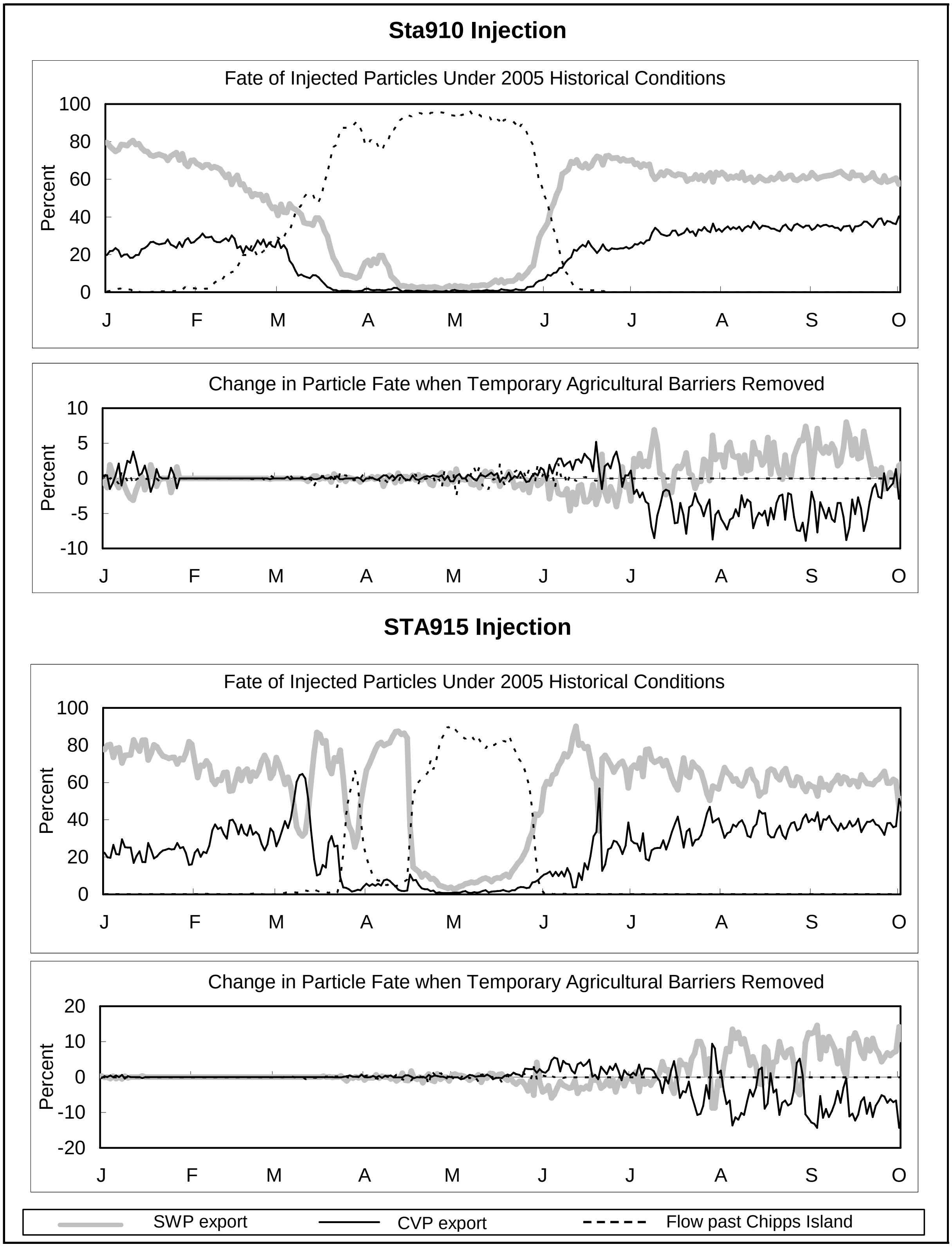

Figure 10.5 (cont.): Daily PTM results for historical and modified 2005 conditions, variable locations of injections.

