Appendix A2
Delta Simulation Model II (DSM2) Methods and Results

A2.1 Introduction

In general, the increased Delta inflow and outflow of the proposed Plan amendments are expected to improve water quality in the Delta. However, to more thoroughly evaluate Delta water quality effects, the California Department of Water Resources' (DWR Delta Simulation Model II (DSM2) model was used to investigate whether occasional reductions in Delta inflow and alterations in Delta circulatory patterns associated with reduced Delta exports might reduce water quality under some circumstances. DSM2 was run using inputs from the Sacramento Water Allocation Model (SacWAM) to evaluate hydrologic changes in the Delta associated with the proposed Plan amendments and to assess whether the following water quality effects might occur.

- Increases in electrical conductivity (EC) that might affect agriculture, drinking water, and attainment of EC standards at some locations.
- Potential for water stagnation that might result in harmful algal blooms (HABs) or growth of nuisance aquatic vegetation in some locations.

The effects of Delta conditions on fish, including X2,[1] were evaluated based on SacWAM results as described in Section 7.6.2, *Aquatic Biological Resources,* and not in this appendix.

DSM2 is a one-dimensional mathematical model typically used for simulations of hydrodynamics, water quality, and particle tracking in a network of riverine or estuarine channels (Anderson and Mierzwa 2002). The DSM2 model is used to calculate tidal elevations, flows, velocities, and mixing of salinity in the Delta. DSM2 calculates the tidal flows in each Delta channel and calculates the seawater intrusion effects, which are controlled by the tidal flows and the net Delta outflow.

Two recent calibration efforts have provided very accurate tidal flow and EC results at most measurement stations. DSM2 was re-calibrated as part of early studies for the Bay-Delta Conservation Plan (BDCP) by CH2M Hill for DWR (CHM2 Hill 2009), and DWR re-calibrated DSM2 tidal elevations, tidal flows, and EC to match NAVD88 datum (DWR 2013a). DWR further re-calibrated DSM2 to include the Delta Channel Depletion Model (DCD), which covers the Suisun Marsh area (He et al. 2022). More detailed information about DSM2 development, modeling procedures, calibration, and validation efforts can be found in Attachment 1 and at the DWR web page for the DSM2 model.

A one-dimensional model is appropriate to use for this analysis because it captures the major tidal, dispersion, and mass-balance processes that drive water quality conditions in the Delta and potential effects that may be associated with changes in flow expected with the Plan amendments. Furthermore, it allows simulation of a longer period with a bigger range of hydrologic conditions in much less computer time than would be required by a multi-dimensional model. Two-dimensional or three-dimensional models include additional processes such as variation in water velocity within a channel cross section, vertical salinity gradients, lateral variations in concentration, and more accurate flow splits. Multi-dimensional models would be more appropriate than DSM2 for modeling

[1] X2 is the location in the Bay-Delta where the tidally averaged bottom salinity is 2 parts per thousand. It is expressed as the distance in kilometers from the Golden Gate Bridge.

effects such as precise movement of water at specific locations, gravitational circulation, or modifications to the larger open waterbodies in the more western portion of the Delta. The DSM2 calibration and validation process helps ensure that hydrologic conditions in the Delta are adequately replicated despite some less important processes not being included and some features, such as reservoirs (e.g., Clifton Court, Mildred Island, Bethel Tract, Frank's Tract, and Discovery Bay), being included in a simplified manner.

Several long-term planning analyses have used DSM2 to evaluate Delta hydrodynamics and water quality for the 16-year period from water year (WY) 1976 to WY 1991 as a representative period with wet years and dry years (e.g., DWR and Reclamation 2016). For planning studies, a monthly water budget model is used to calculate the DSM2 inputs. Because it is difficult to collect long records of daily data, planning models typically are run on a monthly time step to evaluate many years under a wide range of hydrologic conditions. Using a subset of monthly planning model results as input to the DSM2 model is useful for determining how the monthly flow conditions may interact with tidal conditions modeled with a 15-minute time step. Even if monthly flow inputs are modified to represent historical daily stochasticity or to smooth values between months, it is possible that the use of monthly inputs may not fully represent actual daily conditions. Monthly inputs are adequate for planning purposes for several reasons. One is that most of the Delta water quality objectives are applied to long-term averages, often 14-day or 30-day moving averages or monthly averages. Another is that model results typically are evaluated by comparing baseline results with alternatives, which helps to remove the effect of any systematic biases, including any that might be associated with the use of monthly results. Typically, monthly planning models, including SacWAM, are run to estimate the Delta inflows that would be necessary to avoid violation of water quality standards. If these estimated flows ultimately would result in water quality violations, the CVP and SWP operations would be adjusted on a day-to-day basis to meet Delta objectives.

A2.2 Methods

For this analysis, monthly water budget terms from SacWAM for WY 1976–1991 were used as DSM2 inputs. DSM2 version 8.2.1 was used for modeling the baseline and the 35, 45, 55, 65, and 75 scenarios (the flow scenarios). The 45, 55, and 65 scenarios capture the range of effects than may be expected with the proposed Plan amendments, and the 35 and 75 scenarios capture the low-end and high-end effects associated with the Low Flow Alternative (Alternative 2) and High Flow Alternative (Alternative 3), respectively. Detailed methods for translating SacWAM information into input for DSM2 were developed jointly by State Water Board staff and DWR and are described in a DSM2 methods memo from DWR (Attachment 1). A summary of the DSM2 inputs described in Attachment 1 is provided in this section along with a description of the differences between typical DSM2 inputs and inputs derived from SacWAM.

The comparison and evaluation of the changes in Delta flows and EC for the flow scenarios were based primarily on the monthly results for the 16-year sequences for the WY 1976–1991 DSM2 modeling period, although daily and 15-minute results were reviewed as well. Evaluation focused on seawater intrusion effects, changes in flow that could affect HABs, and changes in water quality at water quality compliance locations (Figure A2-1, Table A2-1). Most of the objectives for water quality compliance locations are specified in the Bay-Delta Water Quality Control Plan (Bay-Delta Plan). As mentioned above, X2 was evaluated based on SacWAM results; therefore, locations associated with X2 objectives (e.g., Port Chicago and Chipps Island) are not included in Table A2-1.

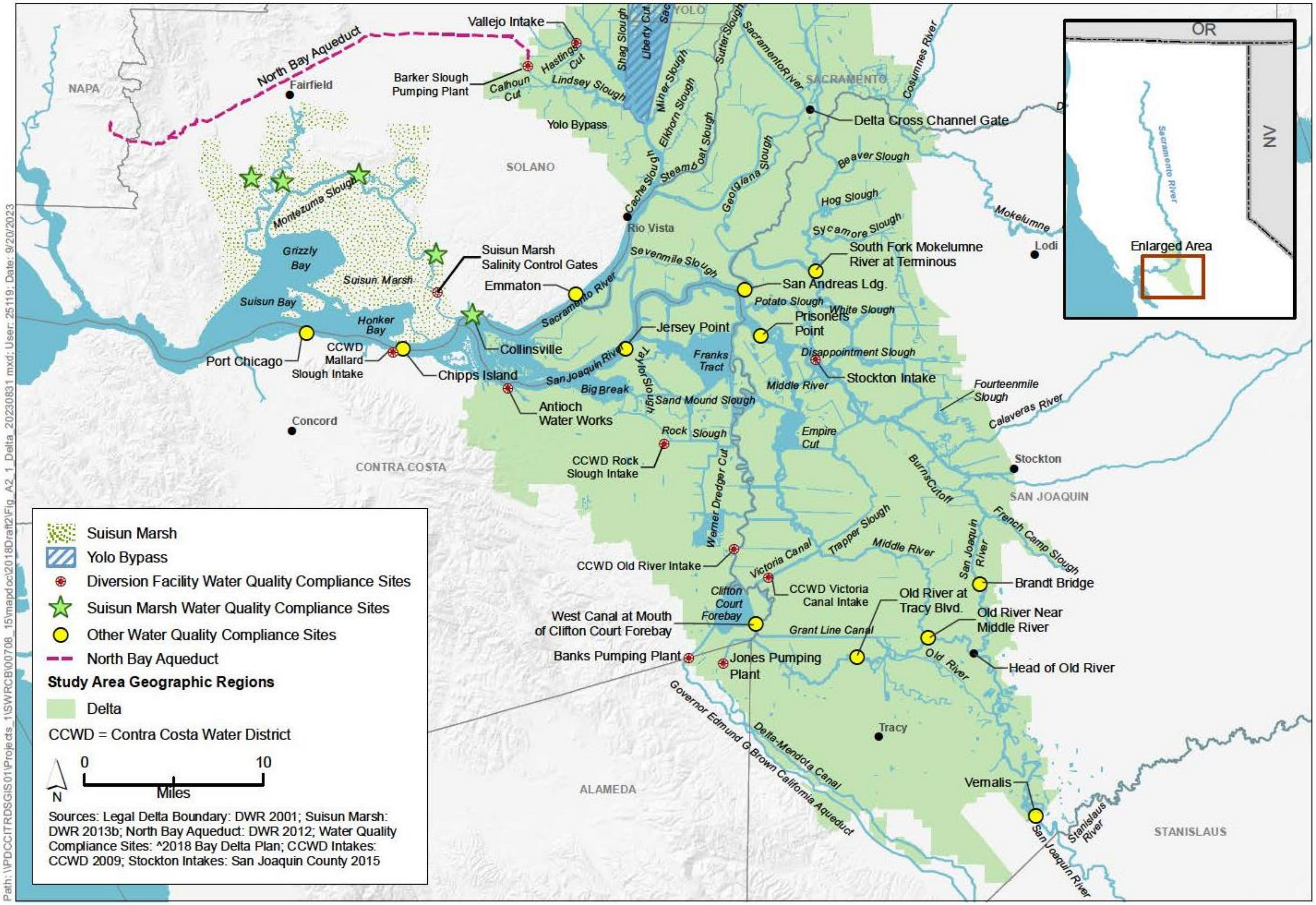


Figure A2-1. Water Quality Compliance Sites in the Delta Region

Table A2-1. Salinity-Related Water Quality Compliance Objectives for the Delta

Location	Objective	Statistical Metric	Period	Notes
Contra Costa Canal at Rock Slough	Chloride; <=250 mg/L, except for 155 to 240 days out of the year chloride should be <=150 mg/L at this location or at the Antioch Water Works intake	Maximum mean daily	Year-round	Bay-Delta Plan objective for municipal [a] beneficial use
West Canal at mouth of Clifton Court Forebay	Chloride; <=250 mg/L	Maximum mean daily	Year-round	Bay-Delta Plan objective for municipal beneficial use
Delta-Mendota Canal at Jones Pumping Plant	Chloride; <=250 mg/L	Maximum mean daily	Year-round	Bay-Delta Plan objective for municipal beneficial use
Barker Slough at North Bay Aqueduct intake	Chloride; <=250 mg/L	Maximum mean daily	Year-round	Bay-Delta Plan objective for municipal beneficial use
Cache Slough at City of Vallejo intake	Chloride; <=250 mg/L	Maximum mean daily	Year-round (when water is being diverted)	Bay-Delta Plan objective for municipal beneficial use
Drinking water intakes [b]	Chloride; <=250 mg/L		Year-round	Secondary MCL [c] for drinking water.
Drinking water intakes [b]	Bromide; 0.05 mg/L		Year-round	CALFED goal for drinking water (CALFED 2005)
Sacramento River at Emmaton	EC; 450 to 2,780 µS/cm depending on date and water year type	Maximum 14-day running average	Apr 1–Aug 15	Bay-Delta Plan objective for agriculture
San Joaquin River at Jersey Point	EC; 450 to 2,200 µS/cm depending on date and water year type	Maximum 14-day running average	Apr 1–Aug 15	Bay-Delta Plan objective for agriculture
South Fork Mokelumne River at Terminous	EC; 450 µS/cm, except 540 µS/cm for critical years	Maximum 14-day running average	Apr 1–Aug 15	Bay-Delta Plan objective for agriculture
San Joaquin River at San Andreas Landing	EC; 450 to 870 µS/cm depending on date and water year type	Maximum 14-day running average	Apr 1–Aug 15	Bay-Delta Plan objective for agriculture
San Joaquin River at Vernalis, and three river segments: San Joaquin River from Vernalis to Brandt Bridge, Middle River from Old River to Victoria	EC; 1,000 µS/cm	Maximum 30-day running average	Year-round	Bay-Delta Plan objective for agriculture

Location	Objective	Statistical Metric	Period	Notes
Canal, and Old River/Grant Line Canal from head of Old River to West Canal [d]				
West Canal at mouth of Clifton Court Forebay and Delta-Mendota Canal at Jones Pumping Plant	EC; 1,000 µS/cm	Maximum monthly average	Year-round	Bay-Delta Plan objective for agriculture
San Joaquin River at and between Jersey Point and Prisoners Point	EC; 440 µS/cm, no objective for critical years	Maximum 14-day running average	Apr–May	Bay-Delta Plan objective for fish and wildlife
Sacramento River at Collinsville	EC; 8,000 – 19,000 µS/cm, depending on month	Maximum monthly average of both daily high tide values	Oct–May	Bay-Delta Plan objective for fish and wildlife
Multiple locations in eastern and western Suisun Marsh	EC; 8,000 – 19,000 µS/cm, depending on month and, for some locations, hydrologic conditions	Maximum monthly average of both daily high tide values	Oct–May	Bay-Delta Plan objectives for fish and wildlife

mg/L = mg per liter

[a] For the purposes of this document, a reference to *municipal use* includes domestic and industrial uses unless otherwise specified. The terms *urban* and *M&I* also sometimes are used to reference municipal-type uses.

[b] Current drinking water intakes include Contra Costa Water District intakes (Mallard Slough Intake, Rock Slough Pumping Plant #1, Old River Intake near Highway 4, and the Victoria Canal Intake), west canal at mouth of Clifton Court Forebay (intake to Banks Pumping Plant and Byron Bethany Irrigation District, which supplies water to the community of Mountain House), Delta-Mendota Canal at Jones Pumping Plant, Barker Slough at the North Bay Aqueduct intake, and the City of Stockton intake (operational starting 2012).

[c] A secondary maximum contaminant level (MCL) is established to protect drinking water taste, odor, and/or appearance at the point of distribution. Water quality at the drinking water intake is indicative of how difficult it may be for the MCL objectives to be met.

[d] The program of implementation in the 2018 Bay Delta Plan update continues the requirement for Vernalis salinity to be maintained at the older objective of 700 microSiemens (µS/cm) from April through August to provide assimilative capacity downstream. Because protocols to monitor compliance in the three river segments have not yet been established, compliance is evaluated in this appendix for the point locations specified in earlier versions of the Bay-Delta Plan (San Joaquin River at Brandt Bridge, Old River near Middle River, and Old River at Tracy Boulevard). Electrical conductivity (EC) in the San Joaquin River at Vernalis is a DSM2 model input and does not change between the scenarios; therefore, it is not one of the compliance locations evaluated.

A2.2.1 Inputs Dependent on SacWAM Water Budget and Operation

The following inputs to DSM2 were dependent on SacWAM water budget and operation results.

- Boundary inflows and losses: SacWAM Delta water budget terms were used for many of the DSM2 Delta inflows and losses, including river inflows, exports, diversions, treated discharge from wastewater treatment plants (WWTPs), and local runoff and return flows from areas surrounding the boundary of the legal Delta. SacWAM flows for the San Joaquin River were the same for all scenarios. For more information on the SacWAM assumptions, see Section 6.2, *SacWAM Model Assumptions* in Chapter 6, *Changes in Hydrology and Water Supply*. The monthly flows for the Sacramento River and San Joaquin River were disaggregated to daily values prior to use in DSM2 to smooth the transition in flows between months (details on the smoothing can be found in Attachment 1).
- Vernalis EC: The Vernalis EC boundary condition was estimated based on the San Joaquin River flows (Suits and Wilde 2003). Because the San Joaquin River flows did not vary between scenarios, the Vernalis EC did not vary either.
- Delta Cross Channel (DCC) operations: The DCC gate operations were based on the DCC closure periods in State Water Board Water Right Decision1641 and in the National Marine Fisheries Service Biological Opinion for CVP and SWP operations and the Sacramento River flow (closed if greater than 25,000 cubic feet per second [cfs]). DCC operations were the same in each flow scenario except to the extent the closures were affected by flows greater than 25,000 cfs.
- Martinez EC boundary conditions: EC at Martinez was estimated using the "G-model" with the monthly Delta outflows calculated in SacWAM along with astronomical tide data (Ateljevich 2001).

A2.2.2 Other Inputs

DSM2 has multiple standard inputs that are not dependent on SacWAM results and are not expected to be substantially affected by the scenarios. Some of the major standard inputs are listed below. These inputs did not vary between the DSM2 simulations for any of the scenarios.

- Martinez tidal boundary elevations: The DSM2 model uses 15-minute adjusted astronomical tide for planning studies (Ateljevich and Yu 2007).
- Operation of barriers and gates other than DCC gates: Gates and barriers were operated as described in Attachment 1.
- Boundary EC: EC values for the Sacramento River, Yolo Bypass, Delta eastside tributaries, small creeks, WWTP discharges, and rainfall runoff and urban outdoor return flows from the area outside of the legal Delta were estimated with constant values that ranged between 150 μS/cm for the Delta eastside tributaries and 779 μS/cm for WWTP discharges.
- Delta Island Consumptive Use: Monthly Delta channel accretions and depletions (diversions, seepage, and drainage) were estimated using DWR's DCD model (Liang and Suits 2017, 2018; Liang 2021), based on a 2020 level of development. DCD estimates for each year (with specified crops and meteorological data) have been adopted by DWR as the standard Delta water budget estimate for use in DSM2 studies to estimate Delta seepage and diversions and drainage for

agricultural lands. The DCD inputs also include estimated EC values for island drainage. The DCD accounting area covers the 738,000 acres of the Legal Delta boundary. The annual DCD estimates for net channel depletions (ET minus rainfall) ranged from 650 thousand acre-feet (TAF) for wet years to about 1,150 TAF in dry years, with an average of about 900 TAF. The DCD water budget also has been adopted by SacWAM for this same area as described in Appendix A1, *Sacramento Water Allocation Model Methods and Results*. The DCD assumptions were not changed between DSM2 model runs.

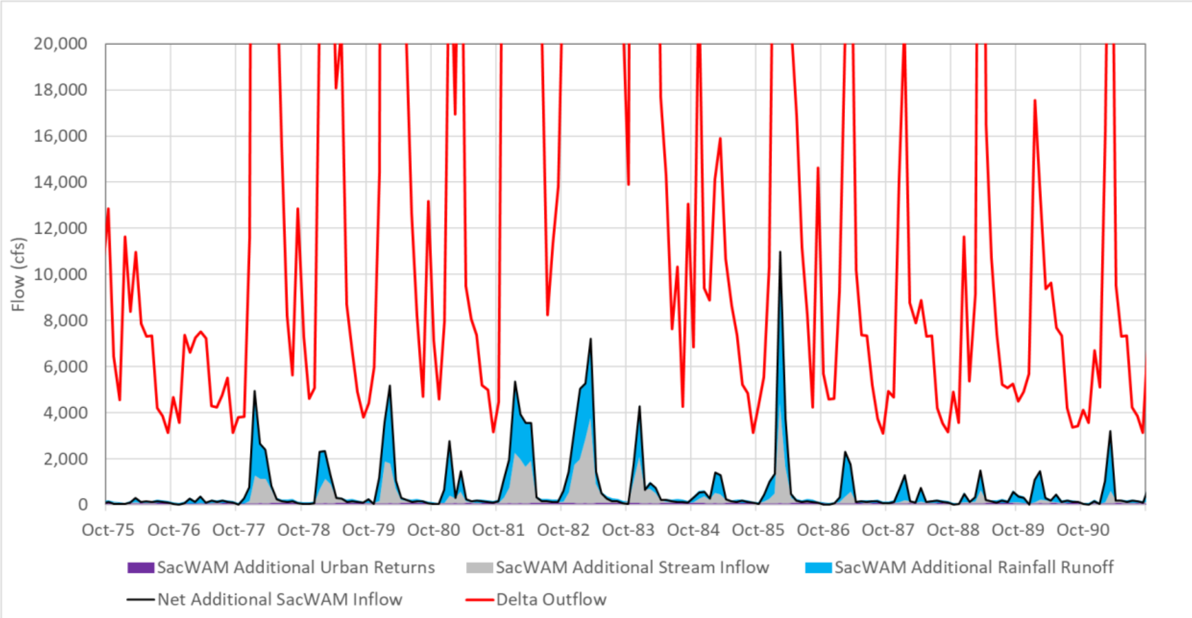
SacWAM modeling shows little reduction in Delta consumptive use associated with the flow scenarios. However, as described in Chapter 6, *Changes in Hydrology and Water Supply*, some Delta diversions could be reduced more than is indicated in the SacWAM modeling. If reductions in Delta depletions did occur under the flow scenarios, it would not have a large effect on Delta salinity because Delta outflow would not likely change; if Delta depletions were reduced, it would not produce a meaningful change in Delta outflow because the same water would be put to use elsewhere instead of in the Delta.

A2.2.3 Delta Water Budget

The Legal Delta covers an area of 738,000 acres. SacWAM uses the same assumptions about the large agricultural diversions (and drainage discharges) from the Legal Delta area that typically are used in a DSM2 study. However, considerable acres of land adjacent to the legal Delta drain into the Delta channels during rainfall-runoff events. SacWAM estimates the runoff from these adjacent lands. In addition, the SacWAM Delta water budget includes some diversions for urban supplies and some wastewater discharges that typically are not included in DSM2 inputs.

SacWAM separately calculates runoff from several watersheds that drain into the Delta but are upstream of the Legal Delta boundary and typically are not included as DSM2 input. For example, Marsh Creek drains about 100 square miles on the eastern (drier) side of Mt. Diablo, flowing into Dutch Slough near Big Break. SacWAM estimates runoff for this watershed as about 17 TAF/yr. SacWAM estimates flows from Dry Creek (Mokelumne River watershed) to be about 118 TAF/yr, and Littlejohn's Creek (French Camp Slough) in San Joaquin County to add about 61 TAF/yr; the total annual average runoff from these streams is 197 TAF/yr. SacWAM estimates an average runoff flow of 338 TAF/yr from the adjacent watersheds beyond what typically is included in DSM2 simulations, but most of this flow occurs during rainfall months with higher runoff in the rivers and from the Legal Delta. SacWAM also includes about 49 TAF/yr of additional inflows from WWTP discharges (urban returns) and includes about 43 TAF/yr of additional urban diversions.

Figure A2-2 shows Delta outflow compared with the net additional SacWAM inflow (additional inflow from adjacent watersheds, creek inflows, and urban returns minus increased diversions). The net average annual change in Delta inflow associated with the inputs from SacWAM represents an increase of 540 TAF/yr, or about 3.4 percent of average baseline Delta outflow of about 16,070 TAF/yr. Because most of the additional Delta inflow is in months with high runoff and river inflows, the effects on the overall Delta water budget are small. During these times of high Delta outflow, EC throughout the Delta is relatively low and increases in flow have little incremental effect on EC. Because the change in the Delta water budget is relatively small compared with the total water budget, the effect of the additional terms associated with use of SacWAM is unlikely to have substantial effects on the simulated Delta water quality.



cfs = cubic feet per second

Figure A2-2. Comparison of Delta Outflow and Additional SacWAM Runoff from Surrounding Watersheds, Creeks, and Urban Areas for WY 1976–1991

A2.2.4 Relationship between EC, Chloride, and Bromide

Chloride and bromide are water quality constituents of concern related to EC. Chloride levels can be indicative of overall saltiness of water and can affect water taste at high levels. As indicated in Table A2-1, 150 milligrams per liter (mg/L) and, more commonly, 250 mg/L are drinking water objectives for the Delta.

Bromide levels should be kept low because, during treatment of drinking water, it is a precursor for the formation of carcinogenic disinfection byproducts, such as trihalomethanes and bromate, which are regulated with MCLs. As part of the CALFED process, a goal of less than 0.05 mg/L was set for bromide, but there are no state or federal drinking water standards for bromide.

DSM2 results for EC can be used to evaluate chloride and bromide based on relationships between EC, bromide, and chloride. Because EC is a general measure of the minerals and salts in water, the chloride/EC ratio depends on the ratio of chlorides to the total minerals and salts in the water. Because the highest chloride and EC values are expected during periods of seawater intrusion, the mineral composition of seawater is a good starting point for estimating the chloride/EC ratio. The standard composition of ocean water with an EC of 54,000 µS/cm, has 18,980 mg/L chloride and 65 mg/L bromide (Lienhard et al. 2012). The seawater chloride/EC ratio is about 0.35, and the bromide/chloride ratio is about 0.0034. The chloride/EC ratios for the Sacramento and San Joaquin Rivers differ from each other and the ocean. The chloride/EC ratio of water collected anywhere in the Delta will depend on the source of the water (i.e., percent seawater, percent Sacramento River water, percent San Joaquin River water). For a given EC value, chloride concentration will generally be higher in the western Delta than farther inland. The average bromide/chloride ratio for the Sacramento River (0.0022) is less than for ocean water (0.0034); the bromide/chloride ratios for the San Joaquin River (0.0030) and San Francisco Bay (0.0035) are similar to ocean water (DWR 2022a, Table 9D-2; DWR 2022b, Table 9F-2).

The California WaterFix Final EIR/EIS (DWR and Reclamation 2016, p. 8-151) used the following EC-chloride relationship developed by Contra Costa Water District (CCWD) (1997) based on data from the western delta (Mallard Slough, Jersey Island, and Old River at Rock Slough):

Chloride = maximum (0.15*EC – 12 or 0.285*EC – 50)

Where chloride is in mg/L and EC is in µS/cm

This equation indicates that an EC of 1,000 µS/cm would have a chloride concentration of approximately 235 mg/L, and an EC of 700 µS/cm would have a chloride concentration of approximately 150 mg/L. These are the EC thresholds that will be used to evaluate attainment of chloride objectives in the Delta. For the general evaluation of the baseline and flow scenarios, an EC greater than 1,000 µS/cm was assumed to represent a violation of the 250 mg/L objective, and EC greater than 700 µS/cm was assumed to represent a violation of the 150 mg/L objective. These EC thresholds are conservative because for locations farther inland, EC values at the chloride thresholds would be higher.

Bromide concentration can be estimated from chloride concentration using the San Francisco Bay bromide to chloride ratio of 0.0035. A maximum chloride of 250 mg/l would correspond to a maximum bromide of 0.875 mg/L, and a chloride of 150 mg/L would correspond to a bromide of 0.525 mg/L. The CALFED goal of less than 0.05 mg/L, corresponds to an unrealistically low level of chloride (14 mg/L) and EC for many locations in the Delta (175 µS/cm).

A2.2.5 Evaluating Compliance with Water Quality Objectives

Average monthly model results for the scenarios were compared with baseline conditions to evaluate EC effects and the attainment of water quality objectives for habitat, agriculture, and municipal water supply at the following locations in the Bay-Delta estuary.

- Suisun Marsh: Four compliance locations within Suisun Marsh and the Sacramento River at Collinsville, near where water enters the marsh at Montezuma Slough.
- Western Delta: Sacramento River at Mallard Slough and Emmaton; San Joaquin River at Antioch and Jersey Point.
- Interior Delta and exports (for convenience of discussion this extends from the SWP and CVP exports to the northern Delta): Barker Slough in the northern Delta, San Joaquin River at San Andreas Landing, Prisoners Point, and Stockton Intake; Mokelumne River at Terminous; Old River at Bacon Island (near Rock Slough) and Highway 4; Victoria Canal; and Clifton Court Forebay and Delta-Mendota Canal (DMC) Intake.
- Southern Delta: San Joaquin River at Brandt Bridge and Vernalis, Old River near Middle River, and Old River at Tracy Boulevard.

A month-by-month comparison of the DSM2 EC values with water quality objectives can be used to verify compliance. However, because the DSM2 model uses monthly average flows from SacWAM, the variations in DSM2 EC values within each month reflect the spring-neap tidal cycle variations but do not include the daily changes in EC caused by changes in outflow that might be allowed to comply with “split-month” EC objectives. CVP and SWP operators adjust exports on a daily basis to maintain the daily average EC below the maximum-allowed EC at each of the EC objective locations.

Although there could be some occasions when the DSM2 monthly average EC would be greater than the EC objectives on a daily basis, EC exceedances (i.e., running-average EC greater than the EC objective) would not likely occur in actual Delta operations because the CVP and SWP operators would increase the Delta outflow to reduce the daily average EC to less than the EC objectives at all locations. The comparison of the monthly EC patterns for the baseline and the scenarios can be used to identify the shifts in the monthly EC distribution from the baseline, which may indicate whether attainment of objectives could become more difficult.

Compliance is more difficult to evaluate for the agricultural EC objectives at Emmaton, Jersey Point, San Andreas Landing, and Terminous, which depend on water year type, may change within a month, and end on August 15 with no EC objective for August 16–31. When the EC objectives are not constant for a month, monthly EC objectives are approximated as the weighted average of the daily objectives. For example, at Emmaton in below-normal water years, the EC objective is 450 microSiemens per centimeter (µS/cm) from June 1 to June 20 and 1,140 µS/cm from June 21 to June 30. The estimated monthly EC objective would be (450*20+1,140*10)/30=680 µS/cm. In the case of the objectives that end on August 15, August monthly EC objectives are approximated as the weighted average of the August 1–15 objective and the highest objective (i.e., critical year) for August 16–31. Compliance with the X2 requirements described in Table 4 of State Water Board Right Decision 1641 are not evaluated here. SacWAM incorporates attainment of X2 objectives in the baseline and flow scenarios simulations.

A2.3 Baseline Delta Processes

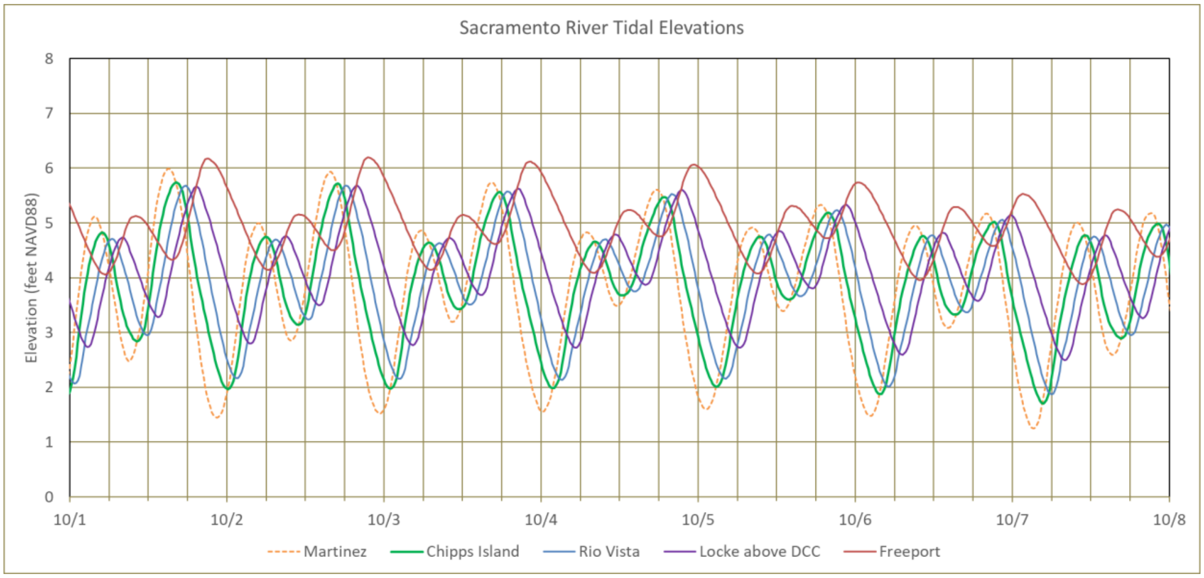
Baseline DSM2 results are provided to illustrate several types of information that will be useful for several purposes:

- Information about variability in water surface elevations and inundation that affect existing habitat,
- Information about tidal and net flows that could influence HABs and growth of nuisance aquatic vegetation, and
- Basic background information about the processes that affect salinity in the Delta.

A2.3.1 Elevation

The major inflows to the Delta (i.e., Sacramento River, Yolo Bypass, Delta eastside tributaries, and San Joaquin River) transition from riverine sections with a water surface elevation that is dependent on flow to tidal channels with water surface elevation that fluctuates with the tide. Tidal elevations propagate upstream in the Sacramento and San Joaquin River channels with only a gradual reduction in the tidal elevation range (maximum minus minimum elevation), while the tidal flows are diminished in proportion to the remaining upstream water surface area. Generally, the net flows will be added (superimposed) on the tidal flows, shifting the ebb-tide flows higher and reducing the flood-tide flows.

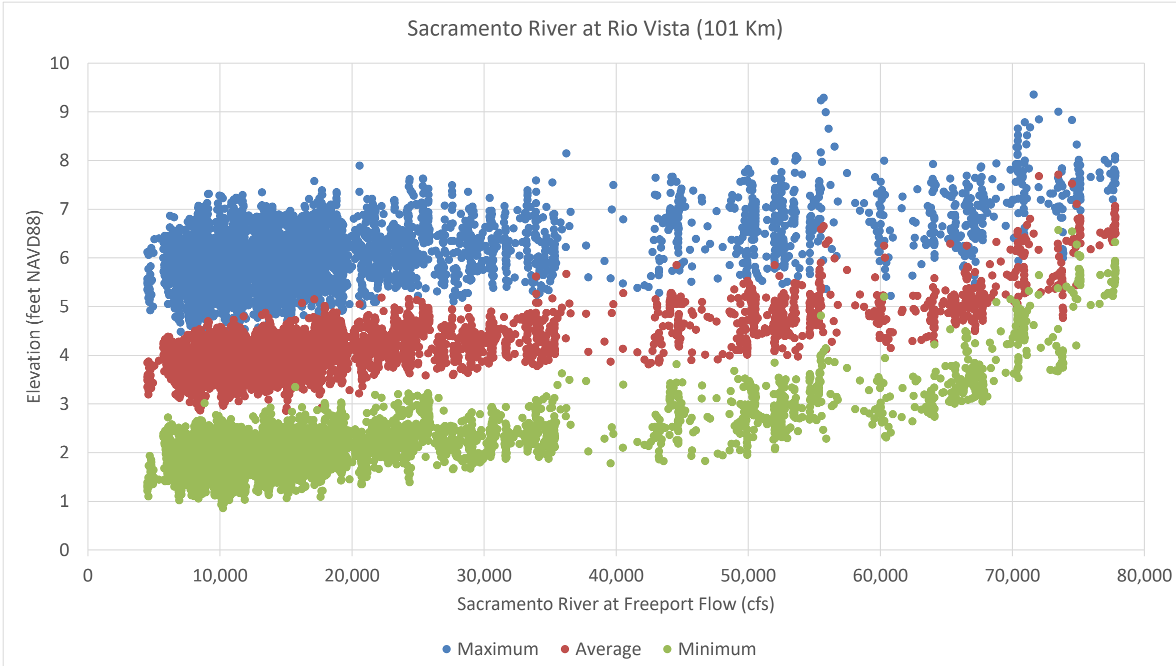
Figure A2-3 shows the DSM2 tidal elevations at Martinez and at several upstream stations on the Sacramento River for the first week of October 1977, as an example of the relationship between tidal elevations and the upstream distance from Martinez, the tidal boundary. There is a delay in the flood-tide elevation rise at upstream locations because a water surface gradient is required to move water upstream (by gravity) in each Delta channel. The tidal signal is shifted by about 6 hours at the upstream end of the Delta channels compared with Martinez. There are differences in the upstream flood-tide variations and the downstream ebb-tide variations, such that the high-tide elevations are very similar at upstream locations, but the low-tide elevations are considerably higher at upstream locations.



