Appendix C Delta Water Quality Model Documentation

C.1 Executive Summary

Hydrodynamic and water quality modeling of the Sacramento-San Joaquin River Delta (Delta) was performed to support the Central Valley Project (CVP) Municipal and Industrial Water Shortage Policy (M&I WSP) Environmental Impact Statement (EIS). The Delta Simulation Model-2 (DSM2) was used to investigate changes to water quality resulting from two action alternatives in comparison with the No Action Alternative. Salinity, modeled as Electrical Conductivity (EC) and bromide changes were investigated for the two action alternatives in comparison with the No Action Alternative: Alternative 2, Equal Agricultural and M&I Allocation, provides M&I and agricultural water service contractors with equal allocations during water shortage conditions; Alternative 3, Full M&I Allocation Preference, provides M&I contractors with 100 percent of their Contract Total until CVP supplies are not available to meet those demands, while agricultural water service contractor deliveries are reduced as needed[1]. Additional model output parameter comparisons were made: changes to the location of the 2 parts per thousand (ppt) salinity isohaline, X2; changes to the magnitude of Old and Middle River (OMR) flow; and, changes in the south Delta water elevations that might affect agricultural operations. With the exception of OMR flow, these parameters are regulated under the State Water Resources Control Board (SWRCB) Bay/Delta Plan (SWRCB 1995) and D-1641 (SWRCB 2000).

Analysis of model output for the two action alternatives in comparison to the No Action Alternative was undertaken for EC and bromide at export locations and for EC at D-1641 locations. The main comparison for EC consisted of percentage change from the No Action Alternative on an Average Monthly basis by water year (WY) type. The results indicate that in comparison with the No Action Alternative, Alternative 2 generally results in greater percent increases in EC on average than Alternative 3 at the State Water Project (SWP) and CVP export locations. Decreases in modeled EC were scattered over WY types and months for both action alternatives, but were generally smaller in magnitude than EC percentage increases for both the SWP and the CVP locations.

[1] Alternatives 4 and 5 were not modeled in DSM2. Alternatives 2 and 3 “bookend” the changes expected under all the alternative actions, so results for all action alternatives fall within the ranges documented here.

The largest percent increases in EC, 2.3 percent to 4.8 percent, at the SWP in Alternative 2 occurred April to June in Critical water years (WYs) although Dry and Below Normal WYs also saw substantial increases in some months. For Alternative 3, the largest increases, 1.7 percent to 2.9 percent, occurred July to September in Critical WYs. At the CVP, percent increases were smaller than at the SWP for both scenarios, with the largest changes occurring April to July in critical WYs for Alternative 2.

EC changes for the Contra Costa Water District (CCWD) export locations depended on the location of the intake and the scenario. For Alternative 2, the largest percent increase in EC from the No Action Alternative at the Old River and Rock Slough locations occurred in Critical WYs, although there were also notable average increases in a few Dry and Below Normal months. At the Victoria Canal intake, the largest EC percent increases were in Critical WYs. For Alternative 3, the percent increases in EC were largest in Critical WYs at all three locations, but they were approximately half the magnitude of the increases seen in Alternative 2. For Alternative 2, percent decreases in EC were scattered over WY types and months, but were fewer and smaller in magnitude in comparison with EC increases. For Alternative 3, percent decreases in EC were scattered overall WY types and months and they were somewhat greater in magnitude and more frequent for this scenario.

Annual average bromide loads calculated from tons of bromide per month at the SWP and CVP export locations increased in comparison with the No Action Alternative as an average of all WY types under Alternative 2, led by increases in Critical through Below Normal WYs. Bromide load decreased as an average for all WY types for Alternative 3 in comparison with the No Action Alternative.

Annual average bromide loads calculated as tons of bromide per year at the SWP and CVP export locations increased in comparison with the No Action Alternative as an average of all WY types under Alternative 2, led by increases in Critical through Below Normal WYs. Bromide load decreased as an annual average for all WY types for the action alternative in comparison with the No Action Alternative. At the CCWD intake locations, the picture for bromide load was mixed; for Alternative 2, it decreased as an average over all WY types at Rock Slough and at Victoria Canal but increased by a small percentage at Old River. Bromide load decreased as an annual average for Alternative 3 at all CCWD locations. The picture for bromide load at each CCWD intake location was more mixed for increases or decreases when considered by WY type.

In comparison with the monthly average X2 location for the No Action Alternative, changes in the monthly average position of X2 were in the range of -0.13 kilometers (km) to +0.08 km February through June, the regulated months, for the average of all WY types for Alternatives 2 and 3. For Alternative 2, X2 generally moved westward (less salinity intrusion). For Alternative 3, X2 generally moved eastward (more salinity intrusion). These changes are due in part to changes in Sacramento River inflow in comparison with the No Action

Alternative. The changes in monthly average X2 position and percent changes in monthly average X2 position indicate that neither alternative changed the position of X2 substantially in comparison with the No Action Alternative during regulated months, as there were only seven months between the two scenarios when X2 position changed more than 1.0 km on a monthly average basis.

Because the potential exists for decreases in water level elevation due operational changes from Alternatives 2 and 3 that might affect agricultural withdrawals of water in the south Delta, a conservative estimate of stage changes was calculated as the change to minimum monthly stage from the No Action Alternative. From DSM2 water elevation calculations, the largest decrease in monthly minimum stage at south Delta barrier locations was -0.2 feet compared to the No Action Alternative. This level of decrease occurred in only ten months out of the 984 months simulated in the scenarios.