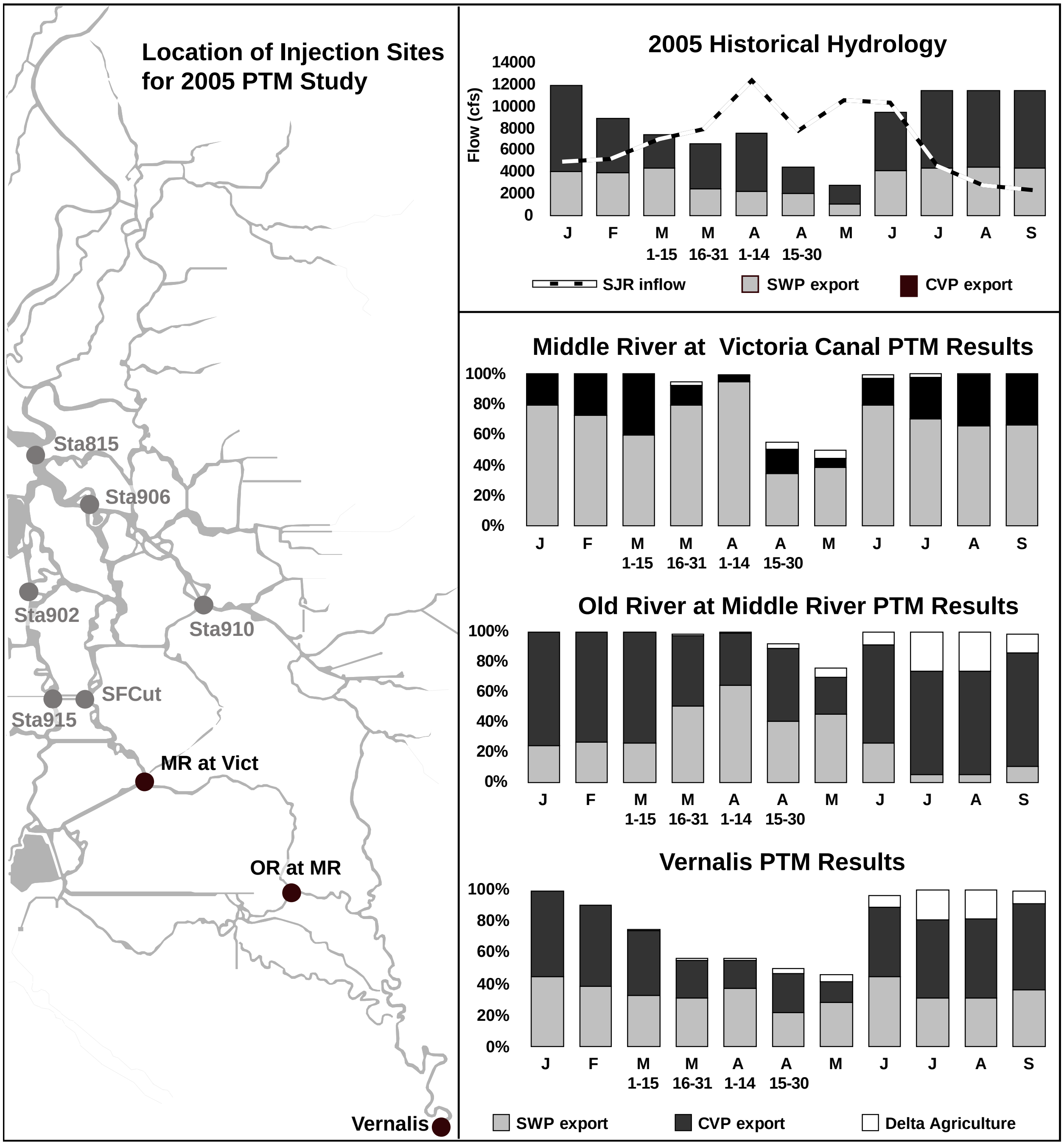

Figure 10.6: PTM results per injection location averaged over time intervals.