DCC = Delta Cross Channel

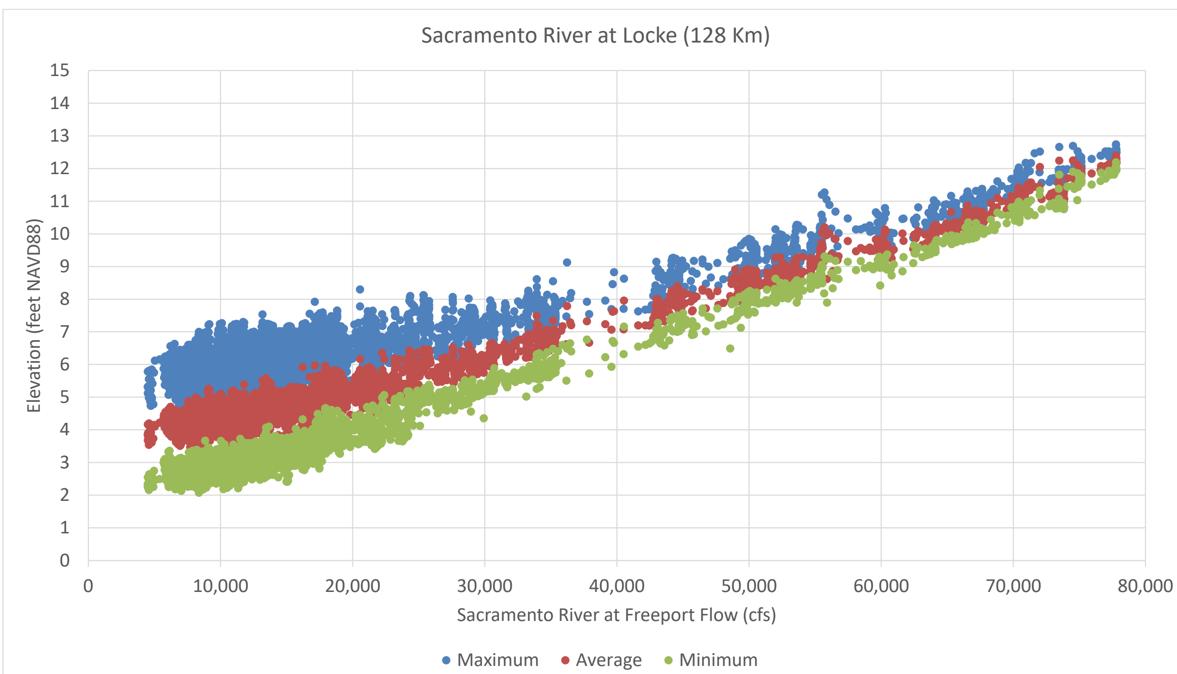
Figure A2-3. DSM2 Tidal Elevations at Martinez and at Upstream Sacramento River Locations for October 1–7, 1977

Between the riverine and tidal areas of the Delta, there is a transition zone where both flow and tide control water surface elevation, with river flow having a stronger effect farther inland. For example, DSM2 results for the Sacramento River at Rio Vista (Figure A2-4) and Locke (Figure A2-5) show the interplay between tide and flow on water surface elevation at locations that are slightly (Rio Vista) and more strongly (Locke) affected by river flow. The flow-stage relationships in Figures A2-4 and A2-5 use baseline DSM2 results, but the relationships would be the same regardless of scenario. At Rio Vista, an increase in flow from 10,000 cfs to 80,000 cfs would produce only about a 2-foot increase in stage, which is relatively small considering that tidal fluctuations are about 4 feet. At Locke, this same increase in flow would produce about an 8-foot increase in stage, which is relatively large considering that the tidal fluctuations are about 3 feet.



km = kilometers

Figure A2-4. DSM2 Daily Tidal Elevations (Minimum, Average, Maximum) at Rio Vista as Influenced by Sacramento River Flow



km = kilometers

Figure A2-5. DSM2 Daily Tidal Elevations (Minimum, Average, Maximum) at Locke as Influenced by Sacramento River Flow

A2.3.2 Tidal Slough Flow and Stagnation in the Southern Delta

Tidal flows in the Delta channels are controlled largely by the channel geometry. The tidal flow and velocity in each channel are controlled by the tidal elevations at the downstream end, the upstream surface area, and the channel cross-section. At the more riverine locations, such as the Sacramento River at Freeport, daily average flow is relatively large compared with the average ebb- and flood-tide flows. For much of the Delta, however, daily average flow is relatively small compared with the tidal flows. Tidal flow patterns would be minimally affected by the flow scenarios. In many places, the low-flow and high-nutrient conditions conducive to the formation of HABs would not be affected by the flow scenarios. The flow scenarios would have little effect on tidal exchange and would generally not cause a reduction in net flows—although in a few locations, net flow may be reduced and this is discussed in the *Results* section. In the southern Delta, low net flow conditions may be due to low flow in the San Joaquin River and/or operation of the temporary barriers, both of which would not be affected by the flow scenarios.

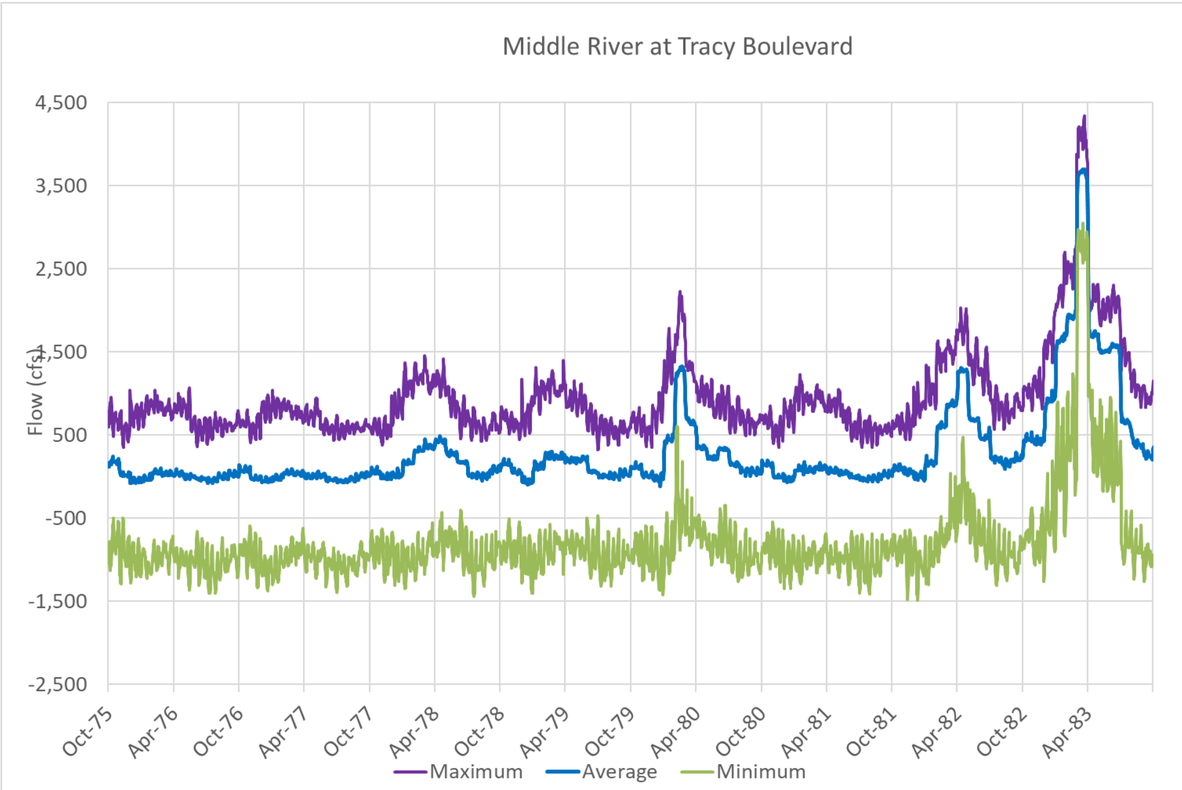
A combination of low tidal flows (because of limited upstream surface area) and reduced net flows (because of limited inflows or higher agricultural diversions) can lead to a relatively high residence time for water in the various dead-end tidal sloughs located around the edges of the Delta or in the southern Delta channels upstream of the temporary agricultural barriers that are installed during the irrigation season. It is possible that these low-circulation channels may have higher densities of submerged or floating aquatic vegetation or may have high concentrations of HABs.

The water exchange in dead-end tidal sloughs is limited to the tidal exchange at the mouth. The tidal filling and draining of a dead-end slough provide good exchange at the lower portion of the slough, but tidal mixing is more limited at the upstream end of the dead-end slough, and high accumulations of aquatic vegetation or HABs are possible. The tidal exchange is lower for dead-end sloughs that are longer or deeper.

Several southern Delta channels may have low tidal exchange, which may contribute to aquatic vegetation growth or HABs in warm summer months. For example, the Stockton Turning basin and the downtown Stockton embayment (McLeod Lake, Weber Point) have developed high densities of blue-green algae mats in some summers. The combination of high temperatures and low flushing rates (and high ammonia concentrations before 2008) may have contributed to this problem.

The San Joaquin River upstream of Turner Cut and downstream of the head of Old River, including the Stockton Deep Water Ship Channel, may have low net flow and limited tidal exchange. Conditions in this somewhat isolated portion of the San Joaquin River may be relatively stagnant, with residence times of weeks rather than days. Because of long residence times, potential for relatively high EC (700–1,000 μS/cm) in the San Joaquin River, and relatively high EC and nitrate concentration of the Stockton wastewater discharge, the water quality in this river reach may be poor and conducive to algal and vegetation growth. However, because the San Joaquin River inflow was held constant for the flow scenarios, there would be minimal change in the Stockton Deep Water Ship Channel travel times.

Another example of long travel times is in Middle River upstream of Victoria Canal. The net flow in this section of Middle River is low (Figure A2-6), except when San Joaquin River flows are higher than about 5,000 cfs. Although the average tidal flows from Victoria Canal into this section of Middle River are about 1,000 cfs, the tidal flows are reduced by about 50 percent when the temporary barrier is installed just upstream of Victoria Canal during June–November each year to protect the minimum tidal elevations for agricultural diversions. Because the agricultural diversions from this portion of Middle River may be a large fraction of the net flow in Middle River, the baseline net flow is low and the travel time is long; high densities of aquatic vegetation and HABs are frequently observed in Middle River upstream of Victoria Canal. Because the San Joaquin River inflow was held constant for the flow scenarios and because this section of Middle River is unlikely to be greatly affected by changes in exports, there would not be much change in the Middle River travel times or water quality upstream of Victoria Canal.



cfs = cubic feet per second

Figure A2-6. DSM2 Daily Tidal Flows in Middle River at Tracy Boulevard Upstream of the Temporary Barrier for WY 1976–1983

For some channels that convey water to the CVP and SWP export pumps, the proposed flow scenarios could sometimes cause a reduction in flow. Because reduction in flow could increase time for algae and floating vegetation to grow before the water leaves the Delta channels, potential reduction in average travel time was assessed with the following equation:

Travel time (days) = Channel volume (af) / [Average flow (cfs) x 1.983 (af/cfs-day)]

Where channel volume is based on DSM2 geometry data.

The effect of the flow scenarios on travel time in a representative channel, Victoria Canal, are described in Section A2.4.1, *Changes in Flow*.

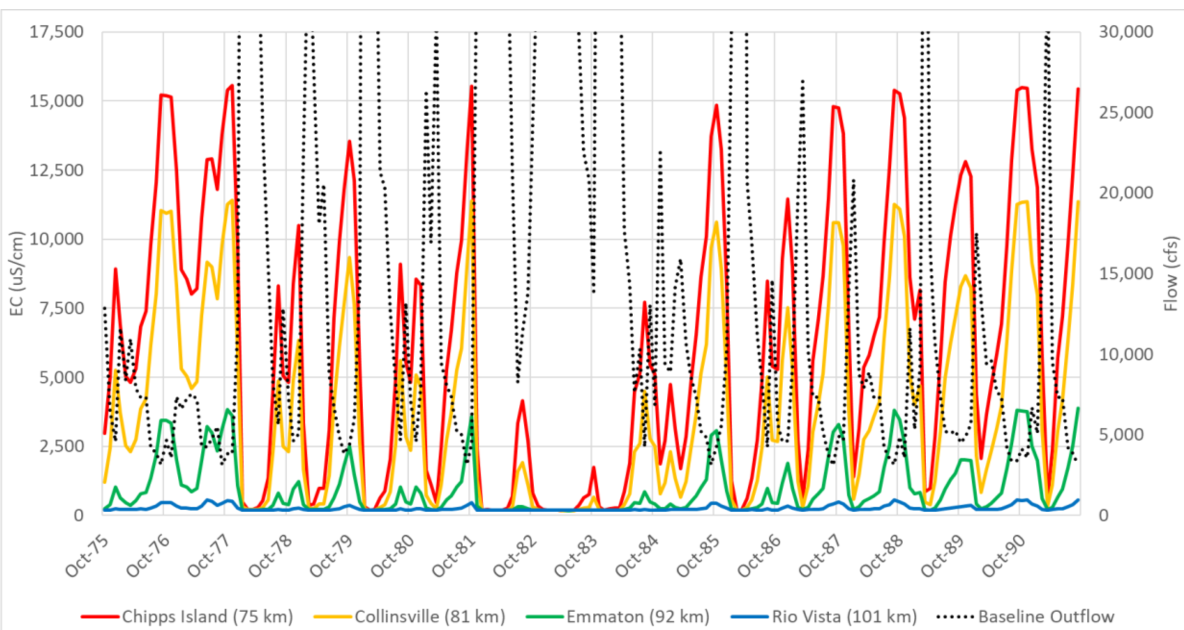
A2.3.3 Effects of Flow on Salinity

A2.3.3.1 Delta Outflow and Delta EC Patterns

The salinity gradient, caused by seawater intrusion into Suisun Bay and the Delta, is controlled by the tidal flows and the inflow of fresh water from the Delta tributaries. The mixing of the fresh water with the sea water produces a salinity gradient that is shifted downstream during high outflows and moves upstream during periods of low outflow. The salinity at each western Delta monitoring station decreases as the Delta outflow increases.

Particular steady-state flow values are associated with particular locations of the salinity gradient. However, when Delta outflow changes, the salinity gradient does not immediately move to the expected new location; antecedent flow conditions affect the current position of the salinity gradient (Denton and Sullivan 1993). Mismatch between current net daily Delta outflow and the antecedent Delta outflow that controls location of the salinity gradient may be large when there is large variability in daily net outflow. Evaluation of Delta outflow and the salinity gradient on a monthly time step helps to reduce the mismatch between current outflow and antecedent outflow, although outflow from previous months may still have some effect on the position of the gradient.

The relationship between Delta outflow and EC can be seen in the monthly average DSM2 baseline results for Delta outflow and EC. Figure A2-7 shows EC at Chipps Island, Collinsville, Emmaton, and Jersey Point. The maximum monthly average EC at Chipps Island (75 km from the Golden Gate Bridge) is about 15,000 µS/cm when Delta outflow is 3,000 cfs. In contrast, the minimum outflow at the end of 1983 is about 12,500 cfs, and the EC at Chipps Island does not exceed 2,500 µS/cm. The maximum monthly average EC at Collinsville (81 km) is about 11,000 µS/cm when Delta outflow is about 3,000 cfs but barely exceeds 500 µS/cm in 1983.



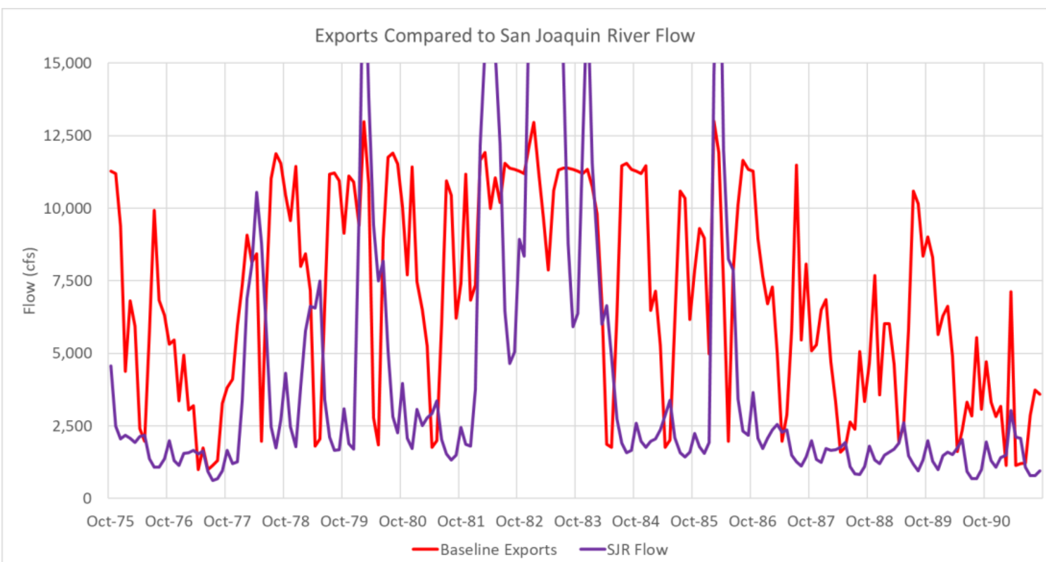
km = kilometers

Figure A2-7. Baseline EC Patterns at Chipps Island, Collinsville, Emmaton, and Jersey Point Compared with Delta Outflow for WY 1976–1991

A2.3.3.2 Southern Interior Delta and Southern Delta

Flow and salinity in the southern Delta are largely influenced by exports, San Joaquin River flow, and the temporary barriers. Figure A2-8 shows the San Joaquin River inflows compared to the CVP and SWP Delta exports for the baseline. Baseline exports are usually greater than the San Joaquin River inflows; only when the San Joaquin River inflow is higher than the exports would San Joaquin water flow past the exports and provide a positive (downstream) flow. Because the combined CVP and SWP exports are almost always greater than the San Joaquin River flows, most of the San Joaquin River flow is exported. When exports plus in-Delta diversions are greater than San Joaquin River inflow, Sacramento River water is drawn to the southern Delta. Because the San Joaquin River EC is relatively high in most months compared with EC in the Sacramento River, the San Joaquin River inflows generally cause a slight increase in the average EC in the CVP and SWP exports. The incremental increase in EC caused by the San Joaquin River depends on the ratio of the San Joaquin River to the total exports. This effect, however, is expected to be relatively small due to the small difference between Sacramento River EC and San Joaquin River EC. Due to the high EC of sea water, seawater intrusion is generally the greater concern.

Because the San Joaquin River inflows are the same for each scenario, and the operations of the head of Old River barrier and the temporary barriers in the southern Delta channels are the same in all the scenarios, changes in net southern Delta channel flows and water quality effects are controlled by changes in southern Delta exports and Delta outflow for each scenario compared with the baseline conditions.



cfs = cubic feet per second

Figure A2-8. Comparison of San Joaquin River Inflows with Baseline Combined CVP and SWP Exports for WY 1976–1991

A2.4 Results

This section compares the DSM2 net monthly flows and monthly average EC at major Delta channels for the flow scenarios (35 through 75 scenarios) with baseline conditions. Changes in the Delta channel flows are caused by changes in inflows from the Sacramento River and Delta eastside tributaries and by changes in CVP and SWP exports. The following evaluation illustrates changes in monthly channel flows and monthly average EC values that were calculated with DSM2 for the scenarios relative to baseline.

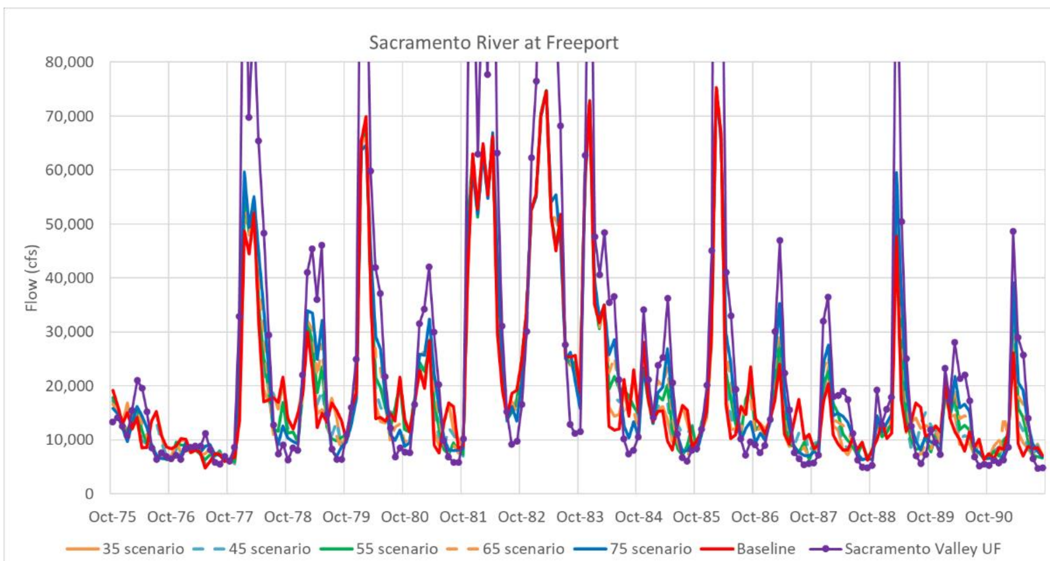
A2.4.1 Changes in Flow

Delta channel flows are largely controlled by the Sacramento River, Yolo Bypass, and Delta eastside tributary inflows, and by the CVP and SWP exports in the southern Delta, all of which were modeled using SacWAM. San Joaquin River inflows are also important, but they do not vary between the scenarios and baseline. Changes in Delta inflow, exports, and outflow are described in detail in Chapter 6, *Changes in Hydrology and Water Supply*. This section provides a summary of those changes as well as changes in flow at some key interior locations within the Delta to inform the description of changes in EC within the Delta that were simulated by DSM2.

A2.4.1.1 Flow at Locations Important for Delta Hydrodynamic Processes

Inflow

Figure A2-9 shows the time series of flows in the Sacramento River at Freeport for the SacWAM baseline conditions and for the flow scenarios for WY 1976–1991. Seasonal variation and differences between years dominate the hydrology for all scenarios. The effect of the scenarios on Sacramento River flows are variable. Comparison of the monthly distribution of flows can be seen in Chapter 6, *Changes in Hydrology and Water Supply*. Flows for the scenarios are generally higher than baseline flows during January–June and lower during July–October.

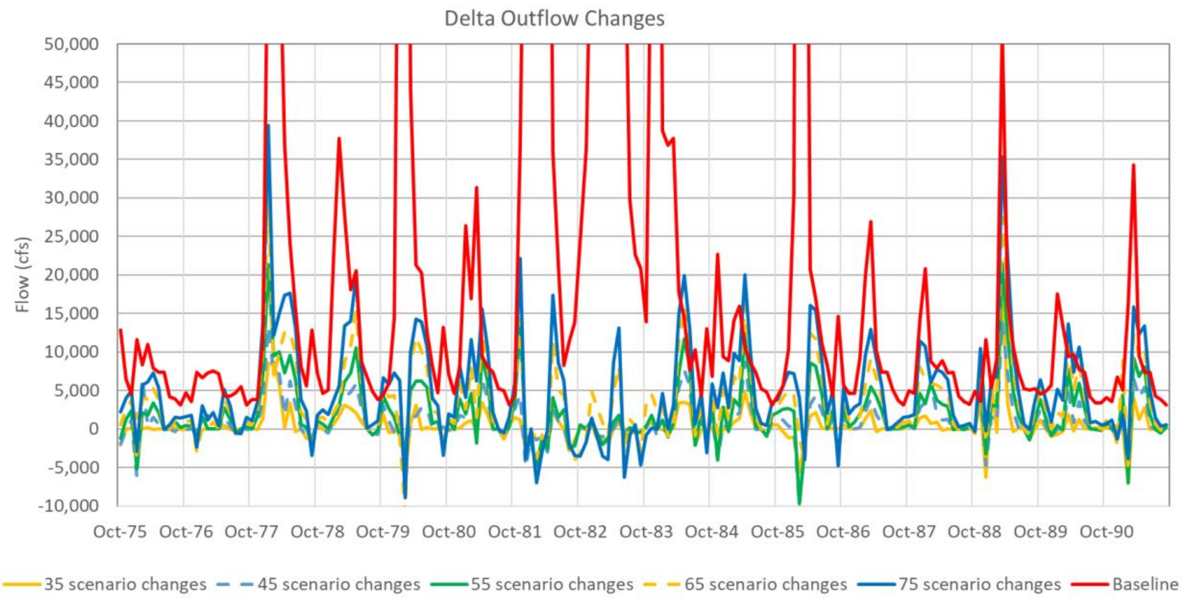


cfs = cubic feet per second
UF = unimpaired flow

Figure A2-9. SacWAM Sacramento River Flow at Freeport – Baseline and Flow Scenarios for WY 1976–1991

Outflow

Figure A2-10 shows the baseline Delta outflows as simulated by SacWAM and the changes in Delta outflows (increases or decreases) for the flow scenarios. In general, the scenarios are expected to produce increases in Delta outflow. As described in Chapter 6, *Changes in Hydrology and Water Supply*, there are some periods with decreases in outflow, but decreases in outflow are smaller and less common than decreases in inflow due to reductions in exports. Increases in median Delta outflow tend to be highest during December–June, the months with greater unimpaired flows.

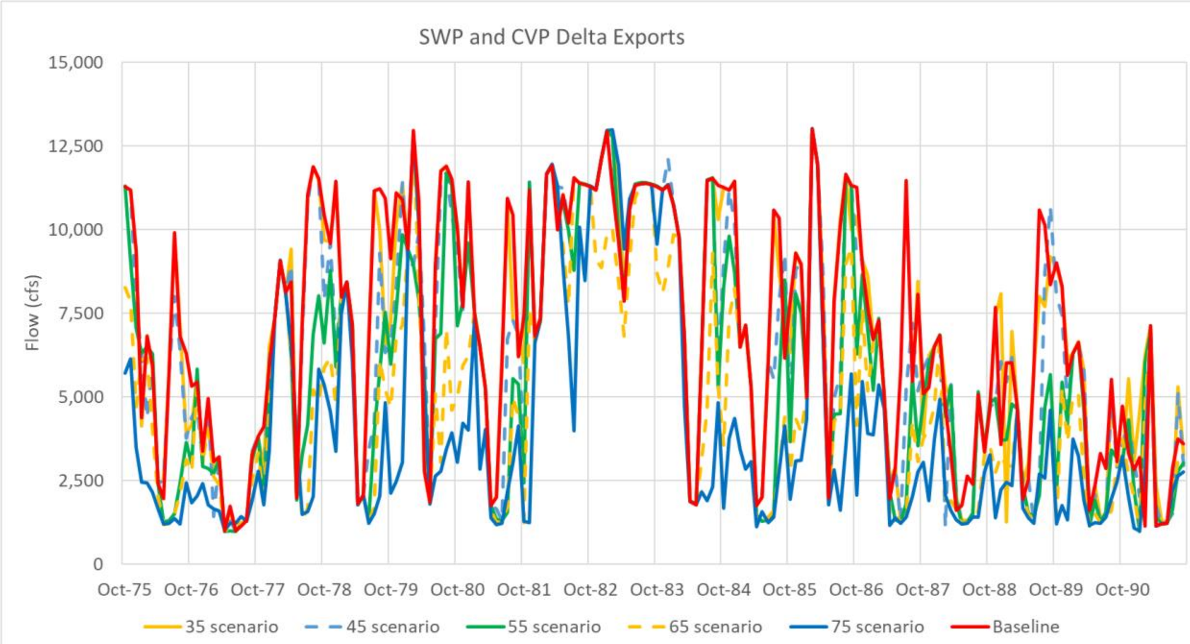


cfs = cubic feet per second

Figure A2-10. Delta Outflow – Baseline and Changes from Baseline for the Flow Scenarios for WY 1976–1991

Exports

Figure A2-11 shows the CVP and SWP Delta exports calculated by SacWAM for baseline conditions and for the flow scenarios for WY 1976–1991. These are inputs to the DSM2 model. Exports are highly variable from year-to-year and season-to-season. The lowest exports for baseline and the flow scenarios typically occur in April and May, when exports are limited by the San Joaquin River inflow to export (I:E) ratio. The maximum combined exports generally are limited to less than 13,100 cfs by the permitted capacities of the CVP and SWP pumping plants. The CVP and SWP exports are reduced substantially in the scenarios.

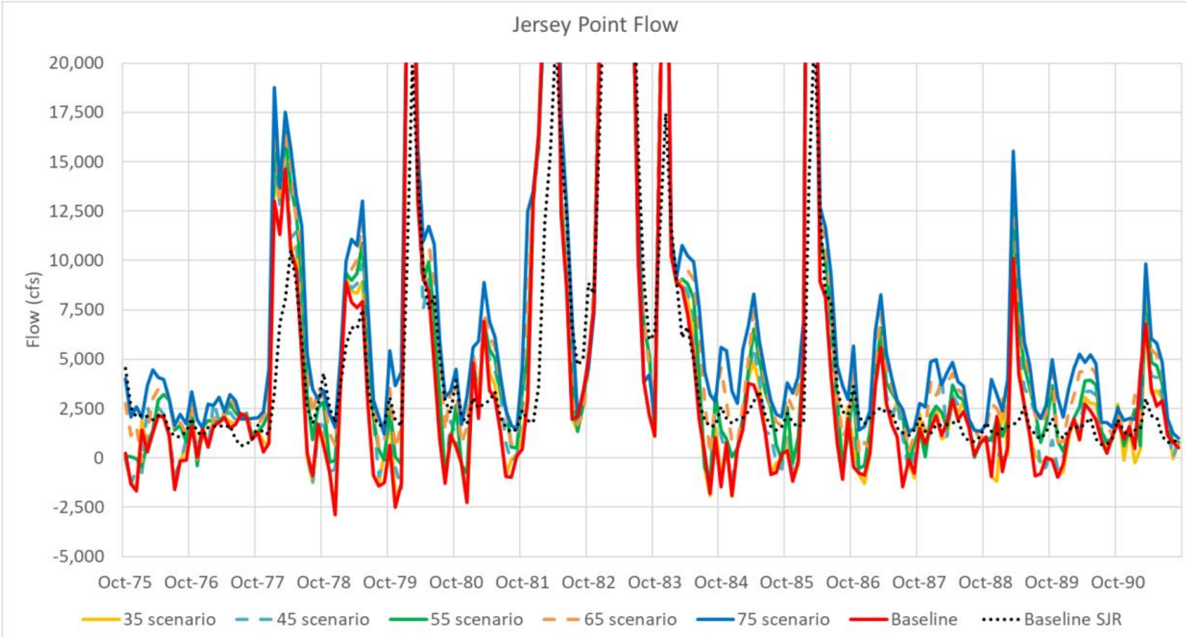


cfs = cubic feet per second

Figure A2-11. SacWAM CVP and SWP Delta Exports – Baseline and Flow Scenarios for WY 1976–1991

San Joaquin River at Jersey Point

Flow at San Joaquin River at Jersey Point (Jersey Point) is important because reverse flow at this location is indicative of potential seawater intrusion into the interior Delta. Figure A2-12 shows the monthly average flow at Jersey Point for baseline compared with the flow scenarios for WY 1976–1991. The baseline flows at Jersey Point are highest when the San Joaquin River inflows at Vernalis are high and additional flows are diverted from the Sacramento River through Georgiana Slough and Threemile Slough. The flows at Jersey Point are controlled by the Delta water balance between the sum of inflows from the San Joaquin River, Delta eastside tributaries, DCC, Georgiana Slough, and Threemile Slough compared with the CVP and SWP exports and the other water diversions in the southern and central Delta channels. Because Delta exports can represent a large fraction of total Delta inflows in summer months, the flows at Jersey Point are generally less than 2,500 cfs and are sometimes negative, indicating that water is moving upstream from Antioch and through False River to Franks Tract and Old River toward the CVP and SWP exports. The Jersey Point flows are sometimes negative (minimum of about -2,500 cfs) in summer and fall months for the baseline and the 35 scenario. The Jersey Point flows generally are increased from baseline for the higher flow scenarios, because the Sacramento River flows are increased from baseline and the Delta exports are reduced for these higher scenarios. The increased (positive) Jersey Point flows and increased Delta outflows generally reduce the EC at Jersey Point, in Old River, and at the CVP and SWP exports.



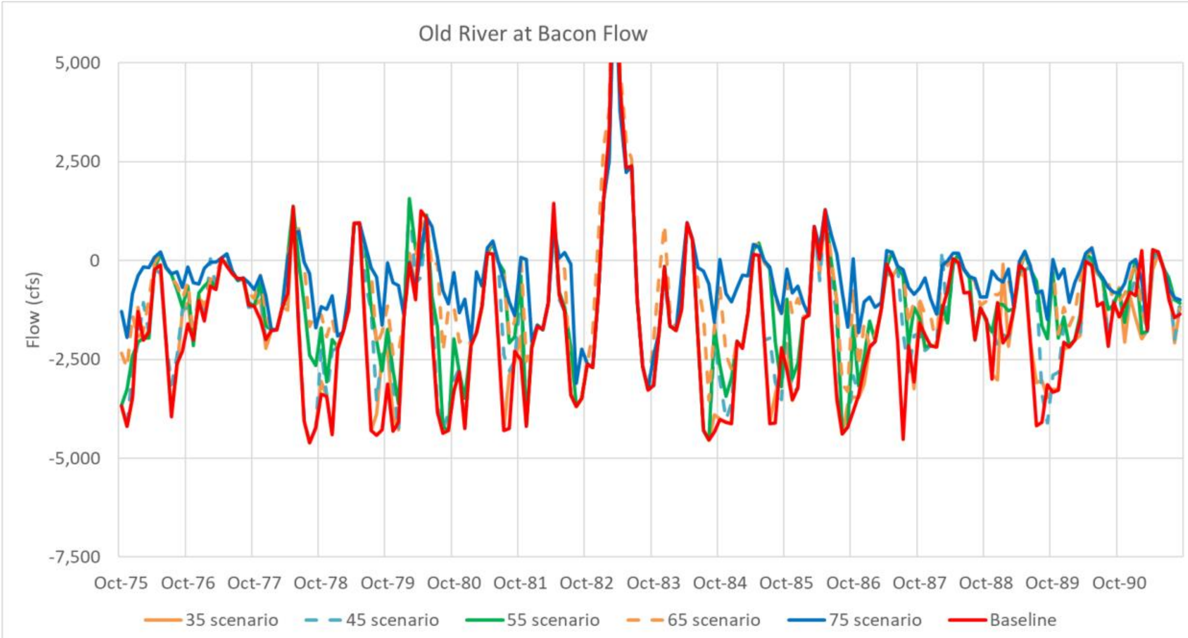
cfs = cubic feet per second
SJR = San Joaquin River

Figure A2-12. San Joaquin River Flow at Jersey Point – Baseline and Flow Scenarios for WY 1976–1991

Old and Middle River

The Old River at Bacon Island and Middle River at Bacon Island flows together are known as Old and Middle River (OMR) flows. Reverse OMR flows indicate that San Joaquin River inflow to the southern Delta is not large enough to provide all the water for southern Delta exports and diversions; this indicates that little San Joaquin River water is reaching the ocean. It also indicates that some of the relatively low salinity water of the Sacramento River is flowing to the southern Delta. It may also indicate that any effect of seawater intrusion is being drawn into the southern Delta as well.