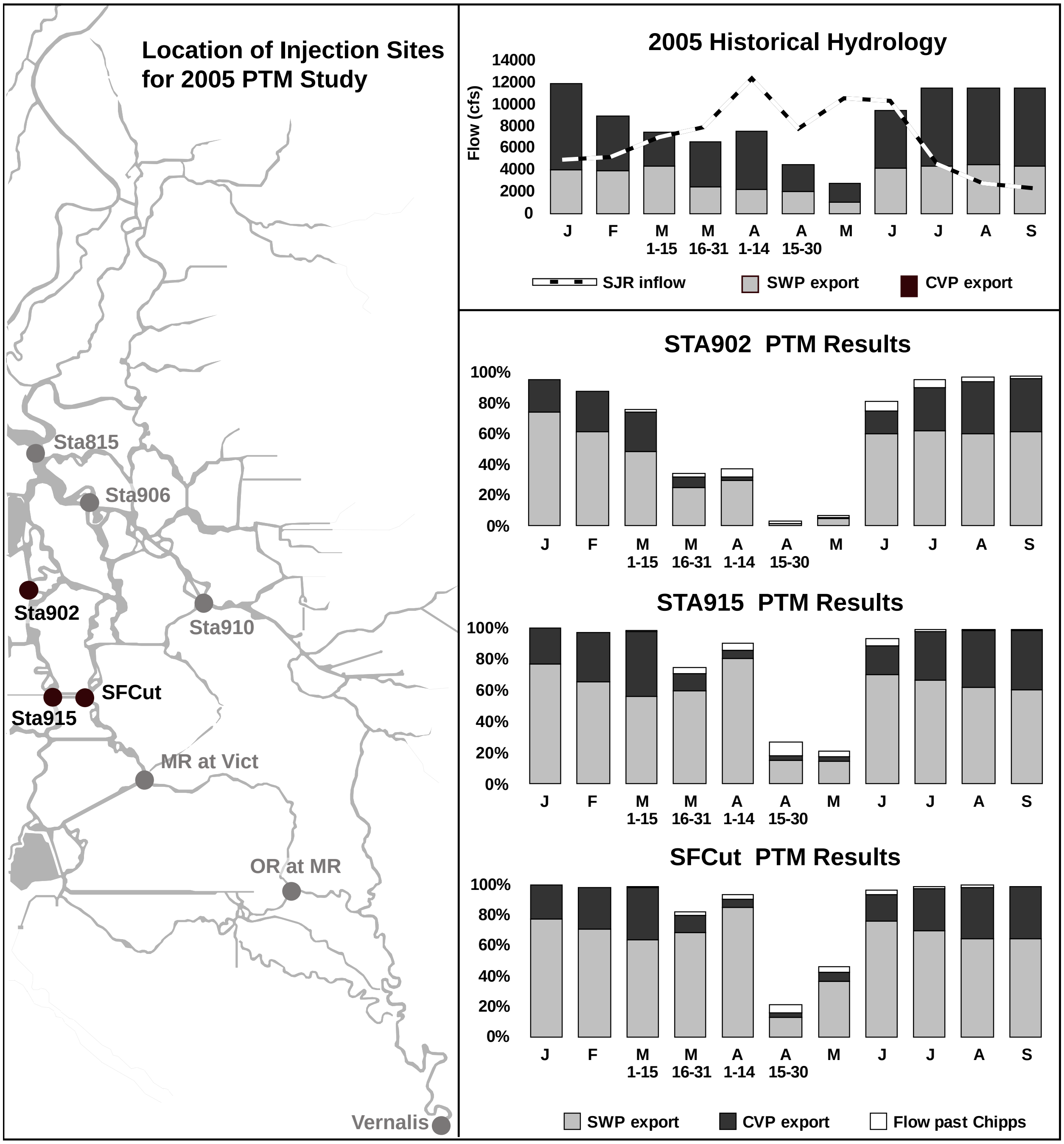

Figure 10.6 (cont.): PTM results per injection location averaged over time intervals.

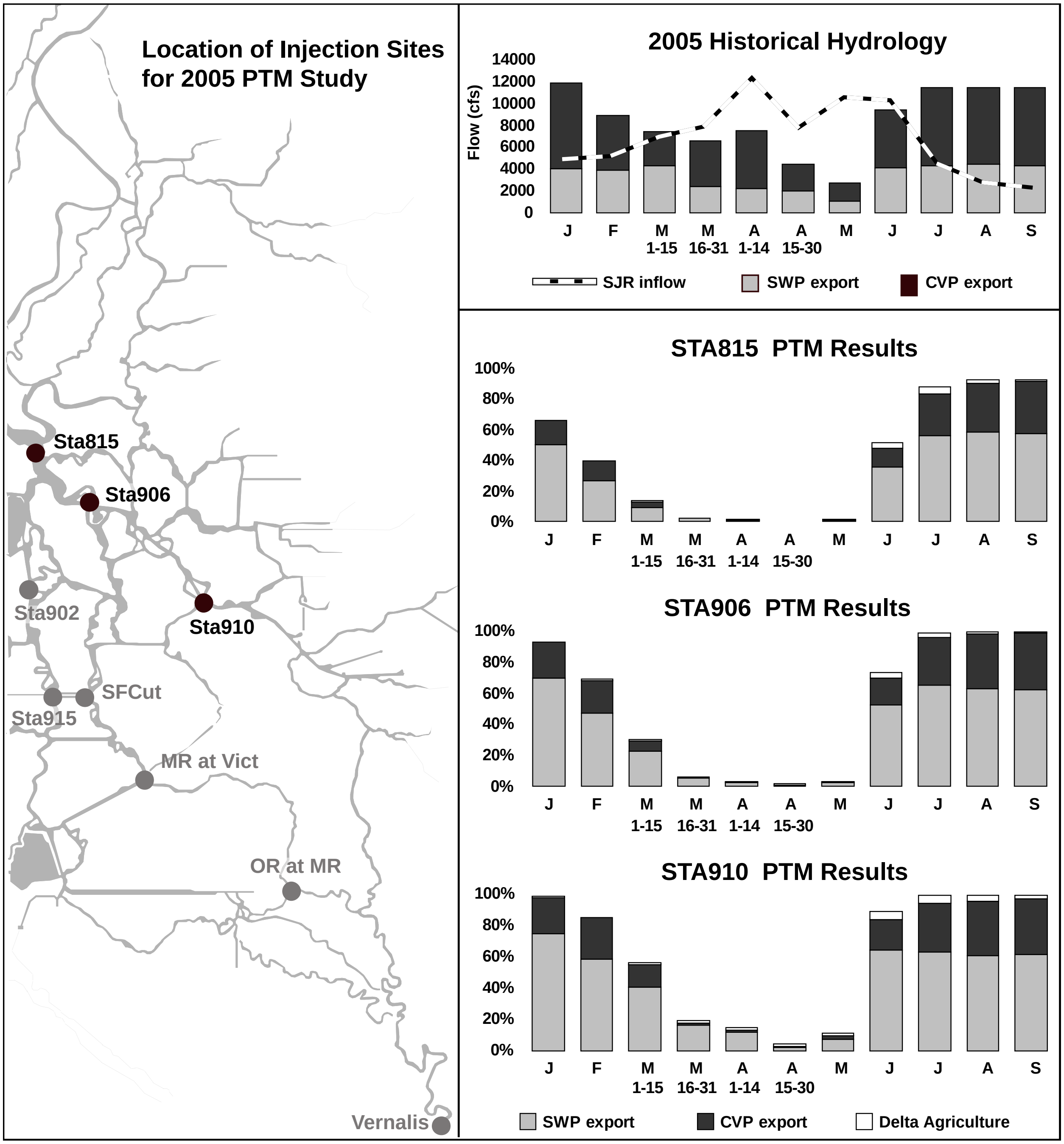

Figure 10.6 (cont.): PTM results per injection location averaged over time intervals.