Figure A2-13 shows the monthly average Old River flows at Bacon Island for baseline conditions compared with the flow scenarios for WY 1976–1991. The Old River at Bacon Island flows are about half of the OMR flows. These flows also represent the general pattern of flow effects seen in other southern Delta channels leading south to the Delta exports. Some flow is diverted into Rock Slough and Indian Slough, but most of the flow in Old River is measured at the Old River at Bacon Island station. The baseline Old River at Bacon Island flows are almost always negative, except when San Joaquin River inflows are higher than the CVP and SWP exports. The Old River flows are increased (less negative) for each of the scenarios, because the Delta exports are reduced to achieve the higher Delta outflow objectives.



cfs = cubic feet per second

Figure A2-13. DSM2 Flow in Old River at Bacon Island – Baseline and Flow Scenarios for WY 1976–1991

A2.4.1.2 Net Flow at Locations Representing Areas with Harmful Algal Blooms

Many factors affect the occurrence of HABs and aquatic vegetation (e.g., nutrients, temperature, motion of water). Low net flows and high agricultural diversions in some Delta channels may cause long water travel times that could allow algae (phytoplankton), floating aquatic vegetation (e.g., water hyacinth), and submerged aquatic vegetation (e.g., Brazilian waterweed) to grow and accumulate if other factors are conducive to growth.

Victoria Canal

The monthly net flows and corresponding water travel times (i.e., channel volume/net flow) in some southern Delta channels could be affected by the flow scenarios because lower exports could reduce the negative (reversed) flow in the southern Delta. As an example of the possible changes in travel time caused by reduced CVP and SWP exports, the water travel times in Victoria Canal are calculated from the DSM2 flows for the baseline and the flow scenarios.

Victoria Canal carries about 40 percent of the reversed OMR flows. The volume of Victoria Canal is about 2,500 acre-feet, so the travel time in days is about 1,250/flow (cfs). Table A2-2 gives the cumulative distribution of monthly travel times in Victoria Canal for the baseline and the flow scenarios. The monthly average flows in Victoria Canal were used to calculate travel time, and the resulting values were used to calculate the cumulative distribution of travel times. For most months, all the flows are negative, and faster travel times are associated with increased flow toward the export pumps, but April and May are exceptions. The average travel times are less than 1 day in most months for the baseline flows but average about 5–6 days in April and May because CVP and SWP exports are usually reduced for fish protection during these months. Furthermore, these two months experience both positive and negative OMR flows. At the transition between positive and negative flows, there is little net flow and maximum travel time approaches 30 days under baseline conditions. Due to relatively cool conditions, these 2 months are not prime HAB months.

The DSM2 results indicate that average monthly baseline travel times through Victoria Canal are between 0.6 and 1.3 days during the June–October HAB season. Average travel time increases in all the flow scenarios during the bloom period compared with the baseline condition, with the higher flow scenarios having a larger effect on exports and travel time through Victoria Canal. For the 55 scenario, monthly average travel times during June–October increase by 0.1–3.6 days; for the 65 scenario, monthly average travel times increase by 0.3–3.8 days; and for the 75 scenario, monthly average travel times increase by 0.4–5.1 days, depending on the month.

Table A2-2. Cumulative Distribution of DSM2 Travel Times in Victoria Canal – Baseline and Changes from Baseline for the Flow Scenarios for WY 1976–1991

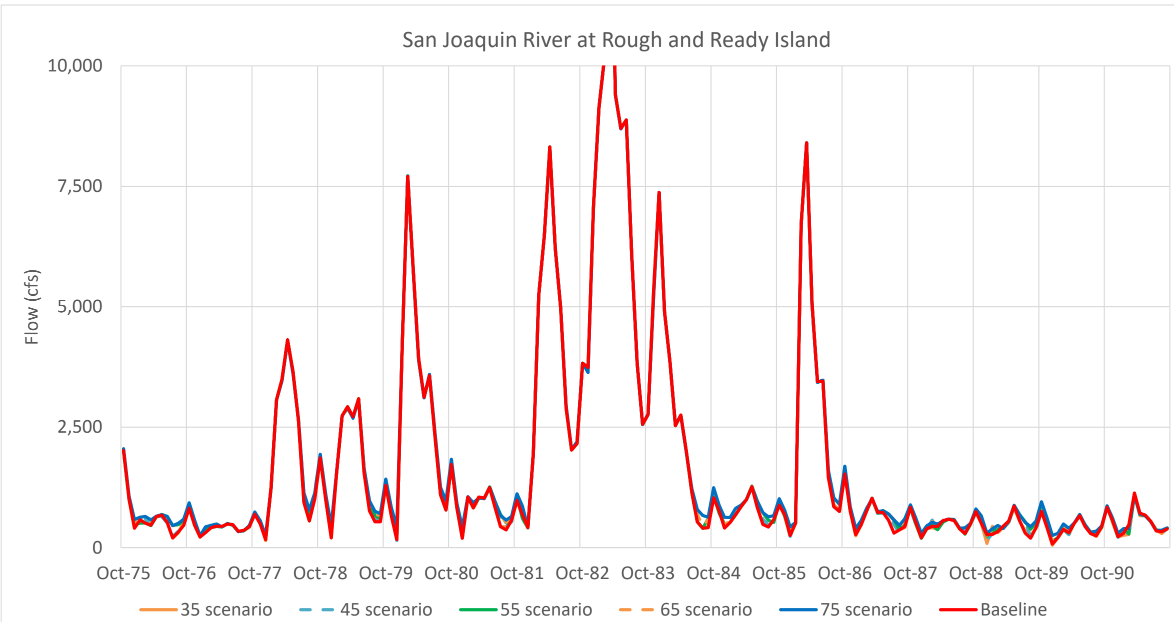
	Victoria Canal Travel Time (days)							Travel Time (days) is 1,250 / flow				
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Baseline												
10%	0.4	0.4	0.4	0.6	0.6	0.7	1.5	2.0	0.7	0.4	0.3	0.3
20%	0.4	0.4	0.4	0.6	0.6	0.8	2.5	2.3	0.7	0.4	0.3	0.3
30%	0.4	0.4	0.5	0.7	0.6	0.8	3.1	2.7	0.7	0.4	0.4	0.4
40%	0.4	0.4	0.5	0.7	0.7	0.9	3.5	3.0	0.7	0.4	0.4	0.4
50%	0.5	0.5	0.6	0.7	0.7	0.9	3.9	3.2	0.7	0.4	0.4	0.5
60%	0.5	0.5	0.7	0.7	0.7	0.9	4.6	3.6	0.8	0.4	0.5	0.6
70%	0.7	0.5	0.7	0.8	0.8	1.0	6.6	4.3	1.0	0.6	0.6	0.6
80%	0.8	0.7	1.0	0.9	1.0	1.0	8.6	8.7	1.5	1.3	0.7	1.0
90%	0.9	0.9	1.2	1.2	1.6	1.5	8.8	9.4	2.9	1.4	0.8	1.1
Average	0.6	0.6	0.7	0.9	1.3	1.0	6.1	5.2	1.3	0.7	0.6	0.6
Change for 35 Scenario												
10%	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	0.0	0.0	0.0	0.0	0.0
20%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0
30%	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	-0.3	0.0	0.0	0.0	0.0
40%	0.0	0.0	-0.1	0.0	0.0	0.0	-0.7	-0.3	0.0	0.0	0.1	0.0
50%	0.1	0.0	-0.1	0.0	0.0	0.0	-0.8	0.0	0.0	0.0	0.1	0.0
60%	0.1	0.0	-0.1	0.0	-0.1	0.0	-1.2	-0.2	0.0	0.1	0.1	0.0
70%	0.1	0.0	-0.1	0.1	-0.1	0.0	-2.5	1.9	1.8	1.0	0.0	0.2
80%	0.3	-0.1	-0.2	0.0	-0.1	0.0	-0.8	0.7	1.7	1.3	0.0	0.1
90%	0.2	-0.2	-0.1	1.1	-0.2	-0.2	-0.1	0.0	0.6	1.3	-0.1	0.0
Average	0.1	0.0	-0.1	0.2	-0.1	0.0	-2.0	-0.3	0.4	0.4	0.0	0.0
Change for 45 Scenario												
10%	0.1	0.0	0.0	0.0	0.0	0.0	-0.4	0.0	0.0	0.0	0.0	0.0
20%	0.1	0.1	0.1	0.0	0.0	0.0	-1.0	0.0	0.1	0.1	0.0	0.0
30%	0.0	0.0	0.1	0.0	0.0	0.0	-0.8	0.0	0.2	0.2	0.0	0.0
40%	0.1	0.0	0.1	0.0	0.0	-0.1	-0.7	-0.2	1.0	0.4	0.1	0.0
50%	0.1	0.0	0.0	0.0	0.0	0.0	-0.9	-0.1	1.6	0.4	0.1	0.1
60%	0.2	0.0	0.0	0.0	0.0	0.0	-1.2	0.4	2.5	0.4	0.0	0.0
70%	0.2	0.0	0.0	0.0	0.2	0.0	-2.1	2.9	2.4	0.8	0.0	0.2
80%	0.2	0.1	-0.2	0.0	0.7	0.0	-1.5	0.7	2.1	1.3	0.0	0.1
90%	0.3	0.0	-0.1	0.5	6.3	-0.2	-0.1	5.8	1.2	1.2	-0.1	0.1
Average	0.1	0.1	0.0	0.1	2.2	0.0	-2.1	1.7	1.2	0.4	0.0	0.1

	Victoria Canal Travel Time (days)						Travel Time (days) is 1,250 / flow					
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Change for 55 Scenario												
10%	0.1	0.1	0.1	0.0	0.0	0.0	1.0	-0.1	0.2	0.3	0.0	0.0
20%	0.1	0.1	0.2	0.0	0.0	0.0	0.2	0.1	1.9	0.4	0.1	0.1
30%	0.3	0.0	0.2	0.0	0.0	0.0	-0.3	0.4	2.3	0.8	0.2	0.1
40%	0.3	0.1	0.1	0.0	0.0	0.0	-0.5	2.0	2.7	0.8	0.3	0.1
50%	0.3	0.1	0.1	0.0	0.0	0.0	-0.5	7.5	2.7	1.8	0.3	0.2
60%	0.3	0.0	0.0	0.0	0.0	0.0	-1.0	9.4	2.8	1.9	0.2	0.2
70%	0.5	0.1	0.2	0.1	0.0	0.0	-0.6	9.6	2.8	1.9	0.2	0.4
80%	0.6	0.0	0.0	0.3	0.0	0.0	0.1	7.6	2.8	1.4	0.4	0.1
90%	0.9	0.0	0.1	1.4	1.9	0.2	1.3	9.1	2.8	1.7	0.6	0.1
Average	0.4	0.1	0.1	0.5	1.4	0.0	-0.4	4.5	3.6	1.2	0.2	0.1
Change for 65 Scenario												
10%	0.2	0.2	0.3	0.0	0.0	0.0	1.0	-0.4	1.1	0.5	0.1	0.1
20%	0.4	0.2	0.3	0.0	0.0	0.0	0.3	0.3	1.4	0.8	0.1	0.4
30%	0.6	0.2	0.4	0.0	0.0	0.1	0.1	3.5	2.5	1.3	0.3	0.4
40%	0.7	0.2	0.4	0.0	0.0	0.1	0.2	6.5	2.7	2.1	0.4	0.4
50%	0.7	0.2	0.3	0.0	0.1	0.1	0.5	7.4	3.0	2.2	0.4	0.4
60%	0.7	0.2	0.5	0.1	0.2	0.1	3.4	8.5	3.0	2.3	0.7	0.4
70%	0.7	0.4	0.6	0.1	0.1	0.5	2.8	9.7	3.1	2.6	0.8	0.5
80%	0.8	0.3	0.5	0.2	0.0	0.9	2.3	5.9	2.8	2.2	1.1	0.2
90%	2.5	0.6	1.0	0.4	0.3	0.7	10.5	10.5	2.3	2.2	1.3	0.1
Average	1.1	0.4	0.5	0.3	-0.2	0.3	2.3	5.7	3.8	1.7	0.5	0.3
Change for 75 Scenario												
10%	0.3	0.3	0.5	0.0	0.0	0.0	0.5	0.2	2.2	1.2	0.5	0.3
20%	0.5	0.4	0.7	0.0	0.0	0.1	0.4	1.0	2.6	1.8	1.0	0.4
30%	0.9	0.6	0.7	0.0	0.1	0.2	0.4	3.7	2.9	2.2	1.0	0.4
40%	1.0	0.8	0.7	0.3	0.3	0.2	0.3	6.7	3.0	2.3	1.0	0.4
50%	1.3	1.3	0.7	0.5	1.0	0.4	1.5	9.0	3.5	2.5	1.2	0.4
60%	2.3	1.5	0.8	0.6	1.3	0.8	3.2	13.6	3.6	2.6	1.3	0.4
70%	2.7	1.6	0.9	0.9	1.6	1.0	3.0	15.6	4.4	3.3	1.5	0.7
80%	3.1	1.6	1.0	1.7	1.7	1.9	13.7	14.7	4.6	3.3	1.7	0.4
90%	3.6	2.1	1.8	2.2	1.9	2.1	19.3	20.0	6.5	3.3	1.7	0.4
Average	1.8	1.2	1.0	1.0	0.7	0.8	4.2	8.9	5.1	2.7	1.1	0.4

Stockton

HABs have been particularly problematic near Stockton, especially near the Stockton Waterfront. The flow scenarios are expected to cause either little change in flow or increases in flow in the San Joaquin River near Stockton during the June through October HAB season, with a trend toward larger increases in the higher flow scenarios (Figure A2-14, Table A2-3). Correspondingly, the flow scenarios would cause either little change or a reduction in San Joaquin River travel time past the City of Stockton.

The Stockton Waterfront is located upstream of the Port of Stockton turning basin for cargo vessels, in a dead-end slough that connects to the San Joaquin River at its west end. As described in Section A2.3.3, *Tidal Slough Flow and Stagnation in the Southern Delta,* dead-end sloughs have limited tidal exchange and minimal net flow, resulting in stagnant water and long residence times that are conducive to HAB formation. Net flow through the turning basin is negligible, and the flow scenarios are not expected to affect flow in and out of this slough (Figure A2-15).



cfs = cubic feet per second

Figure A2-14. DSM2 Flow in the San Joaquin River near Stockton – Baseline and Flow Scenarios for WY 1976–1991

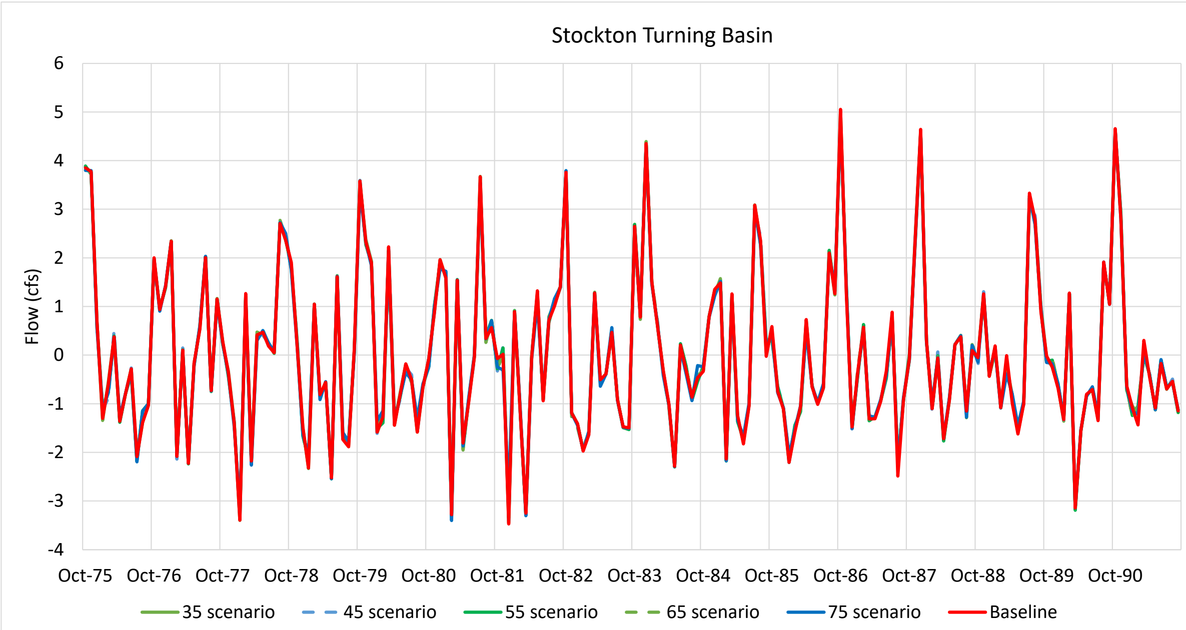
Table A2-3. Cumulative Distribution of DSM2 Flow Values for the San Joaquin River near Stockton – Baseline Compared with Flow Scenarios for WY 1976–1991

San Joaquin River Flow near Stockton (cfs)													
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
Baseline													
10%	751	480	166	284	397	442	528	626	500	296	268	417	445
20%	817	504	196	311	441	445	563	676	548	303	323	434	476
30%	837	539	204	433	491	659	681	702	562	343	343	437	598
40%	877	665	220	507	682	1,028	736	862	568	391	369	462	663
50%	1,007	680	239	550	793	1,094	1,014	1,255	832	458	386	514	792
60%	1,292	755	268	1,052	2,736	2,533	2,717	2,007	1,143	532	430	568	1,623
70%	1,627	797	337	1,417	3,462	3,210	3,343	3,106	2,095	850	544	667	2,281
80%	1,864	982	408	1,953	5,243	5,796	4,316	3,444	3,455	1,454	851	780	2,835
90%	2,386	2,377	3,749	4,570	7,207	7,444	6,698	4,935	4,266	2,585	1,561	1,587	3,208
Average	1,412	1,152	1,121	1,729	2,768	3,164	2,669	2,339	1,971	1,126	762	777	1,749
35 Scenario Change from Baseline													
10%	-6	-12	-50	4	-53	-44	-13	-8	-9	31	2	-11	-3
20%	19	-2	-46	80	-26	-3	-32	-24	-8	45	-19	-16	-9
30%	25	-15	-6	25	-29	1	-29	-13	4	43	-15	-6	-16
40%	24	-50	-16	-4	-1	0	-26	-34	129	46	0	22	26
50%	11	-23	-13	5	-1	-28	-9	-5	-1	51	32	29	1
60%	26	-9	-27	-1	0	-1	-14	-2	-4	36	30	-16	8
70%	3	20	-12	-11	-2	-4	-1	-1	0	1	10	39	-1
80%	6	-5	-3	-4	0	4	-9	-1	-1	-2	0	2	2
90%	-5	-12	-6	0	3	0	-10	-2	0	0	2	2	-1
Average	10	-10	-18	7	-16	-12	-13	-8	9	23	7	6	-1
45 Scenario Change from Baseline													
10%	15	-1	-14	16	-31	-52	-15	-7	-7	31	1	-3	12
20%	-21	39	-38	35	33	-2	-30	-15	-8	69	-29	0	-2
30%	3	18	-8	1	93	-2	-22	-12	72	100	-11	40	-4
40%	72	-52	-5	-4	-1	-1	-24	-17	128	141	-20	72	27
50%	59	-5	-9	-33	-1	-31	-6	5	64	81	35	30	18

San Joaquin River Flow near Stockton (cfs)													
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
60%	38	-6	15	-1	-1	-1	-15	-5	-7	54	48	6	42
70%	12	22	39	-11	-2	-6	-21	-2	34	81	17	30	1
80%	27	-3	36	0	0	5	-5	-2	16	64	-1	13	12
90%	-5	-12	12	2	10	0	-51	-3	4	2	3	3	3
Average	19	3	4	-1	10	-14	-20	-5	31	59	7	16	9
55 Scenario Change from Baseline													
10%	40	22	25	82	-19	-54	-12	0	5	55	53	8	14
20%	44	52	2	78	-19	-6	-30	-15	33	100	32	46	39
30%	82	22	30	17	-4	-8	-16	27	105	154	34	80	22
40%	96	-59	22	2	-2	-2	-15	13	132	149	29	100	59
50%	82	9	24	-25	-1	-35	-2	16	129	171	112	77	49
60%	53	-39	22	0	-1	-1	-16	-7	-11	188	139	38	55
70%	46	-3	52	-12	-2	-16	-17	-1	63	159	117	17	24
80%	47	9	61	0	1	12	-9	-1	17	94	-2	4	6
90%	-5	0	32	1	9	0	-7	-5	5	28	4	31	10
Average	46	1	30	13	-7	-14	-12	5	51	111	57	39	27
65 Scenario Change from Baseline													
10%	74	66	45	73	29	-11	-13	0	4	49	83	23	37
20%	44	58	53	75	-4	30	-21	2	33	103	83	57	64
30%	94	74	53	1	41	25	-9	20	104	148	80	128	34
40%	126	21	61	-3	-1	-28	-3	10	132	193	78	121	69
50%	142	64	112	-29	1	-46	-10	5	124	229	123	103	70
60%	85	14	136	1	-2	-1	-29	-18	66	188	201	91	70
70%	83	29	74	-15	0	-30	-21	-11	67	206	141	74	45
80%	65	51	94	-1	2	-20	-10	-11	15	91	39	150	27
90%	15	-26	69	5	3	1	-36	-20	15	39	39	81	28
Average	74	32	71	12	9	-4	-16	-1	57	127	93	77	44
75 Scenario Change from Baseline													
10%	85	109	86	108	65	1	-2	0	3	48	89	37	59
20%	70	111	98	119	49	46	-6	7	32	103	86	68	76
30%	103	102	93	55	95	70	-4	25	103	146	108	135	59

San Joaquin River Flow near Stockton (cfs)													
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
40%	138	110	181	56	131	-14	11	15	132	186	134	140	102
50%	174	161	180	78	81	-36	-7	-2	125	241	221	125	109
60%	130	107	157	6	-1	29	-30	-24	76	257	236	95	89
70%	136	105	108	-7	-3	-26	-28	-12	58	204	224	135	63
80%	72	90	176	-3	3	-31	-26	-15	22	150	182	191	57
90%	26	-12	104	1	2	1	-38	-24	23	70	85	79	56
Average	94	85	120	46	45	8	-15	-3	58	139	140	96	68

cfs = cubic feet per second



cfs = cubic feet per second

Figure A2-15. DSM2 Flow in the San Joaquin River near Stockton – Baseline and Flow Scenarios for WY 1976–1991

A2.4.2 Changes in Delta Channel Salinity

Changes in EC are evaluated at water quality compliance locations summarized in Table A2-1. Because bromide and chloride are related to EC, the bromide and chloride objectives also are assessed here using the DSM2 EC results. SacWAM estimates net Delta outflow necessary to meet EC objectives for the Sacramento River at Collinsville, Sacramento River at Emmaton, San Joaquin River at Jersey Point, and Old River at Rock Slough. As a result, the hydrologic conditions transferred from SacWAM to DSM2 are expected to show attainment of EC objectives at these four locations. This section evaluates attainment of the objectives at all water quality compliance locations in Table A2-1 and shows the magnitude of expected changes in EC.

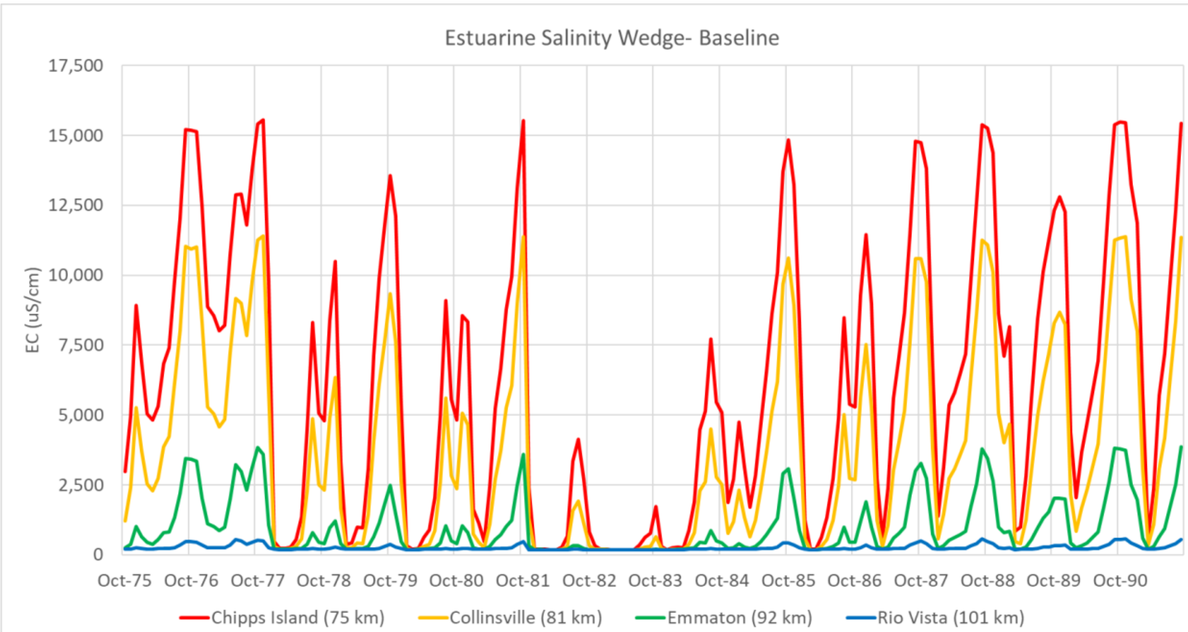
A2.4.2.1 General Effect of Outflow on Seawater Intrusion

As described above in Section A2.4.1, *Changes in Flow*, while there are some periods of reduced Delta inflow, the general effects of the scenarios are higher Delta channel flows (or less negative flows) and higher Delta outflows, which generally reduce EC in the Delta. Changes in Delta outflow have the greatest effect on seawater intrusion and EC at western locations, closer to the ocean, including the Sacramento River downstream of Rio Vista, the San Joaquin River downstream of San Andreas Landing, and in Suisun Bay and Suisun Marsh channels.

Section A2.3.3, *Effects of Flow on Salinity*, describes the basic features of the estuarine salinity gradient that develops from the tidal mixing of sea water and fresh water (i.e., seawater intrusion). The salinity gradient moves upstream with lower Delta outflow and moves downstream with higher Delta outflow. Figures A2-16 and A2-17, respectively, show changes in the salinity gradient between baseline conditions and the 75 scenario. These figures show DSM2 EC at Chipps Island (75 km), Collinsville (81 km), Emmaton (92 km), and Rio Vista (101 km) for WY 1976–1991. Note that the EC values shown in Figure A2-16 are the same as those presented in Figure A2-17. They are repeated here for easy comparison with the EC values for the 75 scenario.

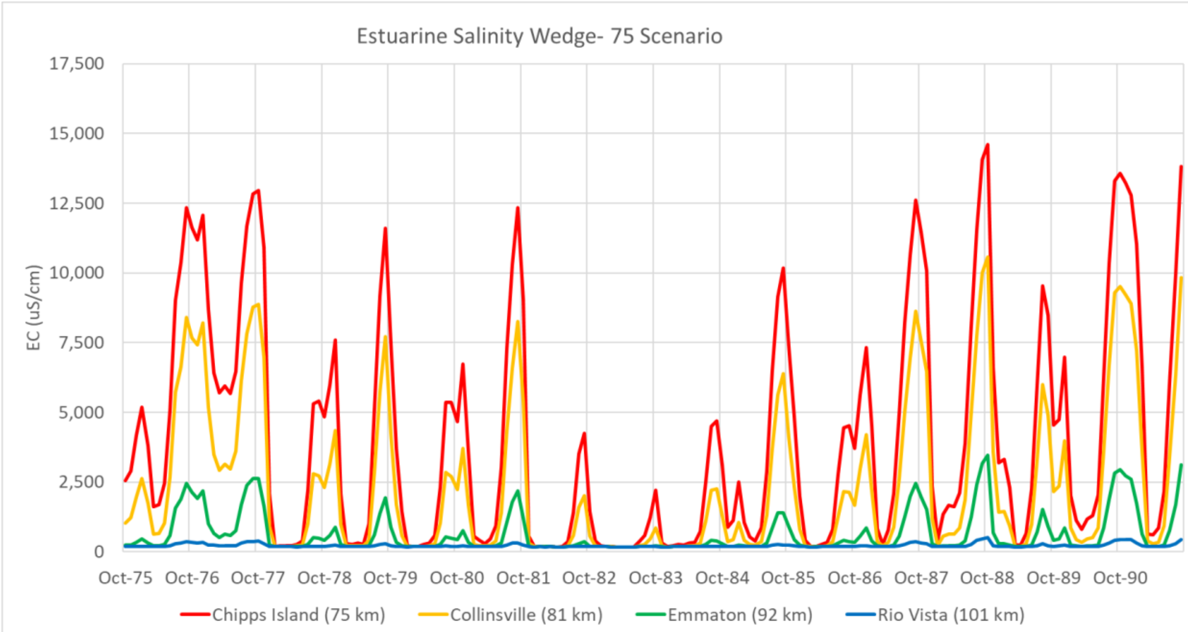
Under baseline conditions, the upstream edge of the salinity gradient (1,000 µS/cm) is always downstream of Rio Vista and often is downstream of Emmaton; the baseline salinity gradient is sometimes downstream of Collinsville (>13,500 cfs Delta outflow) and is downstream of Chipps Island only in a few months with high Delta outflow (>17,000 cfs).

Because the monthly outflows are generally higher for the 75 scenario, the location of the salinity gradient generally is downstream compared with the baseline. The upstream edge of the salinity gradient under the 75 scenario often is downstream of Emmaton and more often is downstream of Collinsville and Chipps Island than under baseline conditions. Because the salinity gradient is downstream of Rio Vista under baseline conditions, the 75 scenario has little effect on EC at Rio Vista.



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometers

Figure A2-16. Time Series of DSM2 EC Values at Chipps Island (75 km), Collinsville (81 km), Emmaton (92 km), and Rio Vista (101 km) – Baseline for WY 1976–1991



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometers

Figure A2-17. Time Series of DSM2 EC Values at Chipps Island (75 km), Collinsville (81 km), Emmaton (92 km), and Rio Vista (101 km) – 75 Scenario for WY 1976–1991

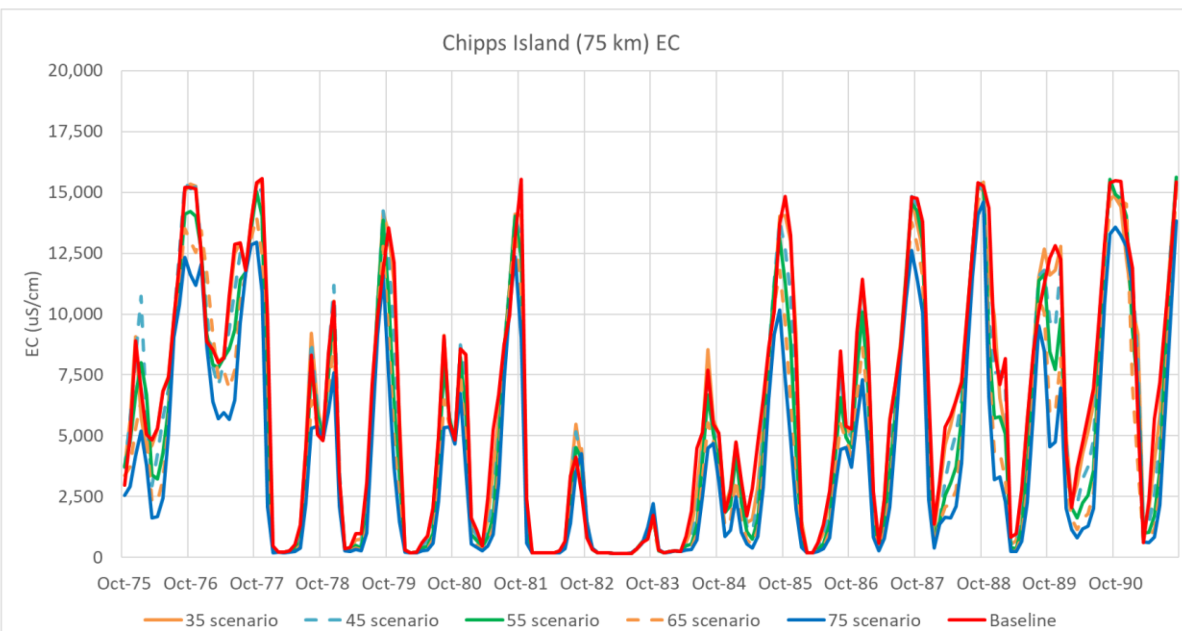
Specific information for particular locations with water quality objectives is summarized below in sections for Suisun Marsh and Delta fish and wildlife objectives, western and interior Delta agricultural objectives, municipal water supply objectives, and southern Delta agricultural objectives. The tables and figures used to evaluate DSM2 results for these locations provide specific information for the locations evaluated, but they also allow some general conclusions to be made, including the following. Once outflow is sufficient to move fresh water to a location, additional increases in outflow will not further reduce EC, the largest EC changes (reductions) are in months with the highest baseline EC, and moderate increases in outflow cause large reductions in EC when the baseline outflow is low. Many months have small changes in the EC either because the baseline outflow is similar to the flow scenarios or because the baseline outflow is already high enough that an increase in outflow does not cause much change in EC. The DSM2 results show that EC for the 35 scenario is similar to baseline, whereas EC is sometimes reduced for the 45 scenario and is often reduced for the 55, 65, and 75 scenarios—with magnitude of effect increasing with the flow requirement.