10.5 Summary and Conclusions

PTM-generated particle fate has promise as an index of the potential for fish entrainment by the SWP. Two areas of interest which could be investigated in the future are varying the time duration over which particle fate is determined (i.e. shortening the 90-day criteria) and attempting to relate salvage to fate weighted by location of injection. If an index for fish entrainment potential is to be generated from particle tracking simulations, it appears that the index needs to be based upon multiple injection locations and be daily. As can be expected, the higher the San Joaquin River inflows, the lower the SWP and CVP pumping, and the further downstream the injection location, the greater the portion of injected particles move out of the Delta past Chipps Island. The installation of the three temporary barriers for agricultural diverters does not appear to strongly affect the fate of particles injected outside of the area affected by the barriers. The fate of particles injection upstream of the agricultural barriers sites tends to shift somewhat from removal by SWP exports to removal by CVP exports when barriers are not installed, but more injection locations and different hydrologic conditions need to be investigated in order to draw any strong conclusions. For locations downstream of the agricultural barriers, injected particles tend to either pass by Chipps Island or be entrained by SWP, depending upon the Delta hydrology.

10.6 References

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Chapter 11:
DSM2 Users Group Update

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11 DSM2 Users Group Update

11.1 Introduction

The DSM2 Users Group (Group) was formed in early 2004 to provide the users of the Delta Simulation Model II (DSM2) a platform to interact, communicate and exchange information about the use of the model and offer suggestions for model enhancement. Since the Group's initiation, a website and an online forum dedicated to the Group have been developed, and a total of ten quarterly meetings have been held. This chapter will review the activities and present some of the key topics covered the past two and half years.

11.2 Group Members

The Group first started with approximately 30 members, mostly subscribers of the previous DSM2-study mailing list. The members initially consisted of staff from DWR, participants from consulting firms including CH2M Hill and Jones & Stokes, and agencies including Contra Costa Water District, East Bay Municipal Utility District, Metropolitan Water District of Southern California, and the Bureau of Reclamation. Over the last two and half years, the Group has steadily grown and currently includes nearly 60 members. The additional members include consultants from Montgomery Watson Harza and Surface Water Resources, Inc., staff from agencies such as State Regional Water Quality Control Board, US Fish Wildlife Service, San Francisco Estuary Institute, and graduate students from UC Davis and Stanford University.

11.3 Meetings

The primary means of interaction of the Group is quarterly meetings which started in January 2004. At the date of this report, a total of 10 meetings have taken place and a variety of DSM2 applications and development related topics have been presented. These topics had a broad appeal to the Group members and the meetings provided the members many peer-to-peer direct learning and interaction opportunities.

11.3.1 Format

Meetings usually consist of updates of the Delta Modeling Section's ongoing project status, presentations of the model applications and/or development, and group discussions.

11.3.2 Update Items

The Delta Modeling Section has completed a number of projects and studies the past two years and several projects are still ongoing. The update on the background and status of these projects are the first part of the Group quarterly meetings. The key projects include Annual Reports 2004 & 2005, DSM2 development, standardization of DSM2 studies, 2005 historical hydrodynamics simulation for the Temporary Barriers project, the modeling support for the Pelagic Organism Decline (POD) workshop, and DSM2 82-year extension study for the Common Assumptions Long-term Update project. Detailed information on these updates is available online at:

http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/dsm2usersgroup.cfm

11.3.3 Presentation Topics

A major element of the meetings is topical presentations given by the participants of the Group on DSM2 applications and development. These presentations are an integral component of the Group and the topics are directly related to each user's knowledge and experience concerning the use of the model. Each meeting usually has two or three speakers who are either DWR staff or outside model users from other agencies and consulting firms.

The topics presented by DWR staff during the past two years were:

- San Joaquin River Geometry Modification (Jim Wilde)
- Particle Tracking Model (PTM) Animations Illustrating the Flexibility of South Delta Permanent Barriers Operations (Bijaya Shrestha)
- Clifton Court Forebay & South Delta Gate Experiments Using DSM2-DB (DSM2 Version 7) (Eli Ateljevich)
- Model Steering and Operating Rules (Eli Ateljevich)
- Using DSM2 to Assess Impacts of Climate Change on the Delta (Jamie Anderson)

Presentations given by outside users included:

- California Aqueduct Extension Project
  (Kyle Winslow, CH2M Hill)

  This work is part of the Department's Municipal Water Quality Investigation Program's Real Time Data and Forecasting (RTDF) project and is coordinated by CH2M Hill. The objective of this work is to develop a DSM2-based tool for monitoring, forecasting and disseminating data pertaining to water supply and quality. The scope of the work includes extending the DSM2 grid to cover the California Aqueduct, the Delta Mendota Canal, the South Bay Aqueduct, San Luis Reservoir, and O'Neil Forebay. The simulation period is from Jan 1, 2000 to Dec 31, 2003. More detailed information on this work is available online at:

  http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/DSM2UsersGroup/
  July262005CaliforniaAqueductDSM2.pdf

- Evaluation of Mountain House Creek and Wastewater Discharge Using DSM2
  (Anne Huber and Russ Brown, Jones & Stokes)

  This presentation includes two investigations of high and low tidal flows in Old River near Mountain House Creek. The presentation is based on work completed in early 2004 by Russ Brown and Anne Huber from Jones & Stokes for Pacific Advanced Civil Engineering, Inc. The first part of the presentation focuses on a study of the high tides and flows for a storm event that occurred in January of 1997. DSM2 estimated the actual Vernalis flow at the time of upstream levee breaks. The second part of the presentation shows the dilution of future effluent discharges and the matching of DSM2-QUAL to two dye studies performed in Old River during the summer Temporary Barrier operation period. The presentation is available online at:

  http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/DSM2UsersGroup/Mt_House.pdf

- PTM Evaluation Results for SDIP
  (Russ Brown, Jones & Stokes)

  The SDIP Draft EIR/EIS report was released in October 2005. This presentation provides an overview on the method of using the DSM2 Particle Tracking Model to simulate the effect of SWP and CVP export pumping on Delta channel hydraulics and assesses fish entrainment as "virtual" particles released from various locations within the Delta. The URL for this presentation is:

  http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/DSM2UsersGroup
  /PTMResults_Russ_Brown.pdf

- Tracking Wastewater Effluents to Drinking Water Intakes within the Delta
  (Russ Brown, Jones & Stokes)

  This presentation is a follow-up on the "Evaluation of Mountain House Creek and Wastewater Discharge Using DSM2" presentation. In addition to the Mountain House Tidal Dilution Study results, this presentation includes an assessment of future treated wastewater discharge data from the Iron House Sanitation District to various locations within the Delta based on DSM2.

- A New Version of the G-model, Using Historical DSM2 Output in the Calibration (Richard Denton, Contra Costa Water District)

  This topic is an overview of the revised salinity-outflow relationship model, commonly referred to as the G-model. The improvement of this new version of the G-model is that EC is now a function of QWEST in addition to the antecedent Delta outflow. The presentation covers the background, the need for improvement of the original G-model, the revised calibration values of the equation factors, the comparisons of the daily EC predictions at Jersey Point between the old and the new version, and future directions. DSM2 planning study output was used for the development of the revised model. For more information on this presentation, please visit the website at:

  http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/DSM2UsersGroup/DSM2UserGroupGQ-Modelpresentation4-25-06rad.pdf

11.4 Website and Bulletin Board

During the initiation of the Group, in addition to the quarterly meetings, a website (i.e., http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/dsm2usersgroup.cfm), an FTP site, and an online bulletin board were also developed to provide users easy access to the information. In the past two and half years, the online bulletin board has been actively used by members to post their questions and answers and share their experience and knowledge with one another on a variety of subjects concerning the use of DSM2.