A2.4.2.2 Compliance with Suisun Marsh and Delta Fish and Wildlife Objectives

The Bay-Delta Plan includes fish and wildlife salinity objectives for five Suisun Marsh stations, one near the marsh entrance at Collinsville and four within the marsh (Table A2-1). In addition, there are fish and wildlife objectives for the San Joaquin River reach between Jersey Point and Prisoners Point.

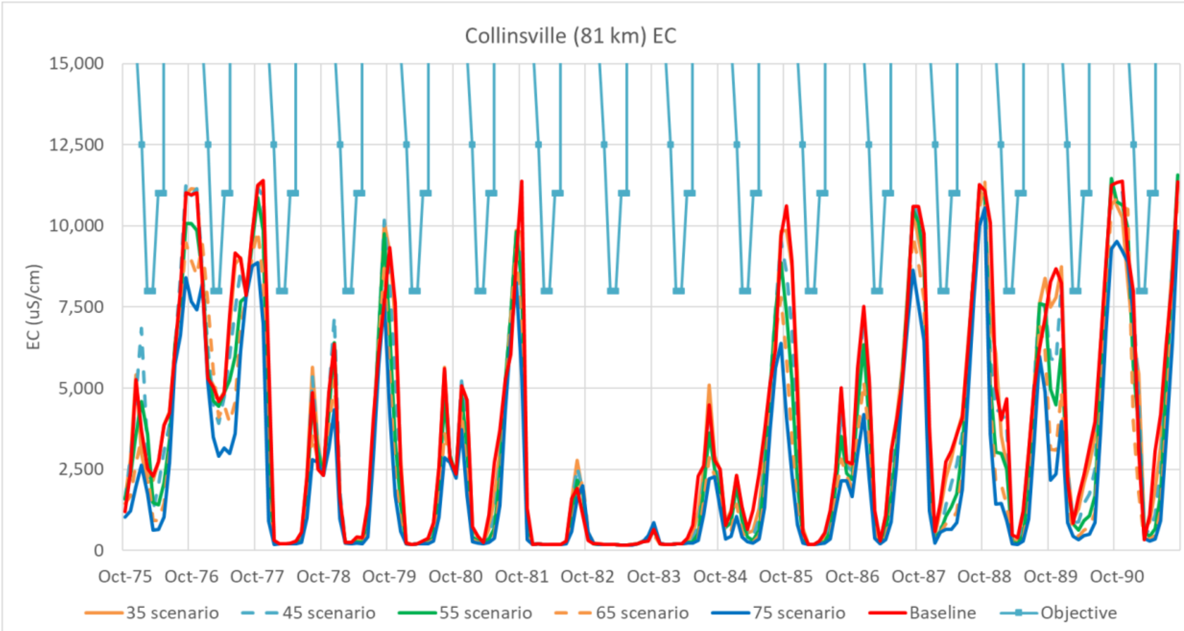
Tidal flows enter the Suisun Marsh channels at the mouth of Montezuma Slough and Suisun Slough, both located at the north end of Grizzly Bay. Because the Suisun Marsh channels are a network of dead-end tidal sloughs, the salinity generally decreases inland from Suisun Bay (for western marsh channels) and inland from the upstream end of Montezuma Slough (for eastern marsh channels). Freshwater enters the upstream end of Montezuma Slough at Collinsville, and the Montezuma Slough Salinity Control Gates are operated (opened during ebb-tide, closed during flood-tide) from October through May each year to reduce salinity in Montezuma Slough and eastern marsh channels. In summer months, the gates are operated per California Department of Fish and Wildlife's Incidental Take Permit requirements.

Changes in EC at Chipps Island and Collinsville indicate the changes expected to occur in Suisun Bay and Suisun Marsh. As shown in Figures A2-18 and A2-19, EC at these locations is expected to generally be reduced in response to the flow scenarios. In addition, Figure A2-19 shows that the EC objective at Collinsville is expected to be satisfied for baseline and each of the scenarios. Tables A2-4 and A2-4 quantify the simulated changes in EC at these two locations. At Chipps Island, EC is expected to almost always be reduced for all scenarios with a few exceptions, primarily in August and September of the lower flow scenarios (Table A2-4). The effect at Collinsville is similar (Table A2-5). When there are increases, they tend to occur outside the October–May fish and wildlife objective period. During the October–May fish and wildlife objective period, EC generally is expected to be similar to or less than baseline, with the largest reductions occurring in October through December and May. Because the scenarios would cause either little change or reductions in EC at Chipps Island and Collinsville during the fish and wildlife objective period, the scenarios also would cause either little change or reduction in EC in Suisun Marsh during October-May, with reductions being greater closer to Suisun Bay and Collinsville.



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometers

Figure A2-18. Time Series of DSM2 EC Values for Chipps Island – Baseline and Flow Scenarios for WY 1976–1991



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometers

Figure A2-19. Time Series of DSM2 EC Values for Collinsville – Baseline and Flow Scenarios for WY 1976–1991 with EC Objectives for Reference

Table A2-4. Cumulative Distribution of DSM2 EC Values for Chipps Island (75 km) – Baseline Compared with Flow Scenarios for WY 1976–1991

	Chipps Island EC (µS/cm)												
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Baseline													
10%	2,353	1,096	198	223	191	188	227	401	1,014	3,910	5,925	3,872	2,439
20%	4,805	2,415	2,704	319	192	215	619	889	2,045	4,881	8,312	5,393	4,580
30%	4,959	6,679	6,058	860	247	238	743	1,155	2,902	5,048	8,790	5,506	5,132
40%	5,286	8,554	8,323	1,383	368	411	978	1,893	4,480	7,138	9,915	11,232	5,141
50%	12,936	10,697	8,476	2,481	1,593	524	1,671	3,770	6,071	8,536	10,034	12,463	5,705
60%	14,754	12,815	8,913	4,369	2,728	617	2,382	5,244	6,671	8,650	10,119	13,713	7,358
70%	15,018	13,523	10,146	5,811	3,132	1,275	2,630	5,658	7,006	9,276	11,641	14,298	7,658
80%	15,269	14,369	11,444	7,104	5,043	3,666	4,713	5,824	7,183	9,780	12,048	15,209	8,543
90%	15,442	15,301	12,355	8,927	6,946	5,091	5,554	6,652	7,292	9,851	12,458	15,387	9,089
Average	9,867	9,288	7,455	3,866	2,580	1,733	2,420	3,754	5,125	7,310	9,472	10,299	6,097
35 Scenario Change from Baseline													
10%	362	3	-1	0	1	0	-2	-63	-44	-13	998	759	-58
20%	31	-301	141	5	1	-5	-136	-141	-47	-69	236	157	-86
30%	19	228	-318	-126	-5	0	-160	-222	-311	-86	390	461	-6
40%	-242	35	-4	136	-24	-63	-289	-707	-1,728	-362	452	1,427	74
50%	-462	-595	522	-77	33	-60	-516	-981	-479	-124	923	1,456	-180
60%	-1,035	-1,509	270	390	-266	-75	-772	-1,681	-891	-88	1,401	400	-56
70%	-969	-1,278	71	-419	-298	57	-435	-1,100	-927	-72	170	163	-170
80%	-504	-1,400	-181	-558	-699	-651	-443	-137	-117	-67	-171	-143	-401
90%	-256	-467	70	17	2	-475	-195	25	49	85	164	-75	-271
Average	-278	-468	28	-175	-58	-107	-264	-483	-412	-62	445	466	-114
45 Scenario Change from Baseline													
10%	354	-188	-2	0	0	0	-6	-92	-256	-334	383	787	-272
20%	-383	-299	55	-26	4	-5	-142	-355	-638	-513	-739	-134	-546
30%	-75	251	-960	-262	-3	0	-233	-437	-1,044	-634	173	238	-548

Chipps Island EC (µS/cm)													
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
40%	-312	-103	-2,053	-339	-40	-79	-440	-1,083	-2,437	-858	511	565	-145
50%	-1,904	-1,780	-1,337	-87	-380	-98	-839	-1,753	-1,271	-155	1,227	1,267	-353
60%	-2,081	-3,375	-1,340	256	-621	-20	-1,262	-2,804	-1,832	-91	1,399	300	-321
70%	-1,266	-3,180	-451	408	-639	-152	-994	-2,507	-1,894	-426	78	229	-335
80%	-248	-1,125	-272	1,740	649	-1,469	-1,473	-1,139	-685	-669	392	23	-919
90%	-318	-241	46	1,454	512	-2,037	-1,296	-1,214	-516	-45	192	-63	-668
Average	-592	-970	-561	260	-94	-444	-638	-1,172	-1,091	-359	348	355	-413
55 Scenario Change from Baseline													
10%	349	-420	-3	-5	0	0	-14	-118	-396	-937	-384	629	-477
20%	-866	-568	-583	-80	4	-7	-274	-499	-1,043	-1,091	-1,614	-316	-1,214
30%	-291	-1,078	-2,255	-375	-3	-3	-371	-638	-1,567	-1,058	-934	327	-1,115
40%	-408	-1,071	-3,640	-582	-50	-103	-513	-1,334	-2,894	-1,324	500	411	-593
50%	-3,346	-2,995	-3,177	-456	-504	-122	-1,051	-2,372	-2,496	-786	1,094	836	-684
60%	-3,465	-4,594	-2,942	-315	-1,022	-198	-1,545	-3,534	-3,002	-529	1,266	149	-945
70%	-1,747	-4,662	-1,924	-792	-987	-243	-1,420	-3,532	-2,561	-962	-138	-238	-1,199
80%	-1,020	-1,329	-1,371	-118	35	-2,037	-2,469	-2,306	-1,455	-1,147	-328	-650	-1,699
90%	-475	-1,286	-929	-314	-205	-2,121	-2,406	-2,642	-1,277	-148	-97	50	-1,164
Average	-1,050	-1,832	-1,522	-473	-317	-470	-957	-1,780	-1,782	-836	-79	191	-909
65 Scenario Change from Baseline													
10%	78	-511	-1	-18	0	0	-22	-12	-543	-1,606	-1,292	775	-734
20%	-1,309	-1,157	-1,191	-88	1	-7	-333	-577	-1,300	-1,937	-2,774	-561	-1,823
30%	-486	-2,390	-3,551	-481	-3	-5	-448	-764	-1,905	-1,722	-2,311	-32	-1,739
40%	-427	-2,633	-5,137	-837	-60	-128	-610	-1,462	-3,223	-1,668	12	-1,166	-1,259
50%	-5,388	-4,208	-4,684	-811	-625	-213	-1,217	-2,754	-3,360	-1,584	476	-175	-1,120
60%	-5,088	-6,087	-4,219	-1,228	1,265	-286	-1,736	-4,062	-3,825	-1,467	804	-592	-1,907
70%	-3,236	-5,744	-3,395	-,2034	-1,585	-586	-1,725	-4,144	-3,401	-1,626	-367	-820	-1,926
80%	-2,247	-2,785	-2,827	-660	-1,836	-2,528	-3,113	-3,136	-2,395	-1,262	-655	-1,436	-2,574
90%	-969	-2,840	-1,237	-2,193	-2,567	-2,913	-3,299	-3,657	-1,856	-510	-838	-730	-1,970
Average	-1,792	-2,814	-2,365	-879	-759	-687	-1,234	-2,251	-2,377	-1,430	-759	-358	-1,475

Chipps Island EC (µS/cm)													
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
75 Scenario Change from Baseline													
10%	38	-618	-1	-22	0	1	-27	-174	-637	-2,105	-1,953	518	-904
20%	-1,686	-1,541	-1,584	-103	1	-11	-372	-620	-1,464	-2,579	-3,824	-690	-2,293
30%	-830	-3,374	-4,335	-547	-10	-12	-477	-834	-2,129	-2,399	-3,465	-127	-2,326
40%	-621	-3,807	-6,241	-976	-84	-164	-664	-1,541	-3,463	-2,029	-771	-2,760	-1,778
50%	-6,834	-5,461	-5,697	-1,193	-969	-257	-1,306	-3,008	-3,978	-2,535	-691	-1,572	-1,574
60%	-7,254	-6,836	-5,324	-2,272	-1,683	-336	-1,912	-4,380	-4,422	-2,411	-153	-1,367	-2,806
70%	-4,765	-6,856	-4,565	-2,910	-1,883	-679	-1,931	-4,543	-4,048	-2,377	-1,316	-1,816	-2,716
80%	-3,639	-4,285	-4,132	-2,585	-2,735	-2,863	-3,528	-3,737	-3,294	-1,662	-1,673	-2,381	-3,412
90%	-2,174	-4,251	-2,528	-1,976	-1,846	-3,452	-3,898	-4,377	-2,287	-1,233	-1,372	-1,832	-2,423
Average	-2,663	-3,744	-3,250	-1,255	-990	-905	-1,501	-2,577	-2,826	-2,077	-1,576	-1,109	-2,039

µS/cm = microSiemens per centimeter
EC = electrical conductivity

Table A2-5. Cumulative Distribution of DSM2 EC Values for Collinsville (81 km) – Baseline Compared with Flow Scenarios for WY 1976–1991

	Collinsville EC (µS/cm)												
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
Baseline													
10%	922	491	190	194	185	185	197	240	427	1,931	3,202	1,806	1,402
20%	2,305	1,306	1,182	235	186	198	291	380	865	2,463	4,870	2,725	2,730
30%	2,431	3,655	3,219	435	203	203	336	478	1,336	2,593	5,306	2,802	3,034
40%	2,679	5,073	4,639	574	253	243	397	784	2,298	4,047	6,043	7,169	3,127
50%	8,809	6,620	4,921	1,200	638	267	741	1,800	3,343	5,064	6,160	8,329	3,386
60%	10,591	8,673	5,263	2,167	1,229	340	1,091	2,716	3,710	5,144	6,229	9,681	4,452
70%	10,780	9,338	6,102	3,007	1,397	563	1,161	3,050	3,988	5,705	7,734	10,180	4,687
80%	11,078	10,096	7,510	4,011	2,528	1,664	2,327	3,149	4,092	6,304	8,015	11,024	5,475
90%	11,286	11,193	8,267	5,278	3,877	2,516	2,908	3,711	4,208	6,357	8,491	11,257	5,981
Average	6,675	6,209	4,582	2,212	1,375	917	1,238	2,062	2,932	4,404	6,004	6,937	3,796
35 Scenario Change from Baseline													
10%	187	46	-1	0	0	0	-2	-17	-14	-9	645	431	-52
20%	60	-344	65	1	1	1	-32	-46	-24	-47	228	106	-49
30%	-1	134	-206	-75	-2	-2	-55	-83	-170	-51	340	311	-26
40%	-148	30	-2	124	-7	-15	-99	-300	-1,072	-249	523	1,216	38
50%	-471	-410	361	-30	27	-17	-272	-579	-336	-59	883	1,490	18
60%	-1,015	-1,583	186	150	-124	-15	-432	-1,069	-616	-52	1,380	168	-43
70%	-960	-1,090	124	-243	-165	51	-171	-782	-621	136	126	125	-106
80%	-469	-1,354	-202	-468	-427	-381	-256	-67	-38	-93	-92	-39	-288
90%	-308	-500	60	14	-3	-322	-127	20	3	47	152	-79	-261
Average	-302	-432	21	-143	-27	-60	-128	-295	-273	-18	389	377	-74
45 Scenario Change from Baseline													
10%	184	-7	-2	0	0	0	-2	-24	-96	-193	176	421	-193
20%	-219	-474	11	-7	3	2	-50	-107	-291	-313	-568	-85	-383
30%	-36	145	-598	-130	-1	-2	-82	-159	-553	-361	156	161	-370
40%	-221	-98	-1,340	-112	-14	-19	-125	-434	-1,416	-458	624	329	26
50%	-1,754	-1,326	-1,088	-1	-151	-26	-390	-969	-837	38	1,179	1,244	-154

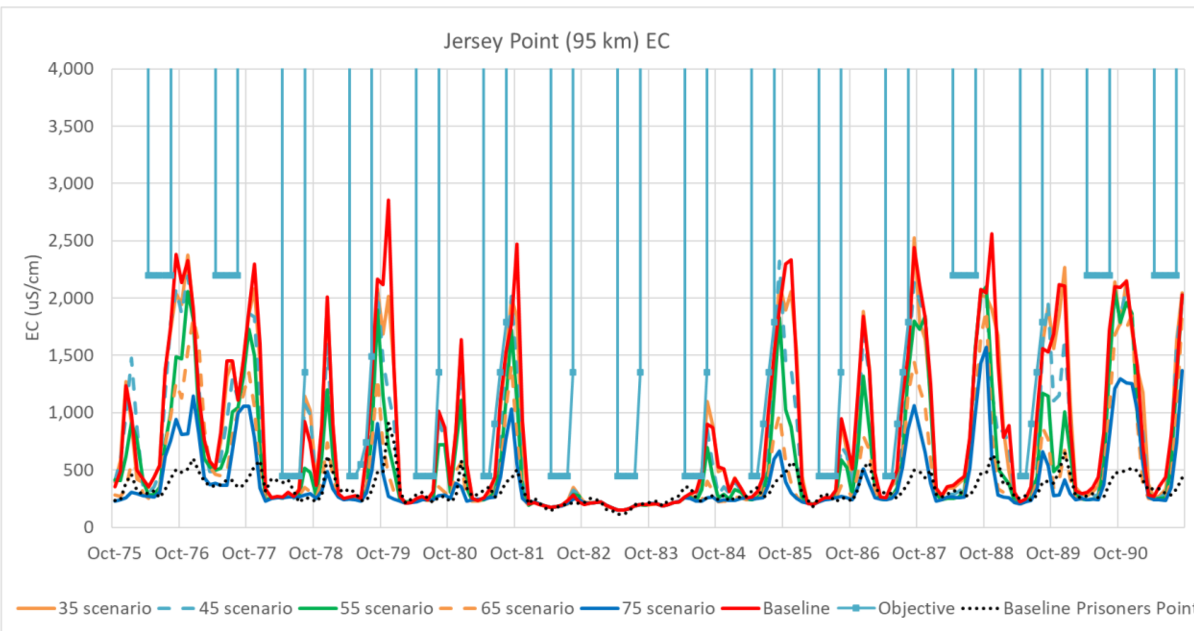
Collinsville EC (µS/cm)													
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
60%	-2,024	-2,890	-957	70	-371	14	-646	-1,691	-1,199	82	1,386	40	-134
70%	-1,199	-2,947	-128	356	-327	-52	-464	-1,637	-1,299	-164	45	261	-166
80%	-201	-909	-244	1,150	475	-795	-870	-755	-478	-507	378	70	-863
90%	-373	-240	120	1,252	311	-1,201	-872	-866	-389	-65	198	-65	-439
Average	-572	-836	-368	226	-37	-252	-339	-723	-718	-190	327	271	-267
55 Scenario Change from Baseline													
10%	184	-121	-2	0	1	0	-2	-29	-136	-519	-362	312	-323
20%	-547	-596	-317	-30	3	2	-78	-141	-452	-560	-1,247	-217	-858
30%	-169	-819	-1,473	-171	-2	-2	-111	-214	-787	-644	-688	188	-729
40%	-326	-871	-2,234	-228	-19	-24	-144	-506	-1,630	-768	738	383	-297
50%	-2,950	-2,180	-2,137	-210	-197	-34	-454	-1,245	-1,632	-374	1,145	842	-356
60%	-3,267	-3,840	-2,209	-226	-505	-78	-748	-2,039	-1,930	-198	1,290	73	-552
70%	-1,640	-4,174	-1,220	-502	-530	-74	-658	-2,173	-1,712	-570	-49	-232	-738
80%	-962	-1,133	-1,168	-183	-35	-1,037	-1,399	-1,481	-1,008	-940	-210	-539	-1,481
90%	-475	-1,329	-786	-189	-211	-1,261	-1,534	-1,798	-891	-64	-1	68	-768
Average	-959	-1,528	-1,024	-319	-178	-251	-492	-1,068	-1,157	-508	31	142	-609
65 Scenario Change from Baseline													
10%	90	-172	0	1	0	0	-9	-39	-175	-891	-945	422	-483
20%	-783	-824	-590	-39	2	0	-83	-159	-537	-1,068	-2,014	-426	-1,245
30%	-306	-1,655	-2,171	-208	-1	-2	-124	-243	-918	-1,024	-1,680	-41	-1,155
40%	-347	-1,971	-3,135	-315	-23	-30	-167	-540	-1,776	-958	295	-982	-737
50%	-4,518	-3,115	-3,051	-410	-228	-53	-497	-1,395	-2,129	-1,001	654	-44	-656
60%	-4,653	-5,001	-2,952	-749	-641	-120	-815	-2,254	-2,420	-838	906	-588	-1,212
70%	-2,983	-4,899	-2,310	-1,269	-773	-222	-777	-2,450	-2,248	-1,116	-275	-808	-1,281
80%	-2,156	-2,356	-2,309	-593	-1,149	-1,218	-1,694	-1,959	-1,647	-1,024	-418	-1,308	-1,966
90%	-935	-2,795	-915	-1,566	-1,781	-1,648	-1,992	-2,390	-1,275	-361	-696	-665	-1,326
Average	-1,569	-2,266	-1,531	-559	-429	-356	-620	-1,329	-1,530	-925	-489	-357	-997

Collinsville EC (µS/cm)													
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
75 Scenario Change from Baseline													
10%	25	-219	-1	-1	1	0	-12	-45	-200	-1,140	-1,332	264	-595
20%	-997	-950	-735	-41	1	-4	-89	-167	-581	-1,428	-2,655	-460	-1,547
30%	-512	-2,200	-2,531	-225	-3	-4	-131	-260	-995	-1,405	-2,482	-89	-1,540
40%	-448	-2,732	-3,730	-347	-29	-43	-177	-559	-1,874	-1,199	-414	-2,282	-1,083
50%	-5,597	-3,961	-3,605	-633	-335	-57	-514	-1,482	-2,453	-1,716	-304	-1,274	-974
60%	-6,361	-5,536	-3,586	-1,184	-809	-128	-848	-2,359	-2,741	-1,550	106	-1,425	-1,820
70%	-4,316	-5,693	-3,125	-1,761	-900	-258	-848	-2,607	-2,630	-1,692	-1,115	-1,663	-1,849
80%	-3,420	-3,638	-3,318	-1,830	-1,609	-1,282	-1,860	-2,290	-2,225	-1,325	-1,303	-2,252	-2,471
90%	-2,092	-3,997	-1,993	-1,373	-1,265	-1,882	-2,261	-2,754	-1,546	-986	-1,141	-1,694	-1,702
Average	-2,299	-2,947	-2,133	-759	-554	-471	-763	-1,496	-1,790	-1,388	-1,129	-1,033	-1,397

µS/cm = microSiemens per centimeter
EC = electrical conductivity
Shading indicates when fish and wildlife objectives are applicable (October–May).

Jersey Point is located about 95 km upstream of the Golden Gate Bridge. Jersey Point has EC objectives for fish and wildlife and for agriculture. The agricultural objectives are discussed in the next section, *Compliance with Western and Interior Delta Agricultural Objectives*. To meet the Jersey Point-Prisoners Point fish and wildlife objective, the 14-day running average EC during April and May must remain below 440 µS/cm for the San Joaquin River between Jersey Point and Prisoners Point. In general, EC at Jersey Point is much greater than EC at Prisoners Point (Figure A2-20), so this discussion focuses on Jersey Point. The monthly objectives shown in Figure A2-20 are the most restrictive of the fish and wildlife objectives for April and May and the agricultural objectives for April 1–August 15. The Jersey Point EC values for the 35 scenario are close to the baseline EC values, with both having some annual peaks exceeding 2,000 µS/cm. In contrast, the Jersey Point EC values for the 75 scenario are usually less than 1,000 µS/cm (Figure A2-20).

Table A2-6 gives the tabular summary of the DSM2 baseline EC and the changes in EC for the flow scenarios at Jersey Point for WY 1976–1991. None of the scenarios have maximum monthly values for April and May that exceed the 440-µS/cm objective for fish and wildlife. The summary table clearly identifies the seasonal EC patterns and indicates that the EC generally will be reduced for each of the scenarios, with reductions being greatest for the 75 scenario. The reductions during the April and May objective period are relatively small compared with the reductions later in the year. For example, under the 55 scenario, the average reduction in EC is 595 µS/cm in November but is only 25 and 73 µS/cm during April and May, respectively.



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometers
The monthly objectives shown in the figure are the most restrictive of the fish and wildlife objectives for April and May and the agricultural objectives for April 1–August 15.

Figure A2-20. Time Series of DSM2 EC Values for Jersey Point – Baseline and the 35, 55, and 75 Scenarios for WY 1976–1991 with EC Objectives for Reference

Table A2-6. Cumulative Distribution of DSM2 EC Values for Jersey Point – Baseline Compared with Flow Scenarios for WY 1976–1991

							Jersey Point EC (µS/cm)						
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
Baseline													
10%	280	350	211	220	206	194	198	213	217	272	590	481	411
20%	368	511	312	272	211	219	228	261	253	324	924	743	651
30%	441	860	1,241	338	235	229	254	273	263	403	980	872	784
40%	528	922	1,393	391	260	250	259	296	313	639	1,112	1,461	800
50%	1,791	1,494	1,421	488	286	261	262	308	394	792	1,344	1,652	820
60%	2,043	2,116	1,599	788	317	272	265	328	439	820	1,480	1,906	902
70%	2,102	2,222	1,691	906	409	290	268	355	439	1,010	1,515	2,052	983
80%	2,118	2,328	1,843	981	501	304	307	371	443	1,115	1,535	2,096	1,077
90%	2,216	2,447	1,955	1,259	728	389	361	424	519	1,257	1,636	2,273	1,114
Average	1,337	1,480	1,280	653	381	282	275	336	420	750	1,196	1,469	822
35 Scenario Change from Baseline													
10%	6	9	-3	0	1	0	-4	-5	-2	-1	46	-9	-28
20%	4	68	12	1	2	2	-5	-6	-9	-3	56	90	-4
30%	-50	-106	-25	-26	-1	0	-5	-7	-9	-16	125	80	-48
40%	-44	-76	0	43	-4	-3	-9	-27	-50	-49	32	-12	-26
50%	-166	-159	60	3	-9	-6	-9	-31	-56	-134	16	312	-31
60%	-274	-268	18	71	17	-12	-9	-47	-81	-77	-6	119	-33
70%	-289	-263	2	-8	-25	-14	-6	-53	-77	-215	-1	-10	-70
80%	-256	-273	36	118	-33	40	-28	-10	-38	-168	64	-13	-50
90%	-297	-331	-14	0	-106	-5	-17	-13	-37	-47	-12	-138	-3
Average	-164	-171	17	9	-1	-2	-8	-25	-42	-71	29	46	-32
45 Scenario Change from Baseline													
10%	-36	-70	-5	1	1	0	-5	-10	-5	-23	-72	-73	-90
20%	-48	-115	-19	-15	6	3	-8	-13	-15	-31	-64	-114	-78
30%	-93	-161	-374	-48	-2	1	-16	-20	-17	-82	35	-8	-195
40%	-116	-112	-429	-65	-10	-5	-14	-37	-58	-270	2	-60	-106
50%	-565	-475	-400	-70	-18	-7	-13	-46	-109	-207	-78	324	-104
60%	-592	-959	-433	-29	-2	-10	-15	-60	-146	-172	-15	91	-53
70%	-462	-932	-176	-21	-21	-25	-12	-74	-116	-331	-7	-31	-100
80%	-254	-493	-194	242	204	-15	-47	-66	-78	-388	63	-34	-176
90%	-295	-476	-206	12	32	-67	-66	-92	-96	-299	-19	-165	-108
Average	-271	-411	-231	-3	10	-20	-21	-56	-93	-182	-17	-9	-109

Jersey Point EC (µS/cm)													
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
55 Scenario Change from Baseline													
10%	-47	-102	-7	1	1	0	-6	-11	-8	-48	-188	-125	-120
20%	-99	-208	-66	-36	7	3	-4	-14	-19	-59	-336	-261	-219
30%	-150	-384	-733	-91	-6	-1	-17	-24	-20	-106	-272	-252	-309
40%	-114	-312	-867	-102	-21	-17	-17	-45	-58	-308	-295	-317	-236
50%	-1,035	-808	-773	-150	-20	-17	-18	-53	-138	-315	-324	-253	-233
60%	-933	-1,409	-594	-345	-33	-24	-19	-66	-170	-288	-367	-186	-264
70%	-790	-1,147	-600	-270	-91	-39	-13	-89	-141	-473	-359	-237	-308
80%	-391	-831	-641	-140	-122	-41	-49	-104	-119	-534	-259	-201	-380
90%	-456	-543	-387	-324	-132	-37	-88	-134	-176	-530	-288	-238	-170
Average	-429	-595	-463	-169	-49	-20	-25	-73	-133	-286	-269	-221	-228
65 Scenario Change from Baseline													
10%	-60	-128	-3	1	0	0	-7	-13	-8	-53	-292	-187	-158
20%	-122	-253	-87	-45	2	0	-5	-16	-21	-87	-569	-432	-356
30%	-189	-533	-950	-107	-11	-7	-15	-27	-26	-138	-596	-535	-441
40%	-243	-520	-1,057	-152	-21	-21	-19	-48	-71	-329	-370	-695	-354
50%	-1,330	-1,059	-1,025	-228	-35	-22	-20	-57	-150	-375	-508	-580	-356
60%	-1,329	-1,648	-1,036	-481	-57	-28	-20	-72	-166	-371	-514	-641	-398
70%	-1,148	-1,569	-1,059	-469	-134	-40	-15	-97	-163	-547	-502	-694	-449
80%	-908	-1,276	-1,105	-416	-184	-41	-52	-108	-153	-557	-504	-651	-518
90%	-649	-1,146	-644	-476	-293	-110	-97	-156	-200	-582	-566	-603	-333
Average	-621	-855	-681	-215	-77	-31	-29	-83	-156	-336	-468	-512	-339
75 Scenario Change from Baseline													
10%	-61	-127	-2	0	0	0	-8	-13	-9	-51	-337	-229	-177
20%	-140	-269	-78	-49	2	-3	-8	-22	-24	-84	-653	-479	-395
30%	-195	-598	-993	-110	-7	-7	-20	-33	-29	-142	-701	-584	-493
40%	-273	-642	-1,137	-160	-19	-9	-16	-53	-74	-341	-611	-920	-439
50%	-1,456	-1,185	-1,108	-254	-40	-15	-18	-60	-151	-448	-717	-869	-434
60%	-1,577	-1,771	-1,248	-523	-64	-22	-17	-76	-179	-450	-744	-961	-505
70%	-1,420	-1,731	-1,291	-606	-149	-30	-16	-100	-174	-606	-748	-1,007	-563
80%	-1,262	-1,672	-1,358	-644	-233	-41	-50	-112	-176	-598	-745	-1,033	-628
90%	-1,039	-1,650	-1,126	-666	-365	-118	-95	-160	-212	-688	-713	-984	-505
Average	-780	-1,033	-857	-315	-111	-38	-33	-91	-168	-382	-621	-734	-430

µS/cm = microSiemens per centimeter
EC = electrical conductivity
Shading indicates when fish and wildlife objectives are applicable (April 1–August 15).

A2.4.2.3 Compliance with Western and Interior Delta Agricultural Objectives

The Bay-Delta Plan EC objectives for the agricultural stations in the western and interior Delta (Sacramento River at Emmaton, San Joaquin River at Jersey Point, San Joaquin River at San Andreas Landing, and South Fork Mokelumne River at Terminous) are applicable April 1–August 15 and vary by month, water year type, and location. The actual objective is a 14-day running average EC that begins on April 1 but changes for some year types to a second value on a specified date, which remains applicable through August 15. Because the DSM2 EC results are monthly averages, when the objective changes within a month, the EC objectives must be adjusted to "approximate" monthly average values (see Section A2.2.5, *Evaluating Compliance with Water Quality Objectives*, for a description of the method used for approximating monthly objectives). Because the EC objectives end on August 15, the average DSM2 monthly EC values could be greater than the August 1–15 EC objective but still be in compliance with the EC objective.

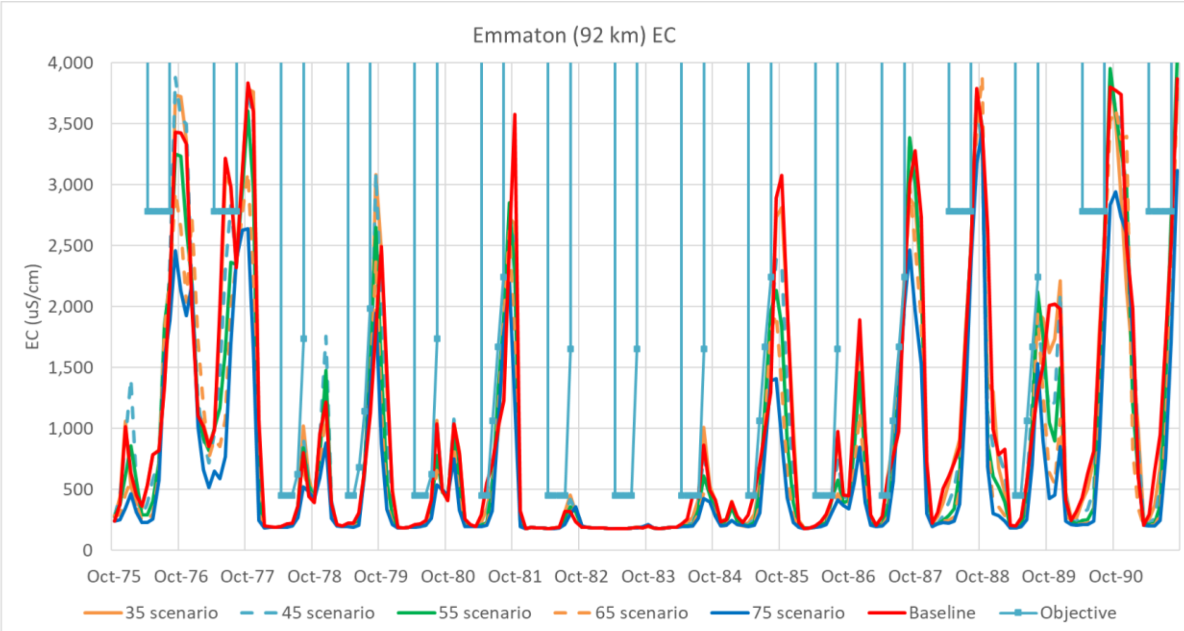
To check compliance with the agricultural EC objectives, monthly EC values were compared with the monthly EC objectives for all months simulated. There are no monthly exceedances of the San Andreas Landing or Terminous objectives under baseline conditions or any of the flow scenarios. Minor exceedances at Emmaton and Jersey Point for the baseline and 35 scenario are discussed with the more detailed text that follows. The flow scenarios would not cause an increase in exceedances of the western and interior Delta agricultural objectives.

Emmaton

Figure A2-21 compares DSM2 Emmaton EC for the baseline and for the flow scenarios for WY 1976–1991. Emmaton is located about 92 km upstream of the Golden Gate Bridge. Outflow is likely controlled by the Emmaton EC objective when the DSM2 EC is close to the objective line, which tends to occur late in the objective period (e.g., July and August).

The Emmaton EC for the 35 and 45 scenarios is close to the baseline EC; and the maximum Emmaton EC values for the 55, 65, and 75 scenarios are reduced moderately. Table A2-7 gives the tabular summary of the DSM2 baseline EC and the EC changes for the flow scenarios at Emmaton for WY 1976–1991. The summary table clearly identifies the seasonal EC patterns and indicates that EC generally will be similar to or reduced relative to baseline for each of the scenarios, although there are increases in average EC of 50–150 μS/cm in August and September for the 35, 45, and 55 scenarios.

The increases in EC do not result in exceedances of water quality objectives beyond what is simulated for baseline conditions. There are six minor exceedances of the objectives for baseline conditions, three for the 35 scenario, and two for the 45 scenario out of 80 months with objectives that are simulated (16 years times 5 months per year of objectives). There are no exceedances for the 55, 65, and 75 scenarios. It is likely that reservoir releases and exports would be controlled to provide sufficient Delta inflow and outflow to meet objectives more precisely than what was modeled by SacWAM.



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometers

Figure A2-21. Time Series of DSM2 EC Values for Emmaton – Baseline and Flow Scenarios for WY 1976–1991 with EC Objectives for Reference

Table A2-7. Cumulative Distribution of DSM2 EC Values for Emmaton – Baseline Compared with Flow Scenarios for WY 1976–1991

	Emmaton EC (µS/cm)												
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
Baseline													
10%	220	211	182	186	181	182	186	200	207	341	558	336	412
20%	389	325	250	188	182	188	200	219	245	412	865	454	633
30%	410	666	606	212	191	189	206	227	302	424	1,005	491	673
40%	447	1,036	798	227	209	195	219	254	452	640	1,126	1,520	761
50%	2,250	1,317	933	320	227	203	249	372	630	965	1,263	2,157	855
60%	3,078	2,013	1,015	398	278	207	289	554	708	1,002	1,298	2,891	1,014
70%	3,355	2,328	1,144	523	303	217	293	611	793	1,178	2,158	3,063	1,102
80%	3,453	2,736	1,892	782	450	323	428	651	818	1,686	2,319	3,433	1,412
90%	3,678	3,467	1,995	1,039	715	436	570	750	895	1,729	2,519	3,798	1,702
Average	1,951	1,626	1,023	520	347	275	332	510	704	1,011	1,462	2,003	980
35 Scenario Change from Baseline													
10%	16	3	0	0	0	0	-1	-4	-2	-3	142	44	-34
20%	18	-67	6	0	1	0	-7	-6	-3	-2	142	34	-11
30%	0	13	-45	-8	-1	-1	-5	-9	-29	-13	37	68	39
40%	-7	11	2	16	-3	-5	-9	-29	-170	-44	191	384	-7
50%	-210	-117	31	-3	6	-6	-32	-94	-72	1	469	574	31
60%	-402	-652	43	2	-11	-5	-58	-208	-137	21	650	-5	12
70%	-534	-471	125	-24	-22	13	-26	-174	-79	222	-23	47	-11
80%	-203	-566	-134	-105	-63	-53	-27	-41	6	29	78	290	-45
90%	-55	-339	113	9	21	-69	-26	13	3	77	-5	-57	-140
Average	-138	-192	4	-36	-3	-11	-17	-60	-51	36	144	129	-16
45 Scenario Change from Baseline													
10%	17	-5	0	-1	0	0	-2	-7	-9	-24	20	43	-58
20%	-33	-86	-1	0	1	-1	-8	-14	-24	-54	-89	28	-99
30%	20	12	-117	-12	-1	0	-10	-19	-65	-22	-19	28	-43
40%	-8	-120	-203	-13	-6	-2	-13	-43	-199	68	223	-8	26
50%	-653	-294	-290	-13	-12	-7	-41	-135	-123	171	567	355	5
60%	-726	-891	-173	11	-32	-7	-77	-295	-192	240	594	173	24
70%	-582	-1,062	187	99	-38	1	-62	-313	-246	177	13	170	-19
80%	-151	-382	-90	163	93	-92	-123	-190	-83	-155	55	264	-204
90%	-88	30	137	282	32	-156	-183	-206	-113	-36	53	-26	-123
Average	-221	-272	-40	47	-5	-35	-52	-153	-158	30	130	101	-52

Emmaton EC (µS/cm)													
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
55 Scenario Change from Baseline													
10%	17	-12	0	-1	0	0	-4	-11	-10	-51	-91	19	-87
20%	-89	-111	-28	-1	1	-3	-7	-18	-37	-55	-256	-3	-207
30%	5	-194	-271	-19	-1	-2	-12	-25	-81	-36	-194	13	-111
40%	-5	-268	-384	-21	-11	-6	-18	-51	-221	10	487	233	-14
50%	-981	-459	-415	-38	-18	-8	-47	-158	-275	180	674	236	-44
60%	-1,239	-1,122	-412	-46	-44	-10	-85	-327	-341	282	825	-40	-38
70%	-716	-1,401	-106	-84	-64	-4	-80	-371	-302	165	22	49	-115
80%	-218	-515	-416	-113	-54	-100	-186	-310	-181	-315	31	-46	-331
90%	-146	-666	-144	-54	-119	-169	-283	-376	-188	58	80	58	-182
Average	-338	-497	-165	-85	-38	-32	-71	-213	-254	-4	135	66	-125
65 Scenario Change from Baseline													
10%	22	-15	0	-2	0	0	-5	-14	-13	-84	-177	30	-122
20%	-88	-123	-46	-3	1	-5	-10	-24	-42	-102	-393	-59	-271
30%	-15	-332	-356	-22	-1	-2	-14	-32	-90	-92	-352	-3	-190
40%	-6	-493	-500	-31	-15	-7	-23	-57	-236	26	290	-243	-95
50%	-1,357	-676	-548	-85	-18	-10	-52	-169	-349	-22	585	4	-145
60%	-1,732	-1,319	-601	-109	-60	-12	-90	-342	-418	82	640	-266	-150
70%	-1,252	-1,462	-377	-196	-80	-14	-89	-393	-413	-45	1	-202	-209
80%	-807	-842	-779	-239	-167	-114	-209	-379	-325	-328	-102	-455	-516
90%	-313	-1,343	-58	-345	-350	-196	-327	-462	-272	-51	-128	-309	-309
Average	-525	-675	-232	-121	-60	-42	-86	-255	-340	-118	17	-129	-214
75 Scenario Change from Baseline													
10%	5	-20	0	-2	0	0	-5	-16	-16	-103	-204	27	-148
20%	-109	-123	-46	-4	1	-5	-12	-28	-44	-148	-440	-57	-317
30%	-31	-375	-385	-23	-2	-3	-18	-36	-97	-137	-474	-1	-275
40%	-22	-606	-552	-34	-13	-6	-24	-62	-241	-25	247	-622	-183
50%	-1,588	-814	-633	-104	-22	-10	-54	-175	-388	-241	199	-478	-232
60%	-2,179	-1,417	-685	-152	-69	-14	-93	-350	-458	-155	406	-699	-297
70%	-1,775	-1,613	-547	-250	-88	-13	-94	-403	-478	-232	-323	-601	-364
80%	-1,326	-1,212	-1,041	-389	-209	-117	-219	-413	-439	-431	-436	-803	-642
90%	-889	-1,683	-464	-299	-241	-211	-345	-501	-325	-314	-332	-823	-486
Average	-785	-836	-393	-135	-84	-60	-107	-283	-390	-256	-168	-414	-326

µS/cm = microSiemens per centimeter
EC = electrical conductivity
Shading indicates when agricultural objectives are applicable (April 1– August 15).

Jersey Point

Jersey Point EC values relative to the Bay-Delta Plan fish and wildlife objectives are discussed in the section above, *Compliance with Suisun Marsh and Delta Fish and Wildlife EC Objectives,* which includes a graphical comparison of DSM2 Jersey Point EC for the baseline and for the flow scenarios for WY 1976–1991 (Figure A2-20, Table A2-6). Jersey Point EC increases when the net flows at Jersey Point are reversed (negative, upstream), which is caused by higher Delta exports compared with San Joaquin River inflow plus Sacramento River diversions to DCC and Georgiana Slough. The monthly Jersey Point objectives shown in Figure A2-20 show the most restrictive of the April–May fish and wildlife objective and the April–August agricultural objectives. In all but critical year types, the April–May fish and wildlife objective is slightly more stringent than the agricultural objective for April and May (440 µS/cm compared with 450 µS/cm). However, because EC increases through the summer as Delta outflow decreases, an exceedance of the agricultural objective is more likely to occur than an exceedance of the fish and wildlife objective.

The agricultural EC objectives for Jersey Point were established in State Water Board Water Right Decision 1485 (1978). The 14-day running average EC must be less than the specified EC objectives during the April 1 to August 15 period; the EC objectives are different for each water year type. The EC objective is 450 µS/cm in wet and above-normal years and 2,200 µS/cm in critical years; the EC objective begins at 450 µS/cm but increases to 740 on June 20 in below-normal years, and begins at 450 µS/cm but increases to 1,350 µS/cm on June 15 in dry years. The monthly average EC objectives are shown in Figure A2-20 (see Section A2.2.5, *Evaluating Compliance with Water Quality Objectives*, for a discussion of estimating objectives that change within a month).

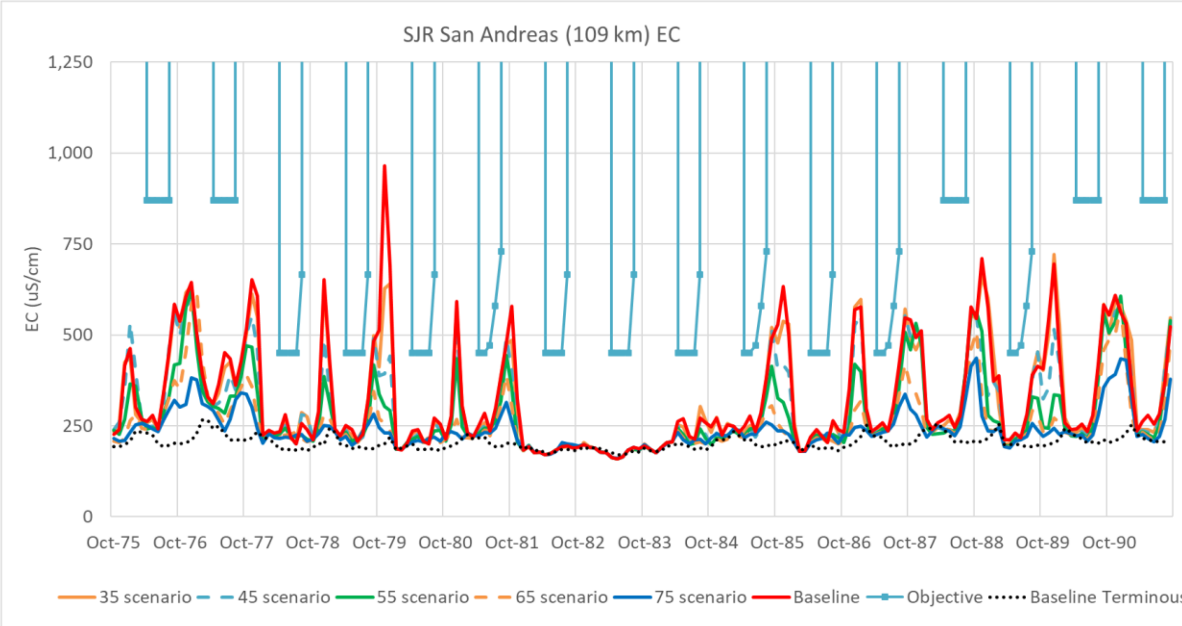
The highest Jersey Point EC values are often in September through November (Table A2-6) when there are no EC objectives at Jersey Point. The DSM2 results show that all scenarios generally would reduce EC at Jersey Point, with the 35 scenario being similar to baseline and reductions for the 75 scenario being the largest. For the 35 and 45 scenarios, a few months have small increases in average EC, but more months have decreases and the decreases are larger; the largest reductions in average values occur in November. For the 55, 65, and 75 scenarios, all months have reductions in EC, with the largest reductions occurring during July–December, partially overlapping the April–August period for agricultural objectives. During the April–August period for agricultural objectives, the largest reductions in monthly average EC are 286 µS/cm for the 55 scenario (in July), 468 µS/cm for the 65 scenario (in August), and 621 µS/cm for the 75 scenario (in August).

There is one minor exceedance of the objectives for baseline conditions (by 31 µS/cm) and none for the flow scenarios out of the 80 months with objectives during the 16-year simulation period.

San Andreas Landing

Figure A2-22 and Table A2-8 compare the DSM2 San Andreas Landing EC for the baseline and the flow scenarios for WY 1976–1991. San Andreas Landing is located on the San Joaquin River at the mouth of the Mokelumne River, about 109 km upstream of the Golden Gate Bridge. The San Andreas Landing EC for the 35 scenario is close to the baseline EC. For the 45 through 75 scenarios, EC is either similar to or less than baseline, with average of the monthly reductions being greatest in November and December (e.g., reaching 144 µS/cm for the 55 scenario in December and 240 µS/cm for the 75 scenario in December). During the April–August period for agricultural objectives, the effect on EC is relatively small; the largest reduction in average monthly EC is 77 µS/cm for the

75 scenario in August. EC at San Andreas Landing is always less than April–August EC objectives (Figure A2-22).



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometers

Figure A2-22. Time Series of DSM2 EC Values for San Andreas Landing – Baseline and Flow Scenarios for WY 1976–1991 with EC Objectives for Reference

Table A2-8. Cumulative Distribution of DSM2 EC Values for San Andreas Landing – Baseline Compared with Flow Scenarios for WY 1976–1991

	San Andreas Landing EC (µS/cm)												
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
Baseline													
10%	203	220	188	190	179	180	191	202	196	197	226	214	225
20%	213	272	225	193	184	203	219	240	208	201	265	239	283
30%	229	284	459	237	217	209	236	240	218	209	271	257	310
40%	248	324	512	253	237	219	241	255	221	226	325	415	315
50%	460	422	565	286	241	226	248	264	228	278	366	453	332
60%	517	541	575	372	249	232	251	278	235	281	380	484	346
70%	533	607	600	441	278	235	257	278	235	284	388	507	359
80%	542	633	644	463	302	240	262	279	242	298	390	547	379
90%	550	682	670	517	375	263	265	283	251	322	417	580	393
Average	390	459	487	337	258	227	240	257	236	263	334	405	324
35 Scenario Change from Baseline													
10%	-3	8	-1	0	0	0	-5	-7	-2	0	5	-2	-6
20%	-1	1	3	0	0	-4	-6	-16	1	2	-4	9	-4
30%	-5	-6	-1	0	-1	-4	-9	-2	-6	-1	25	12	-11
40%	-13	-41	18	2	-6	0	-9	-16	-4	-4	4	0	-8
50%	-53	-37	-2	-5	-5	-5	-11	-19	-8	-17	-8	11	-18
60%	-39	-42	3	46	-1	-1	-11	-30	-11	-8	-3	14	-12
70%	-47	-41	-9	4	-2	-2	-16	-23	-3	-8	1	27	-12
80%	-40	-20	-10	32	-7	3	-10	-20	-4	-11	5	11	-5
90%	-37	-59	-31	17	-29	-11	-10	-17	-5	-10	-6	-11	4
Average	-26	-42	-3	8	0	-3	-9	-15	-7	-6	1	6	-8
45 Scenario Change from Baseline													
10%	-7	-9	-1	0	0	0	-7	-9	-2	0	-9	-5	-16
20%	-9	-43	-5	2	1	-2	-10	-24	0	0	-5	-10	-21
30%	-17	-20	-117	-14	-1	-5	-16	-12	-8	1	1	0	-46
40%	-8	-49	-114	-12	-6	-1	-17	-22	-1	-8	-40	-12	-28
50%	-105	-104	-115	-24	-1	-6	-17	-30	-4	-32	-13	20	-33
60%	-114	-147	-85	-23	-5	-5	-17	-41	-9	-27	-21	11	-16
70%	-82	-177	-95	-44	-6	-7	-20	-32	-7	-27	-15	18	-27
80%	-44	-133	-117	43	44	-11	-22	-29	-3	-29	6	4	-37
90%	-44	-123	-114	4	8	-9	-18	-33	-7	-28	-9	-23	-23
Average	-45	-101	-82	-11	3	-5	-14	-25	-12	-17	-9	-1	-27

San Andreas Landing EC (µS/cm)													
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
55 Scenario Change from Baseline													
10%	-7	-18	-1	0	0	0	-9	-11	-5	1	-15	-11	-21
20%	-9	-54	-13	3	1	-9	-11	-26	-4	5	-39	-23	-50
30%	-22	-49	-189	-28	-4	-5	-18	-17	-2	10	-33	-29	-65
40%	-11	-78	-233	-29	-11	-2	-18	-29	-3	-2	-66	-88	-52
50%	-175	-172	-251	-40	-7	-7	-19	-37	-7	-37	-42	-54	-57
60%	-181	-237	-234	-108	-11	-9	-22	-38	-13	-30	-50	-67	-57
70%	-145	-216	-197	-117	-28	-11	-26	-37	1	-22	-57	-76	-65
80%	-82	-123	-209	-97	-43	-14	-27	-35	0	-34	-37	-40	-80
90%	-62	-148	-130	-92	-41	-14	-24	-38	-7	-43	-42	-32	-35
Average	-70	-130	-144	-57	-16	-8	-17	-30	-14	-22	-39	-41	-49
65 Scenario Change from Baseline													
10%	0	-18	0	1	0	0	-10	-15	-4	0	-26	-17	-26
20%	-4	-68	-17	2	1	-10	-14	-31	-5	13	-57	-39	-72
30%	-18	-64	-241	-32	-6	-7	-21	-23	-7	15	-56	-52	-83
40%	-34	-94	-275	-40	-12	-5	-19	-37	-9	6	-73	-136	-72
50%	-215	-189	-311	-67	-10	-9	-23	-41	-13	-44	-73	-128	-82
60%	-247	-306	-303	-136	-14	-13	-25	-50	-9	-44	-72	-128	-87
70%	-205	-313	-322	-179	-37	-14	-27	-44	-4	-31	-70	-124	-96
80%	-184	-295	-350	-192	-56	-15	-26	-42	-6	-36	-64	-128	-110
90%	-111	-275	-231	-148	-94	-15	-24	-43	-15	-50	-85	-120	-73
Average	-102	-184	-204	-74	-21	-8	-19	-36	-20	-26	-62	-88	-70
75 Scenario Change from Baseline													
10%	4	-16	0	-1	0	-1	-11	-18	-5	11	-19	-14	-26
20%	3	-63	-15	1	1	-11	-18	-33	-3	15	-45	-38	-71
30%	-10	-57	-234	-33	-1	-6	-25	-30	-11	13	-48	-49	-87
40%	-22	-95	-283	-39	-7	-7	-23	-43	-12	-1	-71	-177	-82
50%	-228	-191	-331	-65	-8	-7	-26	-48	-15	-51	-108	-185	-94
60%	-271	-307	-333	-145	-13	-11	-28	-53	-18	-46	-113	-170	-104
70%	-253	-350	-356	-208	-39	-9	-30	-49	-10	-41	-109	-178	-112
80%	-240	-352	-396	-215	-58	-3	-30	-46	-12	-50	-96	-206	-130
90%	-191	-376	-353	-205	-92	-9	-19	-45	-16	-62	-106	-213	-105
Average	-127	-211	-240	-98	-26	-8	-21	-41	-24	-32	-77	-128	-86

µS/cm = microSiemens per centimeter
EC = electrical conductivity
Shading indicates when agricultural objectives are applicable (April 1–August 15).

Terminous

Table A2-9 gives the tabular summary of the DSM2 baseline EC for South Fork Mokelumne River at Terminous for WY 1976–1991; the baseline time series for Terminous EC can be seen in Figure A2-20. The agricultural EC objective at Terminous is only slightly more stringent than the objective for San Andreas Landing. The lowest objective for both locations is 450 µS/cm. Because the baseline EC at Terminous (Figure A2-22) is always less than 270 µS/cm and because the EC at Terminous would not change much for any of the scenarios, there would be no exceedances of the EC objectives.

Table A2-9. Cumulative Distribution of DSM2 Baseline EC Values for South Fork Mokelumne River at Terminous for WY 1976–1991

	South Fork Mokelumne at Terminous Baseline EC (µS/cm)												
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
10%	190	193	185	187	185	187	181	179	182	184	186	181	187
20%	190	194	198	194	189	194	196	186	185	185	188	182	192
30%	192	197	200	206	205	197	199	187	191	187	188	183	197
40%	193	198	204	212	227	200	200	198	192	188	189	188	200
50%	196	201	206	215	233	208	207	207	197	192	192	197	207
60%	197	205	209	218	236	223	216	214	200	192	193	200	208
70%	201	209	213	226	245	225	218	217	200	193	199	202	209
80%	202	210	216	230	252	232	220	220	202	205	202	209	212
90%	205	211	226	235	253	244	235	224	206	208	204	210	220
Average	196	202	206	214	224	214	208	204	196	193	194	195	204

µS/cm = microSiemens per centimeter
EC = electrical conductivity
Shading indicates when agricultural objectives are applicable (April 1–August 15).

A2.4.2.4 Compliance with Municipal Water Supply Objectives

The municipal water quality objectives are given in units of chloride concentration in Table 1 of the Bay-Delta Plan (Table A2-1). Antioch was the original water supply pumping facility in the Delta, and the Contra Costa Canal began operations in 1950 as the first "Delta facility" of Reclamation's CVP. Chloride was the standard measure of salinity because chloride could be accurately determined with a chemical titration procedure. However, EC is now the primary measurement of Delta salinity.

The chloride objective is generally 250 mg/L, with some periods (155–240 days during each calendar year, depending on the water year type) of 150 mg/L chloride at the Antioch intake or at the CCWD Pumping Plant #1, which draws water from the western end of Rock Slough. Rock Slough connects with Old River downstream of Old River at the Bacon Island EC station. In addition, secondary drinking water MCL of 250 mg/L for chloride is applicable to all drinking water intakes. As described in section A2.2.4, *Relationship between EC, Chloride, and Bromide*, the 250-mg/L and 150-mg/L chloride objectives correspond to EC values of approximately 1,000 µS/cm and 700 µS/cm, respectively.

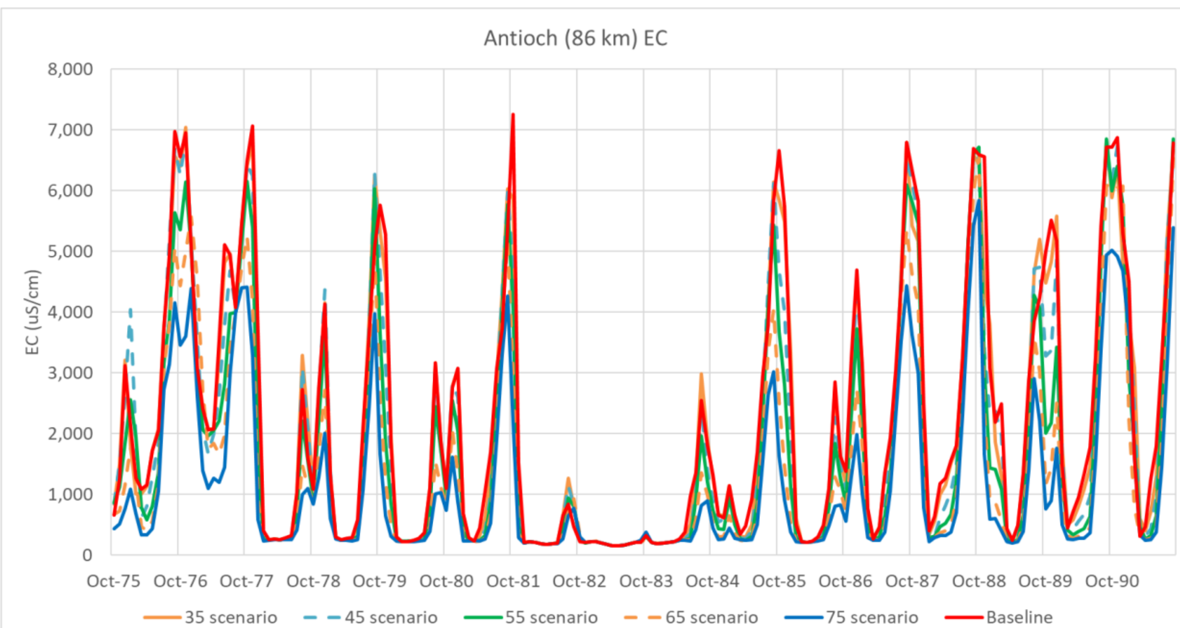
The 1,000-µS/cm surrogate chloride objective is conveniently in agreement with the agricultural EC objective at the CVP and SWP export locations (Table 3 in the Bay-Delta Plan, Table A2-1). Due to this agreement, attainment of CVP and SWP water quality objectives for municipal and agricultural beneficial uses are assessed together in this section.

In general, the flow scenarios would reduce the EC at each of the municipal water intakes or have minimal effect and therefore would reduce the chloride and bromide concentrations at each water intake as well. The reductions in EC associated with the 55 through 75 scenarios typically occur during periods of peak seawater intrusion, although even the baseline EC typically is below the 1,000µS/cm objective. Reductions in EC values that are already below the objective may still have aesthetic benefits (slight taste difference) and health benefits for some individuals (e.g., reduced sodium diets). There also may be some potential benefits for reduced maintenance for plumbing fixtures (reduced scaling).

More information for specific locations is described below, starting with the more westerly sites and moving inland.

Mallard Slough and Antioch

CCWD operates the Mallard Slough pumping plant for municipal water supply whenever the EC at Chipps Island (Figure A2-18 above) is acceptable, and the City of Antioch operates the water supply pumping plant when the EC at Antioch (Figure A2-23) is acceptable. Typically, EC at these locations is either too high for municipal intake or is well below the 1,000-µS/cm objective. However, the flow scenarios could increase the amount of time that chloride would be less than 250 mg/L (1,000 µS/cm) during intermediate flow conditions.



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometers

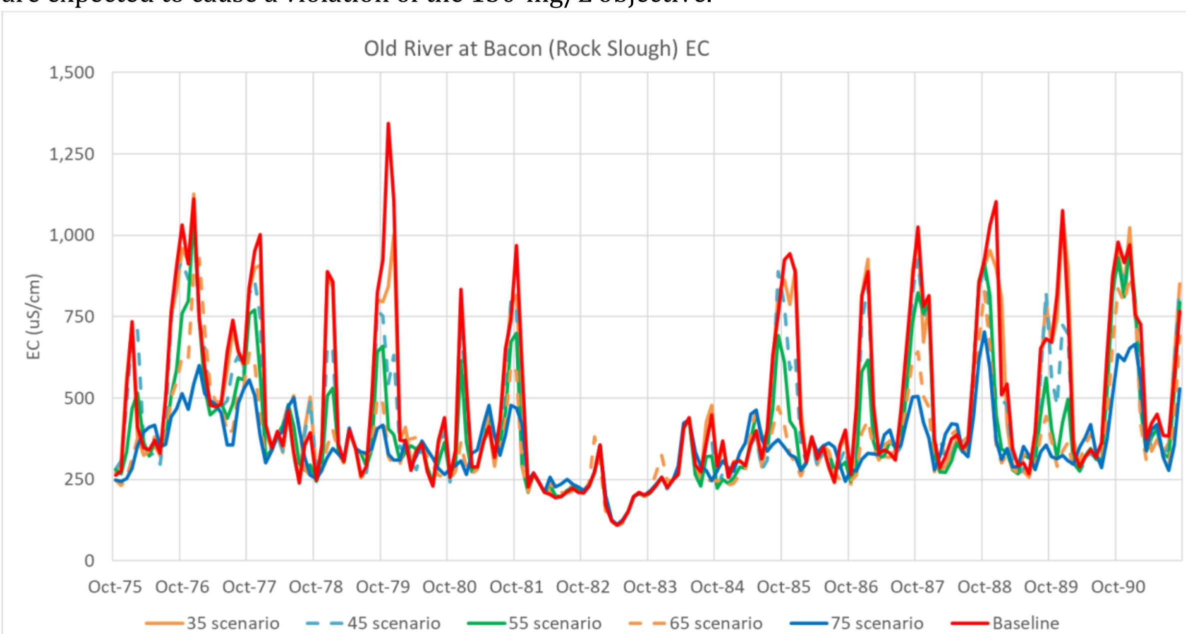
Figure A2-23. Time Series of DSM2 EC Values for Antioch EC – Baseline and Flow Scenarios for WY 1976–1991

CCWD Pumping Plant #1 (Rock Slough)

Figure A2-24 and Table A2-10 compare the DSM2 Old River at Bacon Island EC for the baseline and the flow scenarios for WY 1976–1991. This is the "effective" EC compliance location for the CCWD Contra Costa Canal Rock Slough intake, located about 3 miles west of Old River.

The average monthly EC in Old River at Bacon Island is almost always less than 1,000 µS/cm, but there are some exceptions: 9 for baseline, 5 for the 35 scenario, and 1 each for the 45 and 55 scenarios, but zero for the 65 and 75 scenarios. In general, exceedances of the 250-mg/L objective at the Rock Slough intake are expected to be rare, and the flow scenarios are not expected to cause an increase in exceedances of the objectives. The scenarios are expected typically to result in either minimal change (e.g., in February through July for all scenarios) or reductions in chloride and salinity values—with average reduction in EC of up to 256 µS/cm (in December) under the 55 scenario and up to 414 µS/cm (in December) under the 75 scenario (Table A2-10).

In addition, the scenarios are not expected to cause an increase in violations of the objective of chloride being less than or equal to 150 mg/L for 155 days (about 5 months) for critically dry years to 240 days (about 8 months) for wet years (i.e., for critically dry years, chloride may exceed 150 mg/L for about 7 months out of the year; for wet years, chloride may exceed 150 mg/L for 4 months without violating the 150-mg/L objective). One of the worst water years for salinity intrusion was 1977, which was critically dry (so chloride may exceed 150 mg/L for about 7 months of the year). During this time, the DSM2 baseline results show only 5 months with average EC greater than 700 µS/cm, the EC surrogate for 150 mg/L chloride. For this same period, the 35, 45, 55, 65, and 75 scenarios, have 5 months, 4 months, 4 months, 3 months, and 0 months, respectively, with average EC greater than 700 µS/cm. Based on these results, none of the scenarios or baseline are expected to cause a violation of the 150-mg/L objective.



µS/cm = microSiemens per centimeter; CCWD = Contra Costa Water District; EC = electrical conductivity

Figure A2-24. Time Series of DSM2 EC Values for Old River at Bacon Island (CCWD Rock Slough Intake) – Baseline and Flow Scenarios for WY 1976–1991

Table A2-10. Cumulative Distribution of DSM2 EC Values for Old River at Bacon Island (CCWD Rock Slough Intake) – Baseline Compared with Flow Scenarios for WY 1976–1991

	Old at Bacon EC (µS/cm)												
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
Baseline													
10%	228	254	257	285	243	237	248	248	229	221	288	301	309
20%	257	338	273	356	285	278	314	331	267	239	356	403	390
30%	263	362	675	371	297	288	329	344	280	258	365	444	463
40%	291	471	815	419	308	293	340	349	295	290	505	606	481
50%	756	691	860	467	343	312	347	365	311	365	573	712	496
60%	924	819	888	533	359	329	360	387	317	383	630	757	517
70%	926	914	987	740	389	346	372	407	324	399	640	796	538
80%	969	944	1,077	756	478	375	402	440	331	432	651	854	568
90%	1,003	991	1,105	811	567	388	415	455	366	480	653	870	614
Average	627	661	760	533	375	314	339	359	314	358	510	623	481
35 Scenario Change from Baseline													
10%	-5	15	3	2	0	0	-6	-12	-3	0	2	3	-8
20%	-3	1	0	-8	-13	7	-19	-14	-10	2	0	17	-4
30%	7	-10	0	-8	0	2	-10	-5	-3	-9	51	47	-7
40%	-18	-80	1	-27	-1	0	-8	-3	-10	-12	-11	-9	-15
50%	-24	-120	-16	31	5	-13	-13	-8	-22	-14	-13	81	-22
60%	-107	-75	6	192	14	-24	-24	-14	5	-22	-30	45	-21
70%	-79	-98	-84	0	3	-18	-23	-22	1	-26	-34	30	-25
80%	-63	-102	-74	51	-61	6	-35	-37	3	-51	-34	-17	1
90%	-49	-81	-62	61	-32	9	-10	-10	-13	-26	-21	-13	-14
Average	-32	-77	-24	26	-5	-3	-13	-12	-9	-16	-7	20	-13
45 Scenario Change from Baseline													
10%	-10	-3	-14	-9	1	0	15	-6	4	0	-22	-16	-23
20%	-17	-30	1	-14	-4	-3	-34	-24	13	-2	-6	-32	-26
30%	-2	-38	-192	-21	4	0	-33	-14	2	-5	10	1	-58
40%	-10	-135	-189	-63	27	7	-21	-7	2	-17	-109	-29	-63
50%	-98	-282	-213	-63	-2	-5	-26	-16	-2	-47	-38	73	-46
60%	-154	-276	-164	-39	-16	-16	-23	-20	4	-52	-90	64	-38
70%	-124	-256	-246	-69	32	-8	-14	-17	1	-55	-62	29	-53
80%	-62	-201	-316	-55	0	-14	-37	-15	0	-82	-59	-11	-68
90%	-87	-131	-212	-61	64	-6	-11	-9	-4	-78	-37	-1	-45
Average	-62	-159	-157	-41	12	-4	-16	-13	-8	-42	-38	9	-43

Old at Bacon EC (µS/cm)													
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
55 Scenario Change from Baseline													
10%	-11	-13	-9	-23	1	0	1	15	2	2	-38	-43	-33
20%	-14	-70	0	-79	-12	-7	-6	15	18	4	-68	-100	-35
30%	-11	-75	-314	-59	-16	-11	-7	6	33	26	-54	-101	-103
40%	-12	-179	-412	-91	-9	-9	-15	13	33	10	-163	-50	-101
50%	-249	-387	-422	-118	-25	-19	-10	0	20	-58	-121	-136	-100
60%	-266	-414	-381	-168	-25	-16	5	-20	17	-65	-166	-116	-113
70%	-197	-320	-413	-259	-49	-1	4	14	23	-40	-130	-113	-105
80%	-209	-173	-461	-226	-113	-10	-1	5	51	-72	-133	-122	-121
90%	-134	-186	-229	-127	-75	-7	-4	11	33	-112	-111	-63	-69
Average	-113	-208	-256	-114	-41	-9	-4	7	8	-47	-102	-85	-80
65 Scenario Change from Baseline													
10%	2	-7	-13	-32	1	0	7	21	29	7	-60	-71	-36
20%	-12	-74	20	-86	-18	-1	21	14	48	35	-107	-153	-76
30%	-14	-89	-364	-95	-23	-6	17	16	38	32	-93	-185	-131
40%	-39	-197	-478	-123	-8	5	16	20	28	3	-163	-163	-135
50%	-364	-400	-504	-167	-21	-3	27	21	23	-54	-176	-223	-141
60%	-440	-500	-525	-230	-27	-19	29	15	21	-42	-203	-222	-149
70%	-321	-497	-601	-402	-46	4	26	19	17	-58	-204	-221	-151
80%	-330	-336	-645	-353	-105	0	1	13	43	-74	-171	-236	-146
90%	-268	-351	-433	-194	-169	-8	-2	17	18	-94	-158	-197	-122
Average	-184	-272	-356	-157	-44	1	14	16	16	-46	-142	-174	-111
75 Scenario Change from Baseline													
10%	4	-14	-3	-18	0	12	25	38	47	43	-33	-66	-27
20%	-5	-62	1	-81	10	12	8	20	57	40	-73	-158	-66
30%	15	-76	-379	-92	15	12	27	17	52	30	-58	-180	-133
40%	-10	-163	-505	-134	20	32	48	54	39	27	-170	-251	-132
50%	-421	-371	-545	-163	-13	27	53	53	27	-44	-223	-323	-145
60%	-508	-490	-570	-223	-27	20	47	32	29	-53	-274	-290	-161
70%	-439	-491	-640	-419	-47	24	42	20	28	-56	-259	-307	-170
80%	-455	-479	-700	-410	-126	8	18	15	30	-80	-224	-345	-166
90%	-408	-441	-642	-333	-125	4	21	13	14	-123	-211	-342	-172
Average	-237	-294	-414	-195	-38	15	29	25	22	-44	-162	-235	-127

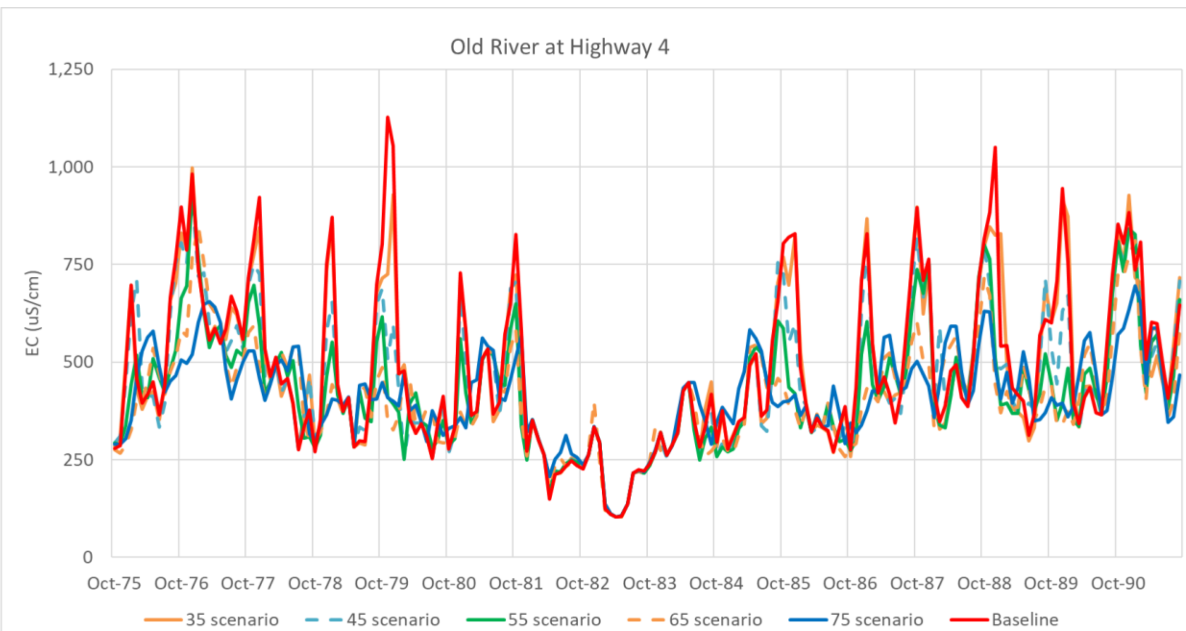
µS/cm = microSiemens per centimeter; CCWD = Contra Costa Water District; EC = electrical conductivity
Shading indicates when municipal objectives are applicable (year-round).