11.5 Survey Results

To ensure the members are satisfied with the DSM2 Users Group, we have conducted two annual surveys in the past to collect participants' feedback. We understand that critical to the long-term success of a users group is its ability to meet participants' needs and expectations. It is important to encourage and support an infrastructure and processes that can enable the Group to accomplish these goals. Surveys help us improve our approach to organizing meetings, determining contents of the meetings, and effectively interacting with members.

According to the latest survey conducted at the end of 2005, 90% of participants had an overall positive evaluation for the Group, and 96% of survey participants are satisfied with the meeting format including meeting schedule and contents. Presentations on DSM2 applications were preferred by 60% of the members, and over half of the group would like to see more tutorials on DSM2 tools and applications as themed meeting format in the future. The survey also found that interest in utilizing DSM2 for different applications continues to grow and studies conducted by outside users will be preferred topics at future meetings.

11.6 Future Directions

The Group has gone through a period of clarification and maturing since its start in the beginning of 2004. This process has been successful due to the strong support from its members. To continue this growth of the Group, we will continuously search for ways to improve. We will continue to share and exchange DSM2-related information through various channels, implement the findings in the survey results, and look for possible partnership opportunities with other users groups, such as the CALSIM Users Group. We remain committed to meeting the DSM2 users' needs and making the Group a valuable experience for all.

Acronyms and Abbreviations

ADCP – acoustic Doppler current profiler

ANN – Artificial Neural Network

CALFED – collaboration of over 25 Federal and California state government agencies

CalSim II – California Water Resources Simulation Model II

CCF – Clifton Court Forebay

CDEC – California Data Exchange Center

CIMIS – California Irrigation Management Information System

CVP – Central Valley Project

CCWD – Contra Costa Water District

CDWR – California Department of Water Resources

DETAW – Delta Evapotranspiration of Applied Water

DICU – Delta Island Consumptive Use

DSM2 – Delta Simulation Model 2

DSM2-HYDRO – DSM2 hydrodynamics module

DSM2-PTM – DSM2 particle tracking module

DSM2-QUAL – DSM2 water quality module

DWR – California Department of Water Resources

EC – electrical conductivity

ESO – DWR's Environmental Services Office

ETAW – evapotranspiration of applied water

Et_c – crop evapotranspiration rate

ET_o – potential evapotranspiration rate

GIS – geographic information system

GLC – Grant Line Canal

GUI – Graphical user interface

HH – higher high tide

HL – higher low tide

HOR – Head of Old River

IEP – Interagency Ecological Program

IST – CDEC station code for I Street Bridge on Sacramento River

IWFM – Integrated Water Flow Model

LH – Lower high tide

LL – Lower low tide

MR – Middle River

MSL – mean sea level

MWQI – DWR's Municipal Water Quality Investigations program

NDO – Net Delta Outflow

NGVD – National Geodetic Vertical Datum

O&M – DWR Operations and Maintenance

OR – Old River

POD – pelagic organism decline

PTM – DSM2 Particle Tracking Model

PWT – IEP DSM2 Project Work Team

RKI – River Kilometer Index

RMID015 – IEP RKI for Middle River at Santa Fe Cut, also located near Lower Jones Tract

RMKL005 – IEP RKI for North Fork of the Mokelumne River at Georgiana Slough

ROLD024 – IEP RKI for Old River at Bacon Island

RSAC081 – IEP RKI for Sacramento River at Collinsville

RSAC123 – IEP RKI for Sacramento River at Georgiana Slough

RSAN018 – IEP RKI for San Joaquin River at Jersey Point

RSAN072 – IEP RKI for San Joaquin River at Brandt Bridge

RTDF – Real Time Data and Forecasting

RVB – CDEC station code for Rio Vista Bridge

SIMETAW – Simulation of Evapotranspiration of Applied Water

SDIP – DWR's South Delta Improvements Program

SJR – San Joaquin River

STA – abbreviation used for station

SWP – State Water Project

USGS – U.S. Geological Survey

VAMP – Vernalis Adaptive Management Plan