CCWD Old River Intake

CCWD constructed the Old River intake near the Highway 4 Bridge in 1997 as part of the Los Vaqueros Project. Figure A2-25 and Table A2-11 compare the DSM2 Old River at Highway 4 EC for the baseline and the flow scenarios for WY 1976–1991.

Under baseline conditions, monthly average simulated EC at this location exceeds 1,000 µS/cm, the EC surrogate for 250 mg/L chloride, on only 3 months. Under the flow scenarios, monthly average EC never exceeds 1,000 µS/cm. On a daily basis, it is possible that EC could exceed 1,000 µS/cm more frequently. The Old River at Highway 4 EC values for the 35 scenario are close to the baseline EC patterns. Because the peak EC values for the 35 scenario are similar to the peak EC values for baseline and because the peak EC values for the 45 through 75 scenarios are generally less than the peak EC values for baseline, the flow scenarios are not expected to cause an increase in the number of exceedances of the 250-mg/L daily objective.

At this location, there are a few short instances during periods of low EC when EC values for the flow scenarios are slightly greater than the baseline EC. These small increases in EC are associated with a reduction in exports, which reduces the southward flow of the relatively low salinity water from the Sacramento River and increases the influence of the San Joaquin River and local drainages on water quality. Generally, these increases in EC occur when EC is less than 500 µS/cm (Figure A2-25). As indicated in Table A2-11, these small increases are represented by small increases in EC relative to baseline. Overall, the flow scenarios are expected to cause a reduction in average EC in Old River at Highway 4, particularly for the higher flow scenarios during months with higher EC.



µS/cm = microSiemens per centimeter; CCWD = Contra Costa Water District; EC = electrical conductivity

Figure A2-25. Time Series of DSM2 EC Values for Old River at Highway 4 (CCWD Old River Intake) – Baseline Compared with Flow Scenarios for WY 1976–1991

Table A2-11. Cumulative Distribution of DSM2 EC Values for Old River at Highway 4 (CCWD Old River Intake) - Baseline Compared with Flow Scenarios for WY 1976–1991

	Old River at Highway 4 EC (µS/cm)												
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
Baseline													
10%	254	278	298	303	294	291	233	247	257	243	290	306	327
20%	275	334	333	351	348	322	356	332	308	270	333	386	410
30%	278	364	595	448	355	348	408	371	318	279	338	415	464
40%	295	434	728	484	394	357	415	417	343	296	448	558	473
50%	658	644	757	536	419	374	422	441	355	366	510	627	495
60%	802	710	828	581	459	388	443	450	364	377	549	647	520
70%	810	795	902	716	470	409	470	476	369	391	561	677	532
80%	828	815	944	737	542	434	492	520	396	408	572	710	550
90%	874	851	1,016	793	590	510	548	541	454	429	603	732	616
Average	567	597	706	555	433	377	411	411	352	353	462	550	481
35 Scenario Change from Baseline													
10%	-7	12	3	2	1	0	4	1	-2	0	2	4	-6
20%	0	1	1	-1	-19	0	-19	-1	-9	-2	0	10	-3
30%	5	-8	8	-13	-2	-9	-18	-21	-2	-6	37	43	-10
40%	-4	-66	-14	17	4	-3	-3	-20	-7	-8	-8	-9	-8
50%	-1	-97	-18	13	13	-1	-7	-9	-11	-22	-6	54	-24
60%	-88	-58	-7	116	-23	-9	-19	-3	-11	0	-24	45	-15
70%	-64	-85	-68	8	4	-22	-38	4	32	6	-28	25	-10
80%	-31	-69	-28	92	-49	-15	-29	-4	21	13	-27	-7	12
90%	-46	-68	-88	69	3	-12	-49	-16	-1	3	-20	-17	-22
Average	-21	-60	-27	24	-9	-7	-18	-9	0	-4	-6	15	-10
45 Scenario Change from Baseline													
10%	-8	4	-14	-7	-23	0	36	6	16	1	-12	-15	-16
20%	-9	-23	1	2	-46	-1	-12	-1	22	-14	-4	-11	-18
30%	2	-39	-125	-41	-9	-12	-17	-11	15	15	8	4	-56
40%	8	-97	-148	-51	-5	-5	-2	-23	-7	27	-75	-24	-54
50%	-47	-238	-160	-66	-13	-3	-5	-13	30	-21	-35	41	-23
60%	-106	-200	-198	-77	-6	9	-22	-3	30	-9	-68	47	-41
70%	-95	-187	-247	-76	43	-1	-43	6	41	-12	-54	24	-40
80%	-31	-120	-218	-66	49	1	-3	-4	53	-12	-49	-3	-41
90%	-71	-99	-195	-53	93	-34	-38	4	33	-24	-43	2	-29
Average	-41	-120	-137	-48	6	-4	-12	-5	19	-13	-32	7	-32

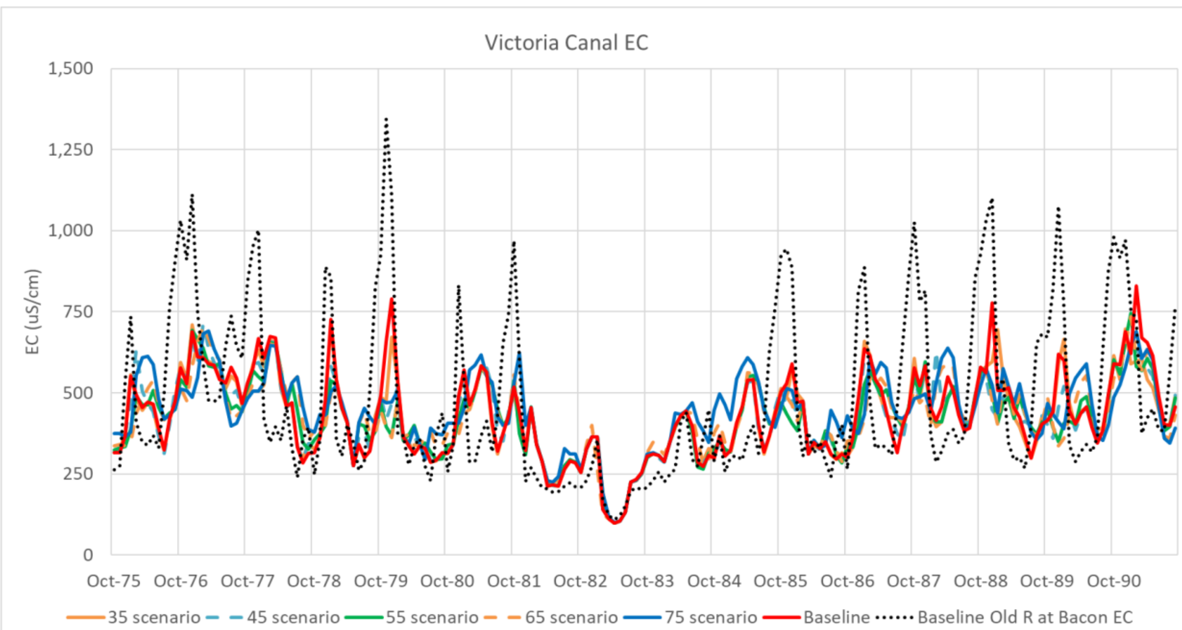
Old River at Highway 4 EC (µS/cm)													
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
55 Scenario Change from Baseline													
10%	-7	-2	-4	-17	-24	-1	36	4	14	2	-17	-33	-24
20%	-1	-46	0	-20	-46	-2	12	0	28	10	-34	-77	-38
30%	6	-63	-231	-86	-22	-15	0	26	88	66	-32	-74	-78
40%	-2	-121	-333	-99	-49	-10	-5	45	83	69	-100	-42	-70
50%	-142	-302	-315	-132	-52	-6	2	45	83	12	-81	-101	-64
60%	-187	-299	-318	-160	-65	-19	-7	59	95	7	-104	-95	-78
70%	-159	-240	-363	-253	-41	-11	17	37	97	20	-100	-81	-63
80%	-164	-120	-352	-186	-93	-21	21	12	109	15	-99	-85	-64
90%	-106	-137	-216	-106	-60	-50	-10	14	64	20	-106	-64	-54
Average	-78	-152	-212	-106	-51	-15	5	23	59	10	-72	-66	-55
65 Scenario Change from Baseline													
10%	7	5	-25	-29	2	-1	27	12	61	26	-40	-57	-21
20%	6	-28	-46	-24	-35	-1	9	0	87	64	-56	-115	-60
30%	15	-51	-262	-118	-17	3	-12	24	100	76	-18	-118	-87
40%	3	-104	-361	-147	-10	9	11	69	94	72	-88	-120	-82
50%	-217	-300	-382	-180	-15	17	59	68	100	21	-117	-172	-87
60%	-317	-355	-448	-211	-41	10	70	84	99	41	-139	-143	-95
70%	-232	-349	-482	-327	-35	-6	53	64	101	36	-139	-153	-90
80%	-244	-248	-458	-304	-86	25	45	26	105	23	-115	-159	-72
90%	-214	-220	-383	-166	-87	-4	14	36	62	6	-137	-158	-80
Average	-125	-185	-292	-148	-33	10	28	37	74	25	-93	-127	-69
75 Scenario Change from Baseline													
10%	13	4	22	10	0	1	53	20	25	86	14	-33	6
20%	23	-14	1	-8	38	40	33	0	29	80	15	-95	-42
30%	59	-27	-247	-96	39	34	13	26	126	92	19	-101	-84
40%	52	-49	-365	-126	33	37	19	60	116	96	-80	-187	-44
50%	-255	-249	-377	-175	19	62	108	93	110	33	-124	-231	-62
60%	-354	-301	-428	-204	-13	66	119	110	109	31	-148	-193	-86
70%	-306	-313	-475	-321	-16	63	94	96	112	34	-146	-213	-84
80%	-315	-286	-484	-332	-69	58	90	58	92	32	-144	-245	-78
90%	-325	-275	-511	-289	-30	29	41	49	75	17	-161	-240	-109
Average	-155	-179	-303	-162	-8	42	57	50	75	39	-85	-161	-66

µS/cm = microSiemens per centimeter
EC = electrical conductivity
Shading indicates when municipal objectives are applicable (year-round).

CCWD Middle River Intake (Victoria Canal)

CCWD constructed the Middle River Intake on Victoria Canal in 2005. This location often has the lowest EC of the CCWD intakes. Figure A2-26 and Table A2-12 compare the DSM2 Victoria Canal EC for the baseline and the flow scenarios for WY 1976–1991. Victoria Canal connects Middle River with Old River and West Canal; the Middle River portion of the reversed OMR flows moves through Victoria Canal. Because most of the Victoria Canal water originates from the Sacramento River diversions to the DCC and Georgiana Slough, the maximum baseline EC in Victoria Canal during summer and fall months of years with low outflow is considerably lower (e.g., some peaks 250 µS/cm less) than baseline EC in Old River at Bacon Island (Figure A2-26). There is much less of an effect from seawater intrusion in Victoria Canal than in Old River at Bacon Island or at Highway 4.

The Victoria Canal EC values for the 35 and 45 scenarios are close to the baseline EC values. Victoria Canal EC for the 55, 65, and 75 scenarios are sometimes less than the baseline EC during periods of peak EC associated with seawater intrusion. During a few short periods of low EC, EC for the 55, 65, and 75 scenarios is slightly higher than baseline EC. Under all scenarios, monthly average EC is well below 1,000 µS/cm, the EC surrogate for 250 mg/L chloride.



µS/cm = microSiemens per centimeter; CCWD = Contra Costa Water District; EC = electrical conductivity

Figure A2-26. Time Series of DSM2 EC Values for Victoria Canal EC (CCWD Middle River Intake) for Baseline and Flow Scenarios for WY 1976–1991

Table A2-12. Cumulative Distribution of DSM2 EC Values for Victoria Canal EC (CCWD Middle River Intake) – Baseline Compared with Flow Scenarios for WY 1976–1991

	Victoria Canal EC (µS/cm)												
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
Baseline													
10%	301	320	315	343	345	301	263	246	271	275	278	296	331
20%	304	341	363	453	363	336	347	327	341	286	290	312	397
30%	315	361	423	463	412	401	419	381	357	300	295	314	406
40%	315	369	483	508	444	454	438	443	375	311	320	405	421
50%	452	441	537	543	468	456	464	451	391	317	367	420	434
60%	504	521	589	571	494	458	516	459	398	320	374	433	453
70%	524	529	643	604	524	512	535	487	407	328	388	454	467
80%	577	562	688	611	609	542	551	541	431	346	400	468	480
90%	578	583	733	628	645	629	584	553	479	392	411	481	540
Average	430	452	533	520	479	448	446	420	376	331	353	394	432
35 Scenario Change from Baseline													
10%	-2	4	-2	1	1	0	5	0	1	-2	13	3	-1
20%	1	-9	1	-14	2	11	-9	-1	-3	1	1	3	-3
30%	0	-10	-1	12	-10	-7	-2	-14	-9	-2	0	21	-9
40%	11	-5	-14	24	16	-43	-10	-15	1	-2	3	23	-9
50%	-1	-21	-9	17	5	-6	-7	-5	0	-6	-9	12	-3
60%	-4	-45	-16	9	-13	0	-32	-5	-3	3	1	8	8
70%	-7	-43	-51	-2	20	-18	-35	-3	14	31	10	3	1
80%	-13	-20	-55	49	-11	-5	-16	-25	15	51	5	10	-4
90%	22	-21	-48	52	-29	-29	-24	-10	-20	29	1	4	-20
Average	3	-21	-24	13	-9	-11	-16	-10	-2	8	2	7	-5
45 Scenario Change from Baseline													
10%	7	4	-4	-2	1	0	18	0	6	-5	4	-5	-2
20%	12	-14	1	-31	-8	19	15	-1	25	5	3	-3	-19
30%	3	-22	-20	-30	8	-11	-3	-9	16	23	3	20	-15
40%	29	-10	-36	-49	12	-4	-10	-16	9	23	7	11	-13
50%	-6	-67	-84	-47	12	8	-13	-9	9	48	-16	15	-7
60%	10	-104	-123	-50	38	35	-31	-2	18	56	-19	17	-8
70%	2	-61	-172	-63	95	-7	-35	-3	26	48	-15	-1	-15
80%	-28	-20	-99	-27	24	-7	-17	-3	24	47	-1	16	11
90%	-8	-29	-107	-26	4	-9	-6	5	3	12	-6	11	-17
Average	1	-35	-73	-35	12	-1	-11	-6	11	19	-7	8	-10

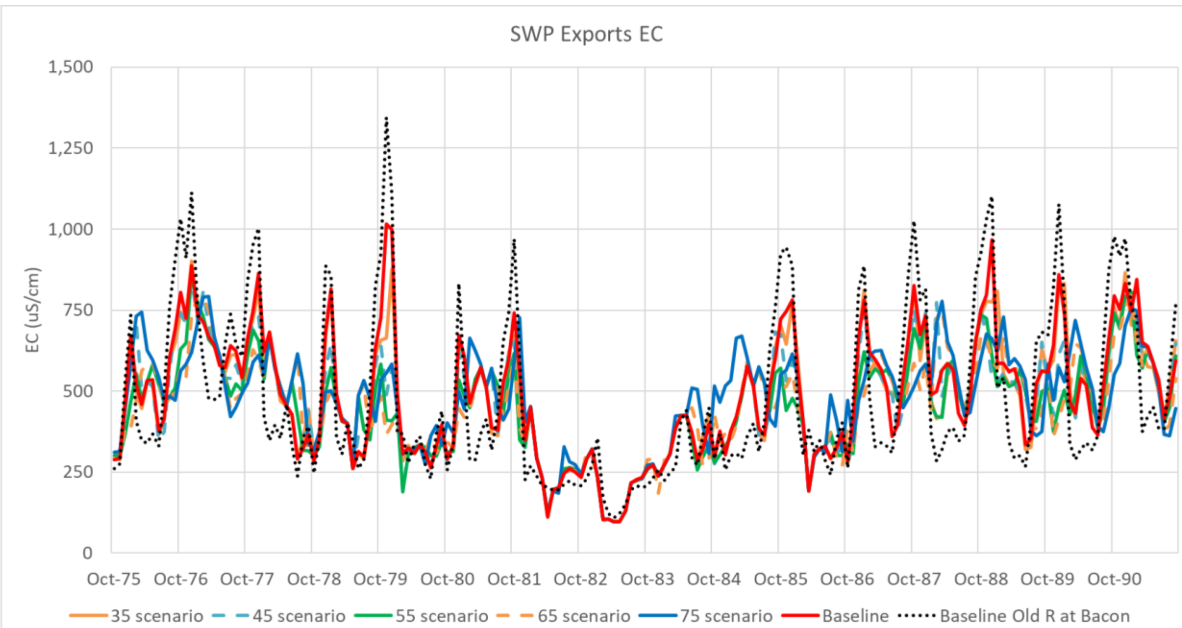
Victoria Canal EC (µS/cm)													
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
55 Scenario Change from Baseline													
10%	12	7	3	-2	1	0	28	1	8	-1	2	-10	-2
20%	25	-9	-29	-70	-9	34	53	0	38	33	6	-16	-28
30%	21	-16	-66	-67	-7	-3	-3	12	37	68	32	6	-16
40%	41	6	-114	-101	-32	-43	-10	17	49	72	34	-24	-2
50%	5	-57	-138	-101	-9	-6	6	37	47	79	7	-13	-12
60%	-34	-125	-183	-95	-25	5	-33	50	57	84	21	-12	-1
70%	-5	-61	-182	-101	-14	-18	-14	28	53	93	9	-8	-9
80%	-36	-44	-137	-75	-40	-14	19	13	69	99	0	-11	-11
90%	-24	-19	-104	-27	-36	-53	-7	11	49	58	10	0	-9
Average	2	-34	-96	-57	-23	-12	0	15	37	47	6	-8	-10
65 Scenario Change from Baseline													
10%	26	25	19	-31	1	0	21	4	26	34	6	-9	11
20%	48	11	-26	-108	0	35	6	0	45	81	31	-22	-21
30%	62	23	-70	-84	-2	17	-1	10	64	68	53	35	-7
40%	68	28	-120	-106	-8	-3	-8	51	61	70	49	-31	5
50%	-2	-31	-152	-128	-9	22	60	57	59	74	6	-10	0
60%	-20	-87	-188	-132	29	41	30	79	58	97	21	-15	-7
70%	-25	-56	-172	-138	4	6	31	65	56	93	17	-17	-10
80%	-61	-73	-201	-115	-62	28	32	19	59	94	14	-25	11
90%	-30	-30	-189	-36	-18	-18	23	35	44	51	14	-29	-8
Average	4	-20	-112	-82	-14	9	19	30	45	59	12	-11	-5
75 Scenario Change from Baseline													
10%	42	30	50	29	0	0	28	5	-3	69	50	34	35
20%	75	48	10	-65	1	7	47	0	-2	79	63	50	3
30%	103	60	-20	-37	73	54	4	12	74	85	71	58	13
40%	130	66	-73	-71	79	66	26	37	79	85	63	-17	36
50%	8	37	-89	-96	69	96	100	89	74	87	31	-28	39
60%	-24	-24	-117	-117	60	124	78	119	71	99	32	-34	23
70%	-42	-22	-150	-125	49	84	76	101	66	98	22	-49	21
80%	-91	-48	-181	-104	-3	65	66	49	48	100	21	-27	21
90%	-60	-32	-217	-88	20	-2	51	46	54	58	17	-32	-15
Average	9	10	-89	-67	29	47	45	44	45	70	29	-6	14

µS/cm = microSiemens per centimeter; CCWD = Contra Costa Water District; EC = electrical conductivity
Shading indicates when municipal objectives are applicable (year-round).

SWP Exports

The agricultural and municipal EC objectives for the SWP exports are both 1,000 µS/cm (250 mg/L chloride) year-round, although the municipal objective is somewhat more restrictive because it is a daily objective instead of a monthly objective (Table A2-1). Figure A2-27 and Table A2-13 compare the DSM2 Clifton Court Forebay (SWP Export) EC for the baseline and the flow scenarios for WY 1976–1991. In 1 month under baseline conditions, monthly average EC exceeds the objective of 1,000 µS/cm, and there are no exceedances under the flow scenarios.

The baseline peak SWP export EC values are slightly lower than the peak Old River at Bacon Island EC values (Figure A2-27), indicating that lower Victoria Canal EC is mixed with the Old River EC in the SWP exports. The SWP export EC values for the 35 scenario are close to the baseline EC values. Under the 45 through 75 scenarios, many of the peak EC values are reduced, suggesting much less seawater intrusion and that the flow scenarios would not increase exceedances of the 1,000-µS/cm objective.



µS/cm = microSiemens per centimeter
EC = electrical conductivity

Figure A2-27. Time Series of DSM2 EC Values for SWP Exports – Baseline and Flow Scenarios for WY 1976–1991 with Baseline Old River at Bacon Island EC for Reference

Table A2-13. Cumulative Distribution of DSM2 EC Values for Clifton Court Forebay – Baseline Compared with Flow Scenarios for WY 1976–1991

	Clifton Court EC (µS/cm)												
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
Baseline													
10%	272	292	312	326	299	212	209	228	256	255	290	309	327
20%	284	333	348	451	308	323	307	323	314	286	322	373	436
30%	290	366	565	492	411	397	411	380	333	292	328	396	447
40%	297	414	671	560	463	433	490	454	360	298	420	541	484
50%	611	599	708	595	480	476	536	512	376	358	484	578	488
60%	724	673	781	621	498	520	568	515	386	365	512	597	533
70%	734	736	846	702	554	562	570	518	387	386	519	618	550
80%	752	748	865	740	619	581	578	535	427	395	527	651	575
90%	800	775	928	763	698	625	612	573	484	415	574	664	624
Average	533	562	664	574	483	448	460	433	366	351	439	514	485
35 Scenario Change from Baseline													
10%	-6	10	2	1	-10	0	1	0	-1	0	4	4	-5
20%	4	0	-9	-1	-2	10	1	0	-1	-12	2	7	-3
30%	1	-14	5	-10	-2	0	0	0	-8	-2	28	39	-10
40%	7	-43	-12	30	-43	-13	-20	0	3	-5	-8	-8	-42
50%	-1	-69	-15	2	-6	-40	-10	-18	-9	-22	-11	41	-6
60%	-66	-77	-11	50	2	-30	-24	0	-16	-3	-19	34	5
70%	-47	-82	-53	15	-26	-42	-10	0	47	25	-20	23	-2
80%	-17	-50	-38	64	2	-7	-3	-11	67	26	-25	-5	-4
90%	-49	-48	-57	47	-9	-24	-30	6	15	47	-16	-12	-19
Average	-18	-51	-25	17	-17	-15	-9	-2	8	4	-6	12	-8
45 Scenario Change from Baseline													
10%	-5	7	6	-7	-57	0	6	2	6	-1	-6	-14	-13
20%	-1	-20	-17	2	-2	-5	17	0	21	-18	-1	-5	-50
30%	2	-41	-70	-21	-5	-1	0	0	20	27	4	7	-33
40%	18	-69	-105	-53	-8	-21	-13	0	3	55	-58	-22	-58
50%	-35	-197	-125	-58	-11	11	-9	-12	19	8	-42	29	1
60%	-81	-184	-168	-59	58	-17	-21	-2	68	10	-63	35	-20
70%	-71	-160	-224	-76	89	-35	-11	-2	99	1	-44	25	-29
80%	-24	-76	-133	-82	74	-8	-2	-8	69	15	-29	-4	-24
90%	-55	-64	-152	-31	45	-37	-13	12	40	14	-38	3	-15
Average	-30	-97	-106	-40	13	-9	-4	0	33	4	-28	6	-22

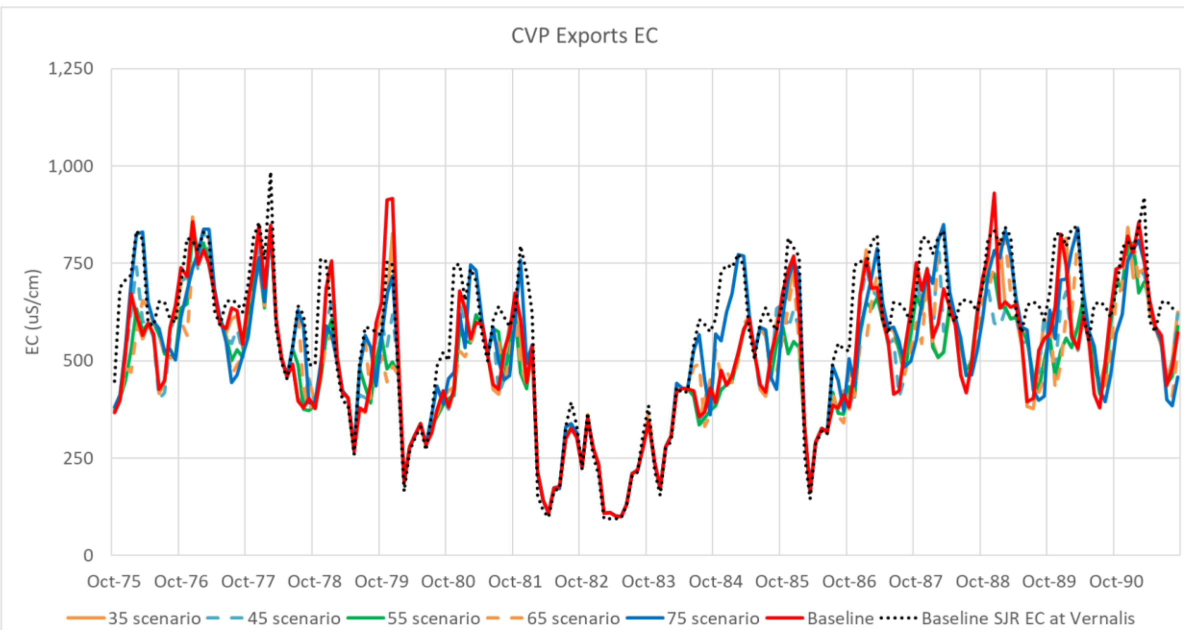
Clifton Court EC (µS/cm)													
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
55 Scenario Change from Baseline													
10%	-3	3	11	-11	-57	0	-2	1	8	4	-10	-30	-19
20%	17	-30	-15	-20	-2	-21	19	0	16	15	-23	-57	-81
30%	17	-56	-176	-43	-12	-2	0	0	75	86	-19	-59	-55
40%	39	-86	-217	-104	-42	-14	24	0	125	88	-69	-42	-38
50%	-71	-235	-220	-120	-41	3	-12	2	123	51	-64	-75	-16
60%	-140	-262	-254	-118	-27	-35	-14	40	126	60	-74	-87	-48
70%	-119	-200	-274	-176	-11	-36	4	49	136	59	-75	-65	-35
80%	-122	-100	-210	-166	-64	-13	4	47	109	76	-71	-72	-29
90%	-85	-84	-166	-68	-55	-53	8	16	70	87	-88	-52	-41
Average	-51	-119	-155	-79	-37	-17	2	15	75	44	-53	-54	-36
65 Scenario Change from Baseline													
10%	19	8	7	-8	0	0	-1	0	-3	50	-29	-47	-12
20%	37	-23	23	-64	0	-7	0	0	12	88	-30	-82	-81
30%	74	-31	-171	-69	-17	-3	0	0	135	87	10	-72	-53
40%	132	-70	-259	-117	-21	68	23	1	130	92	-52	-107	-29
50%	-116	-236	-254	-143	-13	59	35	2	138	53	-93	-135	-26
60%	-171	-286	-315	-143	6	42	17	54	132	79	-106	-103	-35
70%	-162	-228	-277	-207	51	13	32	54	144	87	-89	-113	-35
80%	-165	-203	-270	-198	50	6	56	53	104	100	-79	-126	-26
90%	-160	-129	-263	-80	2	74	25	24	65	99	-105	-127	-41
Average	-62	-133	-190	-98	2	30	18	18	83	68	-64	-96	-35
75 Scenario Change from Baseline													
10%	20	11	51	34	0	0	1	-3	-27	91	32	-18	25
20%	37	12	100	-3	-2	2	11	0	-2	81	40	-60	-38
30%	147	7	-80	-16	20	22	1	0	165	93	56	-61	-24
40%	217	52	-172	-41	148	136	21	0	150	123	-26	-165	14
50%	-90	-85	-163	-65	161	127	56	3	138	79	-75	-179	35
60%	-189	-110	-198	-88	165	106	34	58	135	104	-97	-151	-1
70%	-183	-162	-249	-152	134	93	56	60	147	104	-77	-170	-11
80%	-190	-162	-250	-156	109	137	59	53	115	111	-77	-179	-16
90%	-211	-142	-288	-95	41	137	38	30	75	116	-92	-177	-52
Average	-60	-77	-142	-58	67	79	29	20	87	85	-36	-121	-11

µS/cm = microSiemens per centimeter
EC = electrical conductivity
Shading indicates when agricultural and municipal objectives are applicable (year-round).

CVP Exports

The EC objective for the CVP exports is the same as for SWP exports, 1,000 µS/cm. Figure A2-28 and Table A2-14 compare the DSM2 CVP exports EC for the baseline and the flow scenarios for WY 1976–1991. The EC at the DMC intake is largely San Joaquin River EC, with some Old River at Highway 4 EC and some Victoria Canal EC. The EC of CVP exports often is slightly lower than the EC in the San Joaquin River at Vernalis, indicating that some reversed OMR flow is mixed with the San Joaquin River EC in the CVP exports.

The EC objective of 1,000 µS/cm is satisfied for the baseline and for each of the scenarios. The CVP export EC values for the 35 and 45 scenarios are close to the baseline EC patterns, suggesting few changes in the San Joaquin River flow fraction exported at the DMC intake and only small reductions associated with reductions in seawater intrusion. The changes in CVP export EC for the 55, 65, and 75 scenarios are slightly bigger; most of the EC values are unchanged, but some reductions in EC are associated with reduction in seawater intrusion. Interestingly, reductions in EC for the 55 scenario are slightly greater than reductions for the 65 and 75 scenarios, most likely because CVP exports for the 65 and 75 scenarios sometimes have a greater portion of water originating from the San Joaquin River. Overall, reduced exports under the flow scenarios do not cause any substantial EC increases from reduced dilution of the San Joaquin River EC with Sacramento River water, and the reduced seawater intrusion effects generally have a stronger influence on SWP and CVP export EC values.



µS/cm = microSiemens per centimeter; EC = electrical conductivity; SJR = San Joaquin River

Figure A2-28. Time Series of DSM2 EC Values for CVP Exports – Baseline and Flow Scenarios for WY1976–1991 with Baseline San Joaquin River EC for Reference

Table A2-14. Cumulative Distribution of DSM2 EC Values for the Delta-Mendota Canal Intake – Baseline Compared with Flow Scenarios for WY 1976–1991

	Delta-Mendota Canal EC (µS/cm)												
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
Baseline													
10%	355	377	357	371	202	152	201	221	231	307	347	354	342
20%	377	428	444	489	308	278	311	327	318	357	375	413	450
30%	380	472	595	550	421	419	417	383	387	375	379	427	465
40%	394	481	679	618	522	532	507	460	414	387	442	542	496
50%	610	622	711	635	560	573	595	516	419	400	488	564	532
60%	657	681	770	673	595	599	609	549	426	418	495	573	568
70%	675	724	823	717	633	623	613	552	439	422	522	585	583
80%	713	737	848	748	686	685	637	569	464	426	527	620	603
90%	737	756	887	759	817	718	649	591	528	443	556	629	642
Average	540	586	662	600	521	496	487	445	397	395	455	512	508
35 Scenario Change from Baseline													
10%	0	6	0	1	0	0	0	0	0	0	2	7	-3
20%	-2	1	-4	-1	0	1	0	0	0	-9	3	10	-27
30%	3	-20	7	-7	-2	0	0	0	-7	-3	20	26	-8
40%	-6	-10	-7	12	-12	-8	-5	0	1	-3	-5	-8	-2
50%	-21	-48	-11	21	-22	-32	-1	0	2	4	-8	24	-4
60%	-23	-63	-9	1	-7	-19	-7	-10	0	-4	-1	27	13
70%	-25	-64	-38	12	-14	-21	-3	-2	47	20	-23	24	2
80%	-12	-54	-31	0	1	-76	-15	-7	75	26	-22	-4	-8
90%	-27	-33	-51	39	-56	-16	-15	1	20	65	-14	-9	-16
Average	-11	-37	-19	11	-13	-15	-4	0	12	10	-5	10	-5
45 Scenario Change from Baseline													
10%	2	7	-3	-3	-1	0	0	0	1	2	1	-8	-9
20%	-1	-7	-9	-10	0	0	0	0	-3	-17	-6	-12	-57
30%	1	-45	-43	-6	-4	0	0	0	20	29	2	1	-27
40%	0	-19	-77	-39	-4	-11	-3	0	0	21	-44	-20	-6
50%	-42	-141	-86	-44	-5	4	0	0	37	12	-34	13	1
60%	-26	-147	-132	-51	35	-2	-5	-5	69	-1	-33	29	-17
70%	-35	-117	-176	-66	70	-21	-3	-1	104	8	-50	30	-14
80%	-17	-51	-103	-71	55	-65	-15	-9	86	29	-37	-1	-13
90%	-32	-50	-92	-24	9	-24	-4	7	29	22	-35	-2	-11
Average	-19	-69	-77	-29	13	-9	-3	1	33	5	-25	4	-14

	Delta-Mendota Canal EC (µS/cm)												
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
55 Scenario Change from Baseline													
10%	3	2	-4	-7	-1	0	-1	-1	2	12	-7	-19	-13
20%	8	-21	-4	-24	0	-1	-1	0	-4	-21	-18	-42	-77
30%	14	-54	-122	-20	-6	-1	0	0	58	42	-8	-48	-42
40%	40	-30	-153	-83	-12	-11	1	-1	89	47	-51	-42	11
50%	-46	-160	-156	-89	-37	3	-1	2	118	51	-52	-58	-6
60%	-68	-202	-203	-115	-49	-11	-2	26	124	44	-44	-59	-33
70%	-58	-148	-170	-96	1	-17	-3	29	118	73	-63	-48	-16
80%	-77	-90	-109	-113	-48	-67	13	19	104	91	-62	-53	-20
90%	-55	-56	-109	-42	-78	-36	8	13	54	107	-50	-39	-26
Average	-27	-86	-106	-51	-23	-13	1	9	63	42	-40	-40	-22
65 Scenario Change from Baseline													
10%	13	2	1	-8	0	0	-1	-1	-5	23	-20	-30	-3
20%	20	-20	30	-26	1	-2	-1	0	-4	52	-16	-52	-82
30%	66	-41	-111	-60	-7	0	0	0	95	48	4	-37	-30
40%	118	-35	-190	-80	-19	61	1	-3	110	41	-34	-96	22
50%	-65	-164	-179	-93	-2	25	9	2	122	66	-67	-102	-10
60%	-87	-192	-225	-121	27	56	27	28	129	74	-66	-66	-11
70%	-75	-169	-110	-125	49	67	35	32	125	107	-68	-77	-9
80%	-97	-98	-107	-108	122	36	17	19	112	123	-48	-93	12
90%	-98	-71	-136	4	3	97	24	15	52	116	-70	-100	-21
Average	-29	-90	-107	-55	13	38	12	10	70	63	-46	-68	-16
75 Scenario Change from Baseline													
10%	8	6	28	6	0	0	-1	-1	-3	38	14	-16	22
20%	18	8	93	45	0	0	-2	1	1	43	20	-40	-33
30%	100	9	-10	4	-5	14	1	0	116	50	38	-36	1
40%	159	71	-59	34	195	73	1	-2	119	57	6	-133	60
50%	-50	-34	-45	28	199	169	15	2	123	74	-37	-133	56
60%	-87	-32	-52	23	189	170	40	28	124	82	-38	-115	27
70%	-85	-55	-89	-12	176	156	38	33	130	116	-59	-123	22
80%	-103	-57	-91	-29	140	146	22	20	119	138	-42	-121	8
90%	-124	-40	-126	11	19	122	27	15	58	130	-23	-122	-12
Average	-27	-25	-46	10	81	88	14	10	76	71	-14	-87	13

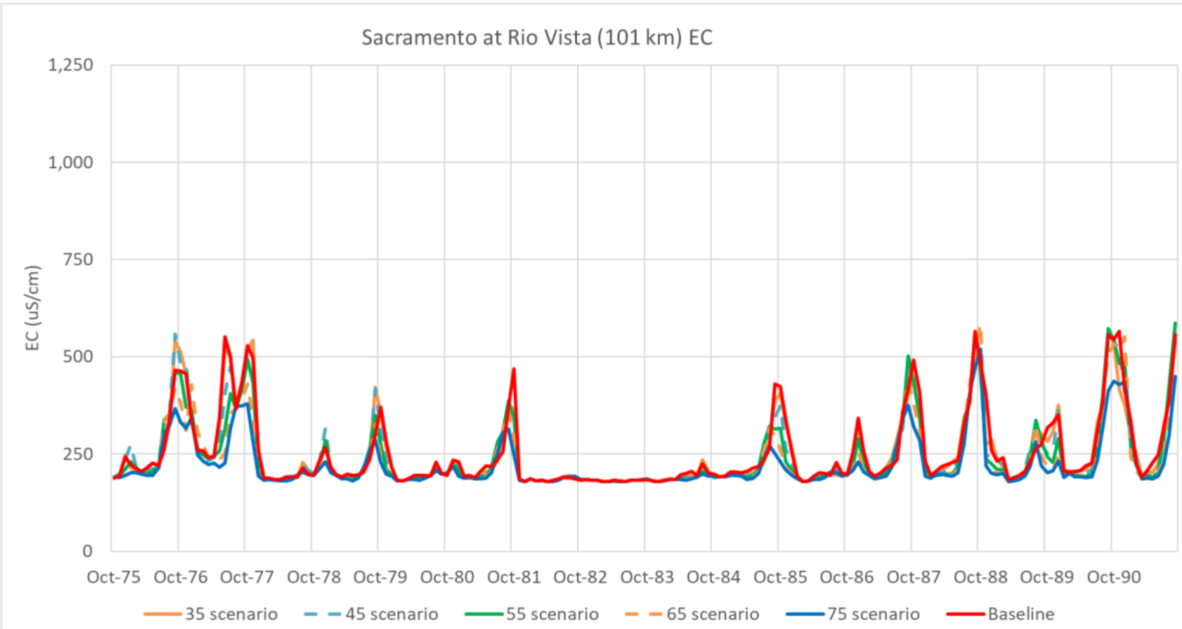
µS/cm = microSiemens per centimeter

EC = electrical conductivity

Shading indicates when agricultural and municipal objectives are applicable (year-round).

North Bay Aqueduct

Table A2-15 provides a summary of the DSM2 EC for the North Bay Aqueduct intake on Barker Slough for the baseline only. EC values at the North Bay Aqueduct are very low compared with the 250-mg/l chloride objective (or the equivalent EC of 1,000 µS/cm) because the Cache Slough EC is dominated by Sacramento River water. The EC in Barker Slough would not change much because the Sacramento River EC is held constant (175 µS/cm) for each of the scenarios, and there is little seawater intrusion upstream of Rio Vista (Figure A2-29), with generally less seawater intrusion under the flow scenarios than under baseline conditions. For similar reasons, the EC at the Vallejo pumping plant on Cache Slough would not be affected by the flow scenarios.



µS/cm = microSiemens per centimeter
EC = electrical conductivity

Figure A2-29. Time Series of DSM2 EC Values for the Sacramento River at Rio Vista – Baseline and Flow Scenarios for WY 1976–1991

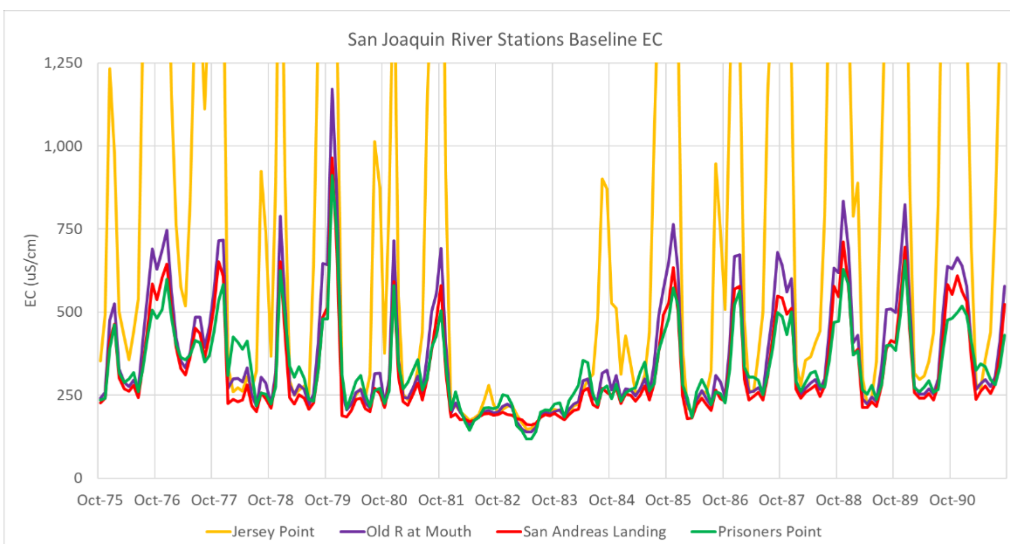
Table A2-15. Cumulative Distribution of DSM2 EC Values for Barker Slough (North Bay Aqueduct Intake) – Baseline for WY 1976–1991

	Barker Slough EC (µS/cm)												
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
10%	284	303	318	310	319	328	329	292	272	269	269	271	303
20%	289	308	322	325	352	336	335	293	276	271	269	274	304
30%	291	311	329	326	354	354	338	296	278	274	269	278	310
40%	292	315	333	331	356	362	340	297	279	275	270	279	314
50%	293	316	335	353	365	363	342	299	283	276	271	282	316
60%	294	320	339	354	367	365	343	301	287	277	273	285	317
70%	297	323	348	362	382	382	347	310	288	277	274	287	325
80%	303	328	354	365	389	388	367	330	320	317	313	336	333
90%	342	340	357	371	397	394	378	366	352	340	336	354	356
Average	302	320	338	343	361	364	348	313	296	290	287	297	322

µS/cm = microSiemens per centimeter
EC = electrical conductivity
Shading indicates when municipal objectives are applicable (year-round).

City of Stockton Intake

The City of Stockton intake was constructed in 2012 at the southwest corner of Empire Tract at the mouth of Disappointment Slough, on the San Joaquin River about 5 miles upstream of Prisoners Point. Figure A2-30 shows the DSM2 baseline EC for several San Joaquin River stations between Jersey Point and Prisoners Point. The Jersey Point EC is much higher than the EC at San Andreas Landing, the mouth of Old River, and Prisoners Point because of reduced seawater intrusion farther inland. Changes in EC at the City of Stockton intake will be similar to the changes in EC at Prisoners Point, which is only approximately 3.5 miles downstream. EC at Prisoners Point is generally expected to be similar or reduced as a result of the flow scenarios. Table A2-16 summarizes the DSM2 EC values for the San Joaquin River at Prisoners Point for the baseline. The Prisoners Point and Stockton intake EC for the baseline and flow scenarios would be much less than 1,000 µS/cm, the EC surrogate for 250 mg/L chloride.



µS/cm = microSiemens per centimeter
EC = electrical conductivity

Figure A2-30. Time Series of DSM2 Baseline EC Values for San Joaquin River Stations for WY 1976–1991

Table A2-16. Cumulative Distribution of DSM2 Baseline EC Values for the San Joaquin River at Prisoners Point near the City of Stockton Intake for WY 1976–1991

	San Joaquin River at Prisoners Point EC (µS/cm)												
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
10%	222	246	218	244	208	176	199	226	210	214	234	231	248
20%	224	264	247	261	242	249	260	293	237	218	260	255	298
30%	231	280	446	286	258	263	283	296	252	221	265	274	328
40%	240	328	518	310	267	273	299	300	254	232	323	369	340
50%	412	390	521	326	271	283	310	313	259	270	342	415	351
60%	473	490	580	370	318	288	317	321	263	281	354	430	360
70%	480	503	582	466	335	296	331	342	267	284	381	450	374
80%	481	533	598	483	383	304	345	349	279	299	384	476	379
90%	484	600	641	489	406	344	356	364	306	321	396	489	387
Average	362	424	480	364	297	274	293	304	261	266	324	372	335

µS/cm = microSiemens per centimeter
EC = electrical conductivity
Shading indicates when municipal objectives are applicable (year-round).

A2.4.2.5 Compliance with Southern Delta Agricultural Objectives

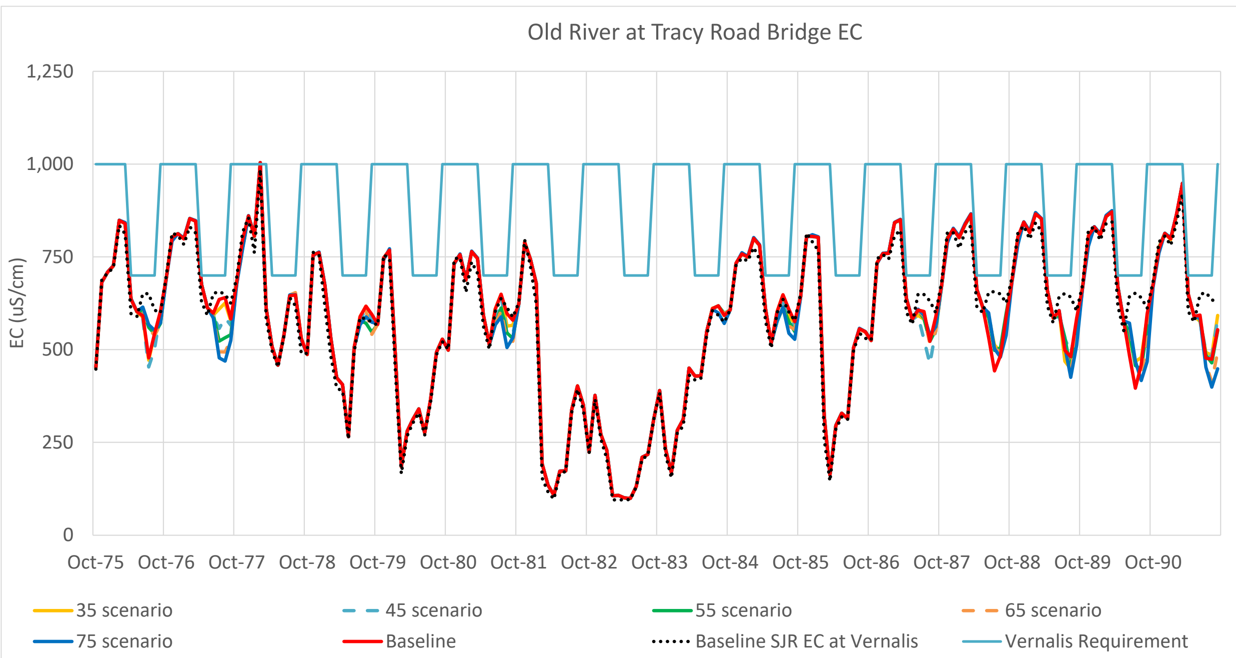
This section focusses on water quality compliance with the agricultural objectives for the southern Delta, the area near the San Joaquin River inflow to the Delta at Vernalis. Southern Delta objectives were modified in the 2018 Bay Delta Plan update to be 1,000 µS/cm year-round. The program of implementation in the 2018 Bay Delta Plan update continues the requirement for Vernalis salinity to be maintained at the older objective of 700 µS/cm for April through August to provide assimilative capacity downstream.

The 2018 update includes provisions to assess compliance with southern Delta salinity objectives at the San Joaquin River at Vernalis and in three river segments (San Joaquin River from Vernalis to Brandt Bridge, Middle River from Old River to Victoria Canal, and Old River/Grant Line Canal from the head of Old River to West Canal). Because protocols to monitor compliance in river segments have not yet been established, compliance is evaluated in this appendix for the point locations specified in earlier versions of the Bay-Delta Plan. These include the San Joaquin River at Brandt Bridge, Old River near Middle River, and Old River at Tracy Boulevard. Most of the water at these locations originates from the San Joaquin River, with water quality being similar to water quality in the San Joaquin River at Vernalis, but with some differences associated with accretions (e.g., agricultural return flows) and occasional influence of Sacramento River water. Although the San Joaquin River at Vernalis is a compliance location for agricultural salinity objectives, it is also a DSM2 model input and does not change between the scenarios; therefore, it is not one of the compliance locations evaluated. The boundary EC at Vernalis was estimated from the EC-flow regression equation (Suits and Wilde 2003).

Changes in EC in Old River at Tracy Boulevard for the flow scenarios relative to baseline EC illustrate the general effects of increased outflow and reduced exports on EC at the southern Delta agricultural compliance locations (Figure A2-31, Table A2-17). Old River at Tracy Boulevard was chosen because it historically has had the highest salinity and shows more differences between flow scenarios. Results for San Joaquin River at Brandt Bridge and Old River near Middle River show EC values similar to the Vernalis EC values for baseline and all scenarios.

The baseline EC in Old River at Tracy Boulevard is very similar to the baseline EC in the San Joaquin River at Vernalis because much of the water in Old River originates from the San Joaquin River at Vernalis when the head of Old River Barrier is not in place. The net flows in Old River at Tracy Boulevard are often small; therefore, small changes in the head of Old River flow, or the net flow past the temporary barrier, or the agricultural diversions and discharges may have moderate effects on the EC at Tracy Boulevard. For example, CVP and SWP exports are reduced substantially in the higher flow scenarios, which slightly reduces the San Joaquin River flow into Old River.

The flow scenarios are not expected to have much effect on the agricultural diversions and discharges in the southern Delta, but they could affect exports, which could influence net flows in Old River at Tracy Boulevard. As shown in Figure A2-31 and Table A2-17, EC results for the flow scenarios are similar to the baseline results or slightly lower. The DSM2 results indicate that the flow scenarios would not cause exceedances of the southern Delta agricultural salinity objectives and occasionally could help to reduce EC at these locations.



µS/cm = microSiemens per centimeter
EC = electrical conductivity

Figure A2-31. Time Series of DSM2 EC Values for Old River at Tracy Boulevard – Baseline and Flow Scenarios for WY 1976–1991 with EC Objectives for Reference

Table A2-17. Cumulative Distribution of DSM2 EC Values for Old River at Tracy Boulevard – Baseline Compared with Flow Scenarios for WY 1976–1991

	Old River at Tracy Boulevard EC (µS/cm)												
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
Baseline													
10%	421	529	490	383	188	148	201	219	224	352	431	440	407
20%	487	733	744	673	312	280	312	329	314	396	474	530	446
30%	512	734	757	683	427	437	417	385	495	460	482	551	529
40%	568	747	759	726	764	612	508	458	533	478	493	575	642
50%	615	763	765	755	819	763	602	515	544	501	533	581	655
60%	644	790	805	798	842	840	636	576	591	589	556	584	668
70%	670	798	813	800	851	848	644	583	596	607	603	589	671
80%	675	803	825	803	858	853	660	590	602	636	617	592	677
90%	684	805	837	807	866	868	666	607	606	646	629	596	687
Average	568	711	718	681	637	611	497	455	482	506	523	544	578
35 Scenario Change from Baseline													
10%	0	0	0	0	0	0	0	0	0	0	-6	0	0
20%	0	0	0	0	0	0	0	0	0	72	5	0	0
30%	0	0	0	0	0	0	0	0	24	10	7	6	0
40%	0	0	0	0	0	0	0	0	5	15	2	-8	-3
50%	0	3	0	0	-1	0	0	0	19	7	0	-10	-3
60%	0	0	0	-2	0	0	0	0	-6	-7	0	-7	-4
70%	0	-3	0	0	0	0	-1	0	-6	-8	-27	-2	5
80%	-1	0	0	0	0	0	0	0	-9	-25	0	0	6
90%	0	0	-2	0	-3	-1	0	0	-3	0	-7	-4	1
Average	0	0	0	0	0	0	0	0	4	5	-4	-2	0
45 Scenario Change from Baseline													
10%	0	0	0	0	0	0	0	0	0	0	-2	0	0
20%	0	0	0	0	0	0	0	0	0	57	-13	1	0
30%	0	0	0	0	0	0	0	0	27	20	1	-5	-1
40%	0	-1	0	0	0	0	0	0	5	26	-2	-22	-10
50%	0	1	0	0	2	0	0	0	14	15	-35	-22	-11
60%	-1	-6	0	0	0	0	0	0	-9	-59	-11	-18	-7
70%	0	-3	0	1	0	0	-1	0	-11	-38	-34	-4	4
80%	0	-2	0	0	0	0	0	0	-13	-25	-32	-6	10
90%	-1	-1	-1	0	-2	-1	0	0	-16	-12	-15	-3	1
Average	0	-1	0	0	0	0	0	0	0	-2	-14	-7	-2

Old River at Tracy Boulevard EC (µS/cm)													
Percentile	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Average
55 Scenario Change from Baseline													
10%	0	0	0	0	0	0	0	0	0	-1	-7	-1	0
20%	0	0	0	1	0	0	0	0	0	61	-27	-2	0
30%	0	0	1	0	0	0	0	0	27	32	-4	-18	-4
40%	0	-1	0	0	0	0	0	0	11	26	11	-35	-14
50%	0	1	1	0	0	0	0	0	14	26	-6	-33	-3
60%	-1	-15	1	1	0	0	0	0	-15	-29	-14	-36	-5
70%	-1	-3	0	1	0	0	0	1	-10	-26	-52	-37	2
80%	-1	-2	0	0	0	0	0	0	-8	-25	-46	-32	6
90%	-1	-2	0	0	-1	-1	0	1	-6	-33	-33	-12	0
Average	0	-2	0	1	0	0	0	0	2	2	-17	-19	-3
65 Scenario Change from Baseline													
10%	0	0	0	0	0	0	0	0	0	-1	-23	-17	0
20%	0	-1	0	1	0	0	0	0	0	64	-35	-19	0
30%	1	-1	2	0	0	0	0	0	27	20	-16	-26	-4
40%	1	-1	1	0	0	0	0	0	17	26	-1	-47	-16
50%	0	-3	2	0	1	0	0	0	20	4	-28	-51	-3
60%	-1	-20	4	1	1	1	1	1	-11	-32	-30	-43	-5
70%	-2	-8	0	2	0	1	0	1	-8	-28	-56	-41	0
80%	-2	-7	2	0	2	1	0	0	-6	-30	-53	-38	-5
90%	-4	-3	1	1	0	2	1	1	-3	-36	-17	-31	-4
Average	-1	-4	1	1	0	1	0	0	5	-3	-25	-30	-5
75 Scenario Change from Baseline													
10%	1	0	0	1	0	0	0	0	0	-1	-30	-40	-2
20%	0	-3	0	2	0	0	0	0	0	57	-57	-63	0
30%	1	-2	2	1	1	0	0	0	27	13	-35	-32	-3
40%	2	-5	2	1	1	0	0	0	16	25	-13	-50	-18
50%	0	-7	3	2	3	2	0	0	25	5	-34	-53	-3
60%	-1	-18	5	2	1	3	2	1	-14	-22	-17	-52	-2
70%	-4	-17	0	3	1	1	0	1	-11	-29	-55	-45	-5
80%	-2	-18	3	3	4	1	1	0	-3	-43	-60	-30	-6
90%	-5	-14	1	2	1	2	1	1	1	-35	-36	-25	-8
Average	-1	-8	1	2	1	1	0	0	6	-5	-33	-38	-6

µS/cm = microSiemens per centimeter
EC = electrical conductivity
Shading indicates when agricultural objectives are applicable (year-round).

A2.5 Summary

The DSM2 model of Delta hydrodynamics and water quality was used to simulate the effect of the flow scenarios on EC and flow in the Delta. The DSM2 results for EC and flow also were used to infer water quality effects for other Delta water quality constituents, including chloride, bromide, and HABs. Salinity-related water quality effects were evaluated for all water quality compliance locations within the Delta, except for X2. X2 position is calculated as part of SacWAM modeling and is evaluated in Section 7.6.2, *Aquatic Biological Resources*, based on SacWAM results.

DSM2 was run using a 15-minute time increment. The inputs to the model were monthly, with the Sacramento River and San Joaquin River inflows disaggregated to daily values in order to smooth the transition in flows between months. The analysis of effects is based on monthly values. The time increment of the surface water quality objectives described in the Bay-Delta Plan vary with the particular objective. For example, Bay-Delta Plan Table 1 objectives for municipal water quality use maximum mean daily values of the chloride concentration, whereas Bay-Delta Plan Table 2 objectives for agricultural water quality use maximum 14-day- or 30-day-running averages of the mean daily EC. If the time increment of an objective is less than monthly, it is possible that the objective could be exceeded even if the monthly results show no exceedances. However, operations typically are managed to meet objectives. In addition, even though the time increment for the water quality objectives does not always match the time increment of the DSM2 model, the model results still indicate whether changes in hydrology would hinder the ability to meet the water quality objectives by indicating whether EC is expected to increase versus decrease and whether any increases occur at a time when baseline EC is close to thresholds.

A2.5.1 Salinity Effects by Region

Elevated salinity within Delta channels is largely associated with seawater intrusion, which is controlled by the balance between tidal exchange and Delta outflow. As a result of increased Delta inflows and reduced Delta exports, the flow scenarios generally would increase Delta outflows relative to baseline conditions in most months, thereby generally reducing salinity.

The detailed results described above in Section A2.4.2, *Changes in Delta Channel Salinity*, are mostly organized by type of water quality objective (fish and wildlife, western and interior Delta agricultural objectives, municipal, and southern Delta agricultural objectives). Water quality objectives generally are expected to be attained under baseline conditions, and none of the scenarios are expected to increase exceedances of objectives.

Salinity and water quality in the Delta under the 35 scenario generally is expected to be similar to baseline conditions. The 45, 55, 65, and 75 scenarios generally are expected to reduce salinity and improve water quality in the Delta relative to baseline, with the magnitude of effect increasing with the flow scenario. The following section describes changes in salinity by region, including highlighting the few circumstances when minor increases in salinity may occur at some locations.

A2.5.1.1 Suisun Marsh

There are four fish and wildlife compliance locations within Suisun Marsh and one at Collinsville near the Montezuma Slough entry to Suisun Marsh. The flow scenarios would result in either little change or a substantial reduction in EC at Chipps Island and Collinsville during the October–May fish and wildlife objective period. EC in Suisun Marsh is dominated by tidal flux from Suisun Bay. As such, the EC effects at Collinsville indicate that the flow scenarios would result in little change or a reduction in EC in Suisun Marsh during the fish and wildlife objective period. A few increases in EC at Collinsville are associated with reductions in Delta inflow, but these increases are outside the October–May fish and wildlife objective period, primarily occurring in August and September under the lower flow scenarios.

A2.5.1.2 Western Delta

The western Delta has water quality compliance locations for agriculture (Sacramento River at Emmaton and San Joaquin River at Jersey Point) and municipal water supply (Sacramento River at Mallard Slough near Chipps Island and San Joaquin River at Antioch).

In the western Delta, the scenarios generally would result in little change or a reduction in EC associated with reductions in seawater intrusion. Some increases in EC may occur during some periods of reduced Delta inflow, particularly in the Sacramento River at Emmaton where simulated average EC increases in August and September under the 35, 45, and 55 scenarios. The increases in EC do not result in exceedances of water quality objectives beyond what is simulated for baseline conditions. In addition, reservoir releases and exports generally are managed to ensure attainment of EC objectives in the western Delta. Consequently, while EC may occasionally increase, it would not result in exceedances.

Water quality in the western Delta is suitable for municipal water supply only for parts of the year when EC is less than about 1,000 μS/cm. The flow scenarios could increase the duration of water quality suitability for drinking water intakes in the western Delta at Mallard Slough and Antioch.

A2.5.1.3 Interior Delta and Exports

As defined for this appendix, the interior Delta and export region includes water quality compliance locations for fish and wildlife (extending from the San Joaquin River at Jersey Point to the San Joaquin River at Prisoners Point), municipal water supply (Rock Slough, Barker Slough, Old River near Highway 4, Victoria Canal, City of Stockton intake on the San Joaquin River upstream of Prisoners Point, CVP exports at Jones Pumping Plant, and SWP exports from Clifton Court Forebay), and agriculture (South Fork Mokelumne River at Terminous and San Joaquin River at San Andreas Landing).

Water in the interior Delta is a mixture of Sacramento River water, San Joaquin River water, Eastside tributary water, ocean water, and local accretions—with the ratios varying by location. For example, at one extreme, water in Barker Slough (where the intake to the North Bay Aqueduct is located) originates primarily from the Sacramento River. The EC in Barker Slough would not change much as a result of the flow scenarios because the Sacramento River EC is held constant (175 μS/cm) for each of the scenarios and because there is minimal seawater intrusion upstream of Rio Vista into the Barker Slough area (Figure A2-29).

In other portions of the interior Delta, water originating from other locations has more of an effect on water quality, but EC often is strongly influenced by the Sacramento River water that flows south through the DCC and Georgiana Slough. Because the San Joaquin River inflow is generally less than the exports, most of the water in the interior Delta channels is Sacramento River water that is tidally mixed with some San Joaquin River water and occasional seawater intrusion.

When the CVP and SWP exports are reduced substantially in some of the scenarios, the amount of water originating from the San Joaquin River may increase at some locations. San Joaquin River water is slightly saltier than Sacramento River water: 175 µS/cm for Sacramento River water compared with typically 250–750 µS/cm for San Joaquin River water (Figure A2-31). As a result, increases in San Joaquin River water associated with the scenarios results in some instances of small increases in EC at some locations. However, even though much of the interior Delta is relatively far from the ocean, the dominant effects associated with the flow scenarios are reductions in EC caused by reductions in seawater intrusion.

At the more northerly locations in the interior Delta such as San Andreas Landing, Rock Slough (Old River at Bacon Island), and Old River at Highway 4, there is little effect from changes in the ratio of San Joaquin River to Sacramento River water, and the scenarios generally result in either little change in EC or reduction in EC. The small effect of increased San Joaquin River water appears at some locations further south, such as Victoria Canal and the CVP and SWP exports. These small increases generally occur during periods of low EC and have minimal effect on water quality. In contrast, reductions in EC associated with reductions in seawater intrusion under the scenarios tend to be greater and occur when baseline EC is higher.

A2.5.1.4 Southern Delta

Effects on southern Delta water quality compliance for agriculture was evaluated by considering EC at four locations: San Joaquin River at Vernalis and at Brandt Bridge, Old River near Middle River, and Old River at Tracy Boulevard. EC at Vernalis is a model input that does not change between baseline and the scenarios.

EC at these southern agricultural compliance stations is controlled primarily by the EC of the San Joaquin River and local drainage, which would not be affected by the flow scenarios. As a result, the flow scenarios would cause little change in EC in the southern Delta and are not expected to cause any exceedances in the southern Delta water quality objectives.

A2.5.2 Chloride and Bromide

Because concentrations of chloride and bromide are correlated with salinity, the effects of the flow scenarios on chloride and bromide are similar to the salinity effects. Chloride and bromide are most relevant to drinking water quality because there are specific objectives for chloride at drinking water intakes listed in Table 1 of the Bay-Delta Plan and because the presence of bromide in water can result in harmful disinfection byproducts during water treatment. The flow scenarios generally are expected to produce either no change or reductions in chloride and bromide at municipal intakes. There could occasionally be small increases in chloride and bromide at some locations, but these would be small and generally would occur when baseline conditions have lower chloride and bromide concentrations; they would not cause exceedances of water quality objectives. Scenario-related reductions in chloride and bromide associated with reductions in seawater intrusion would tend to be greater than any increases and would occur when baseline EC is higher.

A2.5.3 Harmful Algal Blooms

Many factors affect the occurrence of HABs and aquatic vegetation (e.g., nutrients, temperature, light, movement of water). HABs and invasive aquatic plants are affected both by tidal flows and net flows. Tidal back-and-forth flows would not be affected by the flow scenarios, but net flow in some

Delta channels could be affected by the flow scenarios. Net flow is important because it controls residence time and can move harmful algae and floating invasive aquatic plants out of an area.

Victoria Canal was selected as a representative large channel that could be affected by changes in Delta exports and that already has experienced some limited formation of HABs (California Water Quality Monitoring Council 2018). Travel times through Victoria Canal were estimated using DSM2 results for the baseline condition and flow scenarios (Table A2-2).

The DSM2 results indicate that average monthly baseline travel times through Victoria Canal are between 0.6 and 1.3 days during the June–October HAB season. Model results indicate that average travel time stays the same or increases for all scenarios during the bloom period compared with the baseline condition, with the higher flow scenarios having a larger effect on exports and travel time through Victoria Canal. For the 65 scenario, the upper end of the proposed Plan amendments, monthly average travel times increases by 0.3–1.7 days, depending on the month. For the 75 scenario, monthly average travel times increases by 0.4–5.1 days, depending on the month.

A2.6 References

A2.6.1 Common References

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Attachment A2a

Technical Memorandum: DSM2-Hydrodynamic and Water Quality Modeling for the Sacramento/Delta Update to the Bay-Delta Plan

TECHNICAL MEMORANDUM

TO:	Subir Saha, California State Water Resources Control Board	**DATE:**	8/16/2023
FROM:	Yu Zhou, California Department of Water Resources	**SUBJECT:**	DSM2-Hydrodynamic and Water Quality Modeling for the Sacramento/Delta Update to the Bay-Delta Plan

1. Introduction

The State Water Resources Control Board (State Water Board) is in the process of updating the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan). The Sacramento/Delta update to the Bay-Delta Plan involves potential changes to the Bay-Delta Plan to protect fish and wildlife beneficial uses related to Sacramento River mainstem and tributary inflows, Sacramento-San Joaquin Delta (Delta) eastside tributary inflows (Calaveras, Cosumnes, and Mokelumne Rivers), Delta outflows, and interior Delta flows.

The State Water Board has developed the Sacramento Water Allocation Model (SacWAM) to assess the impacts of various regulatory scenarios on flows into and exports from the Delta. SacWAM results for various hydrologic scenarios were used to develop the Delta flow and export boundary conditions used by the Delta Simulation Model II (DSM2) to simulate the hydrodynamic and water quality conditions in the Delta. These simulations were performed with DSM2 version 8.2.1, which uses the Delta Channel Depletion (DCD) model to estimate Delta agricultural diversions, seepage, and drainage.

This memorandum (memo) describes the methods used to run DSM2 with inputs from SacWAM, and it explains the main assumptions made to simulate Delta hydrodynamics and water quality for the SacWAM model runs. The California Department of Water Resources (DWR) assisted the State Water Board with linking SacWAM output to DSM2 input and provided guidance on use of the DCD model.

2. Brief Description of DSM2

DSM2 is a one-dimensional mathematical model for simulating hydrodynamics, water quality, and particle tracking in a network of riverine or estuarine channels (**Figure 1**). DSM2 can calculate water surface elevations, flows, velocities, and mass transport processes for conservative and non-conservative constituents (DWR 2022a).

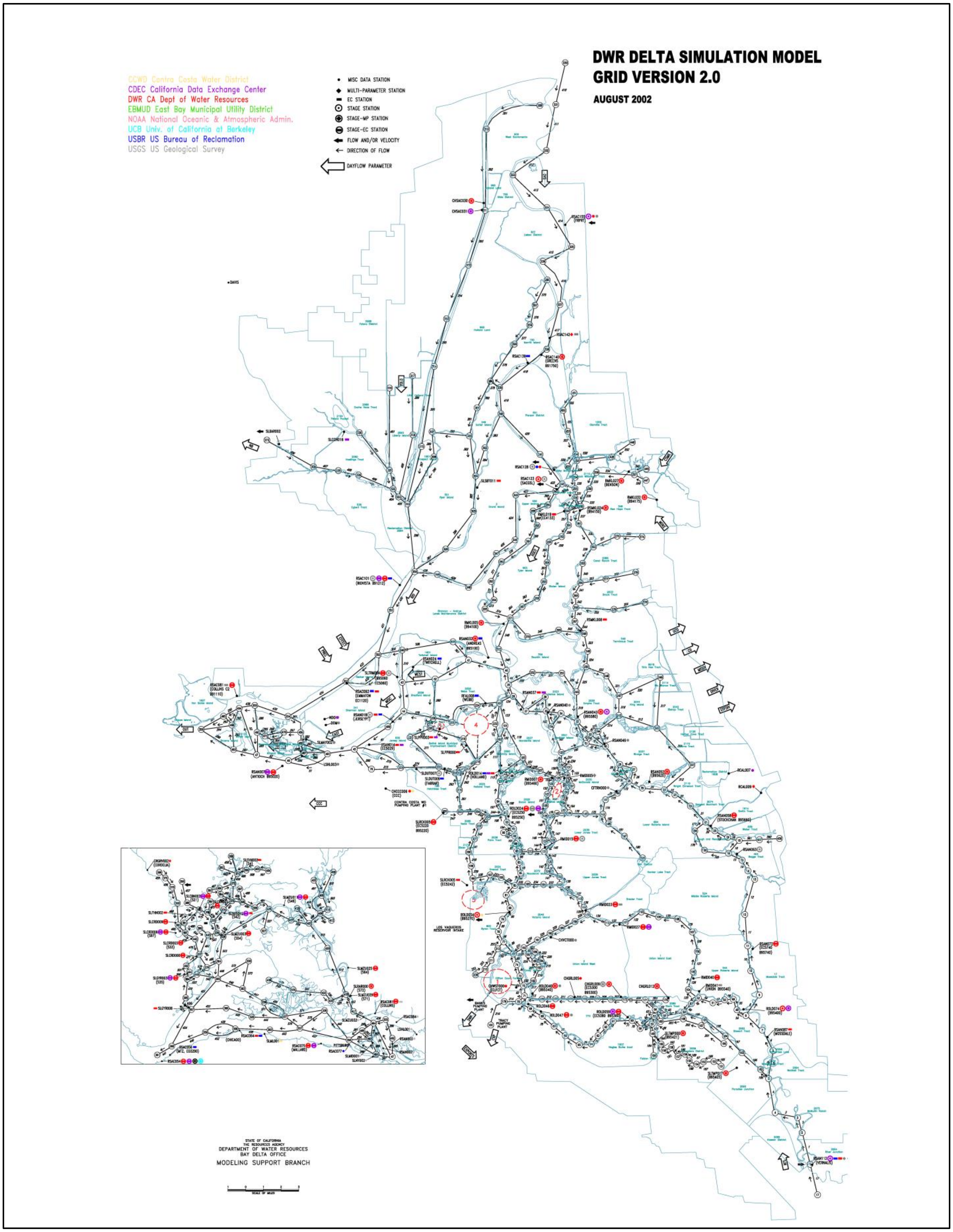

Figure 1. DSM2 Model Grid

DSM2 consists of three modules: HYDRO, QUAL, and PTM. The relationships between the modules are shown in **Figure 2**. HYDRO simulates one-dimensional hydrodynamics, including flows, velocities, depth, and water surface elevations. HYDRO provides the flow inputs for QUAL and PTM. QUAL simulates one-dimensional fate and transport of conservative and non-conservative water quality constituents, given a flow field simulated by HYDRO. QUAL has been calibrated to and is mostly used for simulating electrical conductivity (EC), a measure for salinity. Inputs and outputs for HYDRO and QUAL are summarized in **Figure 3**. PTM simulates pseudo 3-D transport of neutrally buoyant particles based on the flow field simulated by HYDRO. PTM has multiple applications, ranging from visualization of flow patterns to simulation of discrete organisms, such as fish larvae.

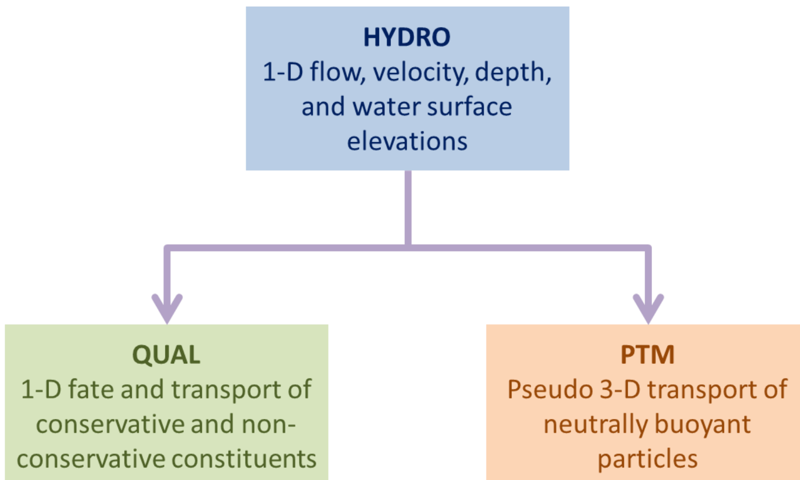

Figure 2. DSM2 Modules

Note: Adapted from Anderson and Mierzwa 2002.

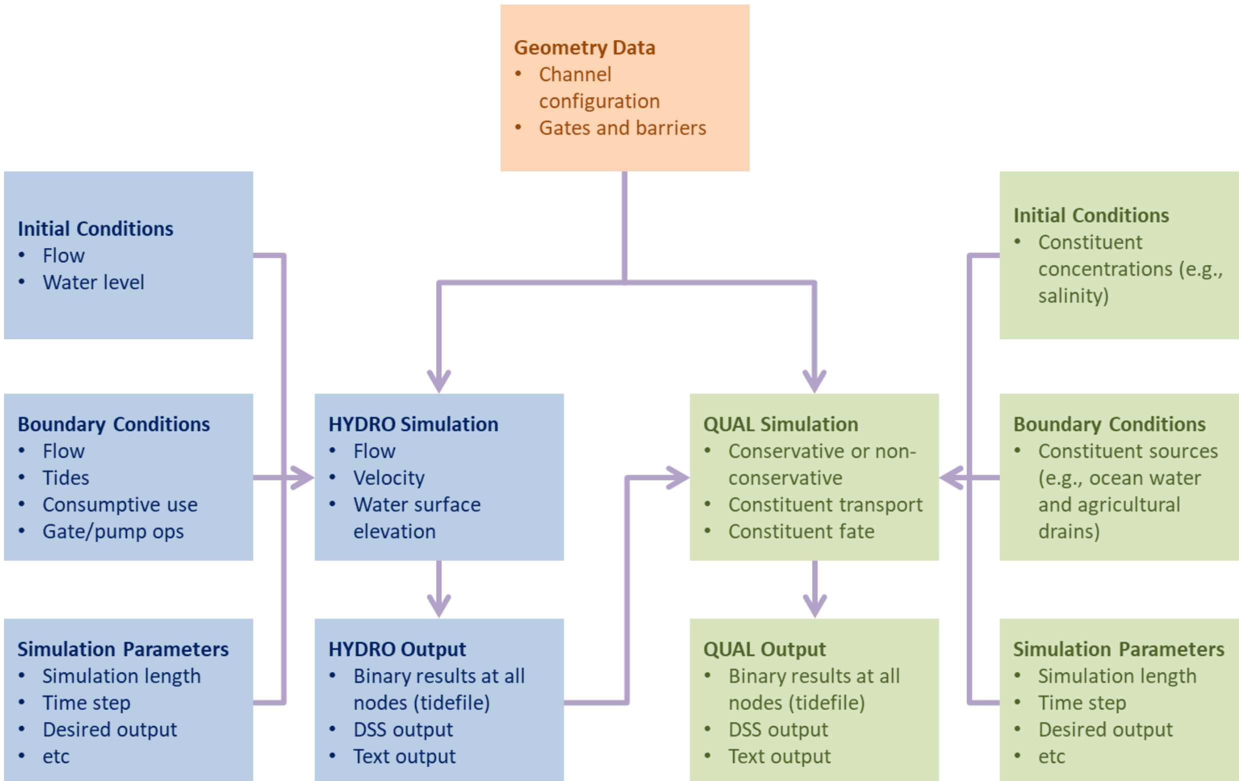

Figure 3. Flow Chart of HYDRO and QUAL Inputs and Outputs

Note: Adapted from Anderson and Mierzwa 2002.

DSM2 is generally used for three kinds of simulations: historical conditions, forecasting future conditions (real-time), and planning studies. For planning studies, like the one described in this memo, DSM2 evaluates how hypothetical changes to factors such as hydrologic regimes, water quality requirements, system operations, and Delta configurations may affect Delta conditions. DSM2 is the best available planning model for Delta tidal hydraulics and salinity modeling with appropriate model runtime and accuracy of results, given the required long simulation period of over 90 years. It is suitable for describing the Delta conditions, as well as for performing simulations for the assessment of incremental environmental impacts caused by any changes to the Delta system. The current release, v8.2.1 (DWR 2022b), was used in this study. More detailed information about DSM2's history, development, model setup, and calibration/validation efforts can be found on the DWR website.

Several past long-term planning analyses used DSM2 to evaluate Delta hydrodynamics and water quality (Reclamation 2008, DWR and Reclamation 2016). In those studies, CalSim II outputs were used as DSM2 inputs. The latest version CalSim, Calsim 3 (DWR 2022c), was jointly developed by DWR and U.S. Bureau of Reclamation (Reclamation). Recent applications of CalSim 3 include the Delta Conveyance Project (DWR 2022d) and The State Water Project Delivery Capability Report 2021 (DWR 2022e).

CalSim II, Calsim 3, and SacWAM produce monthly output. These monthly results are either used directly or converted to daily values for input to DSM2. For evaluation of the Sacramento/Delta update to the Bay-Delta Plan, SacWAM outputs were used as DSM2 inputs. Similar to the CalSim-DSM2 approach, for this effort, DSM2 was run for a 16-year period from WY1976 to WY1991 on a 15-minute time step. Although many of the DSM2 inputs are monthly, the 15-minute time step is necessary to capture tidal conditions. Detailed model assumptions are summarized below.

3. DSM2 Assumptions

The assumptions used in DSM2 for the Sacramento/Delta update to the Bay-Delta Plan are summarized in **Table 1** and are described in sub-sections below.

Table 1. DSM2 Assumptions

General	
Simulation Period	16 years (water years 1976–1991)[a]
Hydrology	
Boundary Flows	Monthly time series from SacWAM output[b]
Delta Island Consumptive Uses (agricultural flows)	Monthly time series from DCD output
Martinez Stage	15-minute adjusted astronomical tide
Operation Criteria	
Delta Cross Channel	Monthly time series of number of days open from SacWAM output
Clifton Court Forebay	Priority 3
South Delta Barriers	Temporary Barriers Program operation was based on the USFWS Delta Smelt BO Action 5
Montezuma Salinity Control Gate	Monthly time series from SacWAM output
Water Quality	
Vernalis EC	Calculated based on a regression analysis
EC of Miscellaneous Delta Inflows	Various constants
Agricultural Return EC	Based on Municipal Water Quality Investigation Program analysis
Martinez EC	Calculated using monthly net Delta outflow from SacWAM output and Martinez EC Generator (G-model)
Urban Wastewater Treatment Discharge EC	Assumed as 779 µS/cm
Sanitary and Agricultural Discharge Project	
Veale Tract Drainage Relocation	The Veale Tract Water Quality Improvement Project, funded by CALFED, relocates the agricultural drainage outlet from Rock Slough channel to the southern end of Veale Tract, on Indian Slough[c]

BO = Biological Opinion; CALFED = CALFED Bay-Delta Program; EC = electrical conductivity; µS/cm = microSiemens per centimeter; USFWS = U.S. Fish and Wildlife Service.

[a] The 16-year simulation period has been used for impact analysis in many previous projects and includes a full range of water year types.

[b] Although monthly SacWAM output was used as the DSM2-HYDRO input, monthly Sacramento and San Joaquin Rivers flows were disaggregated to daily values in order to smooth the transition in flow between months.

[c] Information was obtained from the final draft of "Delta Region Drinking Water Quality Management Plan" dated June 2005, prepared under the CALFED Water Quality Program, and a presentation by David Briggs at State Water Resources Control Board public workshop for periodic review. The presentation, "Compliance location at Contra Costa Canal at Pumping Plant #1—Addressing Local Degradation," noted that the Veale Tract drainage relocation project would be operational in June 2005. The DICU drainage currently simulated at node 204 was moved to node 202 in DSM2.

a. Flows and Tidal Boundary Conditions

The flow boundary conditions—including river inflows, exports, diversions, local runoffs, and discharges from urban wastewater treatments—are based on the monthly flow time series results from SacWAM. The tidal boundary condition at Martinez is provided by an adjusted astronomical tide normalized for sea level rise. It was developed for use in DSM2 planning studies by DWR's Modeling Support Office Delta Modeling Section (Ateljevich and Yu 2007), and it was improved in order to be used with longer CalSim 3 based on a longer record of observed data (Ferreira et al 2018).

The river inflows, exports, diversions, and tidal boundary conditions are shown in **Figure 4**. The local runoffs and discharges from urban wastewater treatments are shown in **Figure 5**.

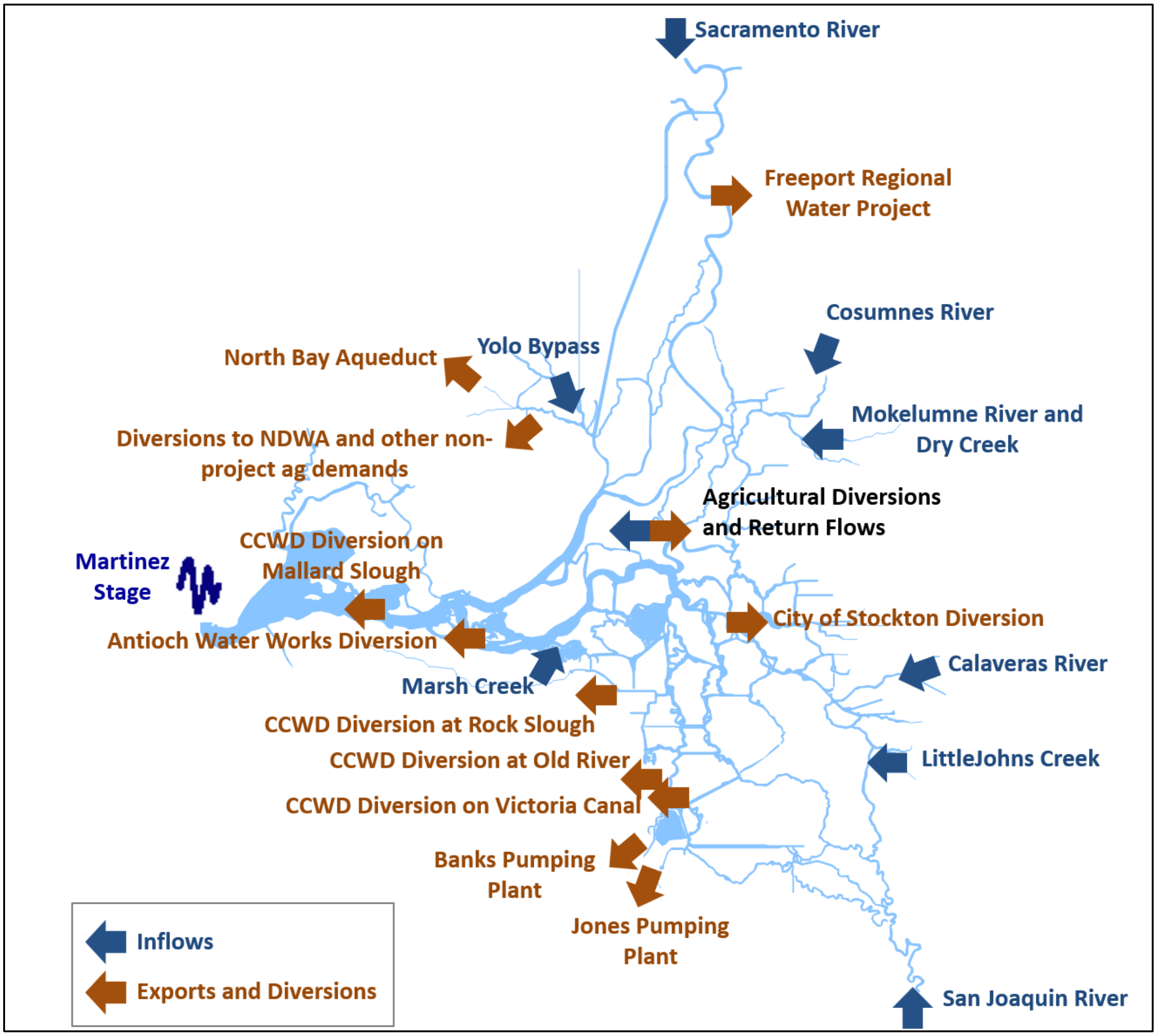

Figure 4. Major Inflows, Exports, and Tidal Boundary Conditions

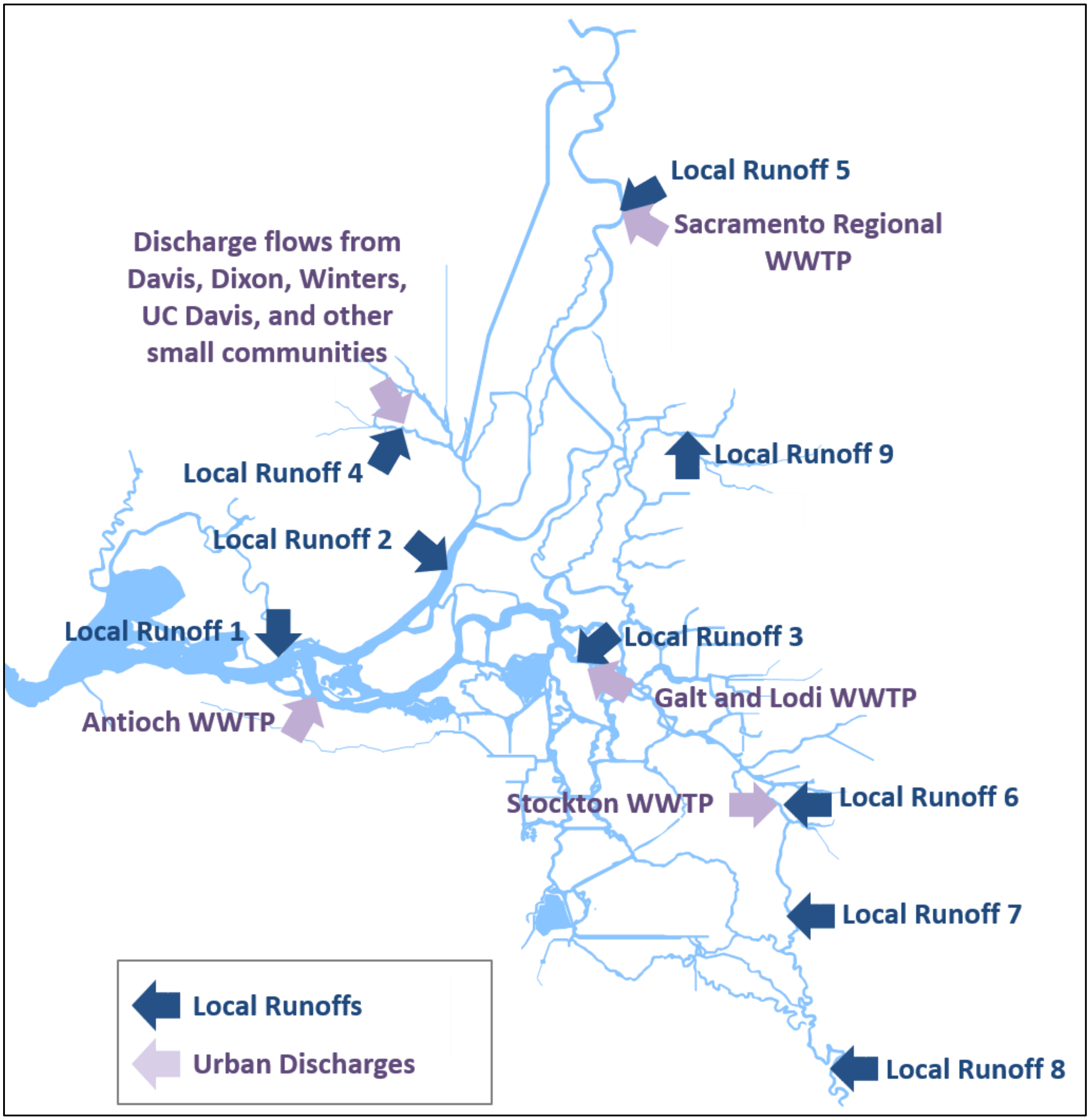

Figure 5. Local Runoff and Urban Discharges Boundary Conditions

Local runoff numbers in Figure 5 and their corresponding SacWAM runoff locations

- Local Runoff 1: Runoff from A_20_25_NA2 to Sacramento River.
- Local Runoff 2: Runoffs from A_20_25_NA2 and A_20_25_PA to Sacramento River.
- Local Runoff 3: Runoffs from A_60N_NA3, A_60N_NA4, A_60N_NA5, A_60S_NA, A_60S_PA, A_61N_NA1, A_61N_NA3, A_61N_PA, and U_60N_NU1_O to San Joaquin River.
- Local Runoff 4: Runoff from U_20_25_PU_O to Cache Slough.
- Local Runoff 5: Runoffs from U_26_NU3, U_26_NU4, U_26_PU4, and U_26_PU5 to Sacramento River.
- Local Runoff 6: Runoff from U_60S_NU1_O to San Joaquin River.
- Local Runoff 7: Runoff from U_61N_NU1_O to San Joaquin River.
- Local Runoff 8: Runoff from U_61N_NU2_O to San Joaquin River.
- Local Runoff 9: Runoffs from A_26_NA, A_60N_NA3, A_60N_NA4, and U_26_NU4_O to Mokelumne River.

b. Monthly Disaggregation

Since SacWAM runs on a monthly time step, values from the model may change rather abruptly between any two consecutive months. Sudden changes in inflows are usually unrealistic and may create undesirable numerical instability in DSM2. Small inflows do not affect DSM2 significantly, but sharp transitions from one month to the next at the two major boundary inflows, the Sacramento and the San Joaquin River flows, may create unwanted signals in the model, so the monthly transitions here are smoothed in a daily time series for input to DSM2.

The method of smoothing follows the rational histospline interpolation (Späth 1995) that preserves area under the curve. This interpolation method is implemented in VTools and used for this study. VTools is a Python package used to perform time-aligned operations on time series, as well as some specialty analyses encountered in hydrology and hydrodynamic work and modeling. **Figure 6** shows an example of the flow data before and after smoothing.

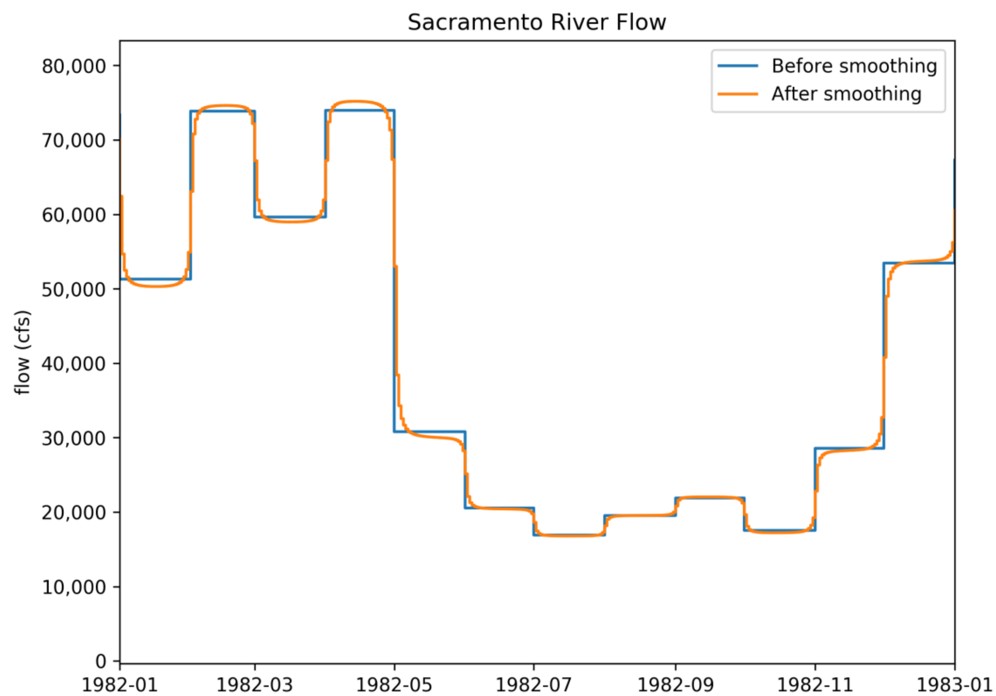

Figure 6. An Example of Flow Data Smoothing

c. Delta Island Consumptive Use

Monthly Delta channel accretions and depletions (i.e., diversions, seepage, and drainage) were estimated using DWR's DCD model (Liang and Suits 2017, 2018; Liang 2021), based on a 2020 level of development.

d. Water Quality Boundary Conditions

Martinez: The Martinez EC boundary condition was estimated using the Martinez EC Generator (a modified G-model) based on the net Delta outflow simulated in SacWAM and the pure astronomical tide (Ateljevich 2001). The generator was re-calibrated to improve performance at higher salinities (Sandhu and Zhou 2015).

Vernalis: The Vernalis EC boundary condition was estimated based on a regression analysis (Suits and Wilde 2003) and the daily San Joaquin River flow after smoothing the monthly time series estimated in SacWAM.

Urban Wastewater Treatment Discharges: The average historical daily EC values for 2007–2011 from the Sacramento Regional Wastewater Treatment Plant (WWTP) of 779 microSiemens per centimeter (µS/cm) was assumed for all WWTP discharges.

Other EC Boundary Conditions: A constant concentration of 175 microSiemens per centimeter (µS/cm) was assumed for the Sacramento River, Yolo Bypass, Marsh Creek, Littlejohns Creek, and local surface runoff and return flows. EC from Delta eastside tributaries was assumed to be 150 µS/cm (Mahadevan 1995).

e. Facilities and Operation Criteria

Delta Cross Chanel: Delta Cross Channel gates were operated based on a monthly time series from SacWAM and were assumed continuously open from the beginning of each month for the number of days specified.

South Delta Temporary Barriers: The South Delta Temporary Barriers consist of three agricultural temporary barriers on Old River, Middle River, and Grant Line Canal, and one fish barrier at the Head of Old River. South Delta Temporary Barriers were operated yearly based on San Joaquin flow conditions and the U.S. Fish and Wildlife Service Delta Smelt Biological Opinion (BO) Action 5 (USFWS 2008). The modeling of the installation and operation of the Head of Old River Barrier was based on a monthly time series from SacWAM.

The agricultural barriers on Old and Middle Rivers were assumed to be installed starting from May 16, and the one on Grant Line Canal starting from June 1. All three agricultural barriers remained installed through November. Flap gates on the culverts in the barriers were operated to block downstream flow from May 16 to 31.

Clifton Court Forebay Gates: Clifton Court Forebay Gates were operated based on the Priority 3 operation protocol to minimize impacts on low water levels in nearby channels by synchronizing with incoming tides. Specifically, the gates were closed during low-low tides to prevent flow out of Clifton Court Forebay, and before high-high tides to allow rising tides to better propagate upstream (Wilde 2006).

Montezuma Salinity Control Gate: The radial gates in the Montezuma Slough Salinity Control Gate Structure were assumed to tidally operate in specified winter and summer months to minimize propagation of high salinity conditions into Suisun Marsh. Gate operations were modeled in SacWAM and passed to DSM2

4. SacWAM-DSM2 Mapping

In order to link SacWAM to DSM2, SacWAM outputs were "mapped" to DSM2 inputs. In general, there are two types of input variables to DSM2: sources and sinks. Sources represent water entering the model domain, such as river channel flows and surface return flows. Sinks represent water leaving the model domain, such as Delta exports and island consumptive use. The schematics of SacWAM and DSM2 include different levels of details. To reconcile these differences, geo-referenced schematics for the two models were overlaid and the location of each SacWAM arc was mapped to the most appropriate DSM2 node.

In other planning studies, DSM2 uses outputs from CalSim II and Calsim 3 as inputs. For the Bay-Delta Plan amendments, the CalSim II-DSM2 variable mapping served as the starting point to develop the SacWAM-DSM2 variable mapping, summarized in **Table 2**.

Table 2. SacWAM-DSM2 Mapping

SacWAM Variables	DSM2 Nodes
Sources	
Calaveras River 27 \ SWRCB Calaveras River	21
Cosumnes River 23 \ SWRCB Cosumnes River	446
San Joaquin River 1 \ Inflow at Vernalis Inflow	17
Yolo Bypass 22 \ Reach	316
Sacramento River 206 \ Reach	330
Mokelumne River 39 \ SWRCB Mokelumne River	447
Dry Creek Mok 10 \ Reach[a]	447
Marsh Creek 6 \ Reach	45
Littlejohns Creek 7 \ SR Littlejohns Creek	13
Runoff/Infiltration from A_20_25_NA2 to Sacramento River 2	464
Runoff/Infiltration from A_20_25_NA2 to Sacramento River	351
Runoff/Infiltration from A_20_25_PA to Sacramento River	
Runoff/Infiltration from A_60N_NA3 to San Joaquin River	37
Runoff/Infiltration from A_60N_NA4 to San Joaquin River	
Runoff/Infiltration from A_60N_NA5 to San Joaquin River	
Runoff/Infiltration from A_60S_NA to San Joaquin River	35
Runoff/Infiltration from A_60S_PA to San Joaquin River	
Runoff/Infiltration from A_61N_NA1 to San Joaquin River	34
Runoff/Infiltration from A_61N_NA3 to San Joaquin River	
Runoff/Infiltration from A_61N_PA to San Joaquin River	
Runoff/Infiltration from U_20_25_PU_O to Cache Slough RM 005	325
Runoff/Infiltration from U_26_NU3_O to Sacramento River	333
Runoff/Infiltration from U_26_NU4_O to Sacramento River	
Runoff/Infiltration from U_26_PU4_O to Sacramento River	
Runoff/Infiltration from U_26_PU5_O to Sacramento River	

SacWAM Variables	DSM2 Nodes
Runoff/Infiltration from U_60N_NU1_O to San Joaquin River	37
Runoff/Infiltration from U_60S_NU1_O to San Joaquin River	14
Runoff/Infiltration from U_61N_NU1_O to San Joaquin River	9
Runoff/Infiltration from U_61N_NU2_O to San Joaquin River	2
Runoff/Infiltration from A_26_NA to Mokelumne River	257
Runoff/Infiltration from A_60N_NA3 to Mokelumne River	
Runoff/Infiltration from A_60N_NA4 to Mokelumne River	
Runoff/Infiltration from U_26_NU4_O to Mokelumne River	
Return Flow from Sacramento Regional WWTP to Sacramento River[a]	333
Return Flow from U_20_25_PU to Cache Slough RM 005	325
Return Flow from U_60N_NU1 to San Joaquin River	37
Return Flow from U_60S_NU1 to San Joaquin River	14
Return Flow from U_ANTOC_NU to San Joaquin River	47
Delta Accretion 1-7 0 \ Headflow	Delta Island Drainage[b]
Sinks	
Freeport Pumping Plant 0 \ Headflow	332
Old River Pipeline 0 \ Headflow[c]	Old River: 80 Victoria Canal: 191
Rock Slough Intake 0 \ Headflow	206
Delta Mendota Canal 0 \ Headflow	181
California Aqueduct 0 \ Headflow	Clifton Court
Transmission Link from San Joaquin River RM 028 to U_60S_NU1	33
Transmission Link from Sacramento River RM 0 to U_CCWD_NU	357
Transmission Link from San Joaquin River RM 006 to U_ANTOC_NU	46
Transmission Link from U_ANTOC_NU Withdrawal to U_ANTOC_NU	460
Transmission Link from Cache Slough RM 005 to A_20_25_NA2	325
Delta Depletion 1-7 0 \ Headflow	Delta Island Diversion and Seepage[b]

Notes:

[a] While the Sacramento Regional WWTP discharge is not a separate output from CalSim, it is included in the CalSim Sacramento River flow into the Delta.

[b] Delta islands diversion, seepage, and drainage flows were calculated from DCD, planning version in DSM2 v8.2.1.

[c] Contra Costa Water District's Old River and Victoria Canal pumping plants were combined in SacWAM. The same proportional split between the diversions assumed in CalSim was applied to separate the Old River and Victoria Canal pumping for DSM2.

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