Under National Marine Fisheries Service and United States Fish and Wildlife Service Biological Opinions (BOs), CVP and SWP operations are mandated to maintain exports at levels to minimize entrainment of delta smelt, steelhead, and winter-run salmon between December and June. Entrainment protection is currently met via prescriptions for OMR flow using measurements supplied by the United States Geological Survey (USGS). This prescription is called into play when delta smelt are found in locations believed to put them at risk for entrainment. Restrictions to OMR flow, and therefore to export levels, are considered to be an “adaptive management” process in which decisions on changes in Delta operations are made after assessing current conditions and data. The period December to March is used to protect pre-spawning adults using turbidity and salvage measurements (delta smelt recovered at export locations) as triggers for action, and the period December through June is used to protect larval smelt along with water temperature triggers. The percent change from the No Action Alternative results indicates that both action alternatives tend to increase the magnitude of negative OMR flow. The range of OMR flow changes is similar for the two action alternatives.

C.2 Introduction

Three M&I WSP alternatives were modeled in DSM2 – a No Action Alternative and two action alternatives. Alternative 2, Equal Agricultural and M&I Allocation, provides M&I and agricultural water service contractors with equal allocation percentages during water shortage conditions. Alternative 3, Full M&I Allocation Preference, provides M&I contractors with 100 percent of their contract allocation until CVP supplies are not available to meet those demands, while agricultural water service contractor deliveries are reduced as needed.

This document provides DSM2 documentation on model background, set-up, and water quality results. Specifically, water quality results include comparisons of modeled EC between the No Action Alternative and each of the action alternatives, calculations to estimate bromide load at export locations using model output, and several additional regulated parameters deemed pertinent to the study.

C.2.1 Objective

The DSM2 analysis compares the water quality outcomes under the No Action Alternative conditions with the conditions occurring in two action alternative scenarios and determines the extent of impacts or benefits on water quality in the Delta due to the alternative conditions. The water quality analyses include two required components: salinity (modeled as EC) at pertinent D-1641 locations and selected other locations in the Delta; and bromide load at five export locations – SWP, CVP, and three CCWD locations (Old River, Rock Slough, and Victoria Canal). A secondary objective is the analysis of model output pertinent to additional regulated parameters – X2, stage, and OMR flow.

C.2.2 Model Set-up

In order to model the hydrodynamics and water quality in the Delta, the input and/or output from three computational models is used: CalSim II, DSM2, and the Delta Island Consumptive Use (DICU) model. These models are covered briefly in this section and more thoroughly below. The CalSim II model is described in Appendix B, Water Operations Model Documentation. The modeled time span covered 82 water years, from October 1, 1921 through September 30, 2003.

CalSim II model outputs simulating California’s water delivery system to the Delta are used to supply boundary conditions to DSM2. Within DSM2, agricultural influences and the effect of meteorological conditions are modeled by boundary conditions supplied by a subsidiary model, the DICU model.

A distinction needs to be made between the uses of models for *absolute* versus *comparative* analyses. In an *absolute analysis,* the model is run once to predict an outcome – for example, the outcome could be the concentration of EC at one of the Delta water intakes. In a *comparative analysis*, the model is run twice, once with conditions representing a baseline and another run with a scenario representing some specific changes to Delta operations and/or bathymetry, in order to assess the change in modeled outcome due to the given change in model configuration. The assumption is that, while the model might not produce results reflecting these changes with absolute certainty, it nevertheless produces a reasonably reliable estimate of the relative change in outcome.

In this project, as is customary in most projects using CalSim II planning models combined with DSM2, the comparative analysis approach is used. The No Action Alternative represents a condition that approximates an operational and regulatory framework that is assumed to determine the hydrodynamics and water quality in the Delta at a future time frame.

C.2.2.1 CalSim II

CalSim is a model that was developed by the California Department of Water Resources (DWR) to simulate SWP and CVP operations in planning studies.

CalSim II is the latest version of CalSim available for general use. CalSim II is a planning model designed to simulate the operations of the CVP and SWP reservoirs and water delivery systems for current and future facilities, flood control operating criteria, water delivery policies, instream flow and Delta outflow requirements, and hydroelectric power generation operations. It represents the Central Valley with a node and link structure to simulate natural and managed flows in rivers and canals. It generates monthly flows showing the effect of land use, potential climate change, and water operations on flows throughout the Central Valley.

CalSim II is a simulation by optimization model. The model simulates operations by solving a mixed-integer linear program to maximize an objective function for each month of the simulation. CalSim II simulates the operation of the CVP and SWP systems for defined physical conditions and a set of regulatory requirements. The model simulates these conditions using 82 years of historical hydrology from WY 1922 through WY 2003. For some DSM2 planning studies using CalSim II model output, the modeled time frame is restricted to the WYs 1976 to 1991.

The system objectives and constraints are specified as input to the model, and CalSim II then utilizes optimization techniques to route water through a network representing the California water system given user-defined priority weights. A linear programming (LP)/mixed integer linear programming (MILP) solver determines an optimal set of decisions for each time period given this set of weights and system constraints. The CalSim II model has been designed to separate the physical and operational criteria from the actual process of determining the allocations of water to competing interests. Thus, CalSim II provides quantitative hydrologic-based information to those responsible for planning, managing and operating the SWP and the CVP. As the official model of those projects, CalSim II is the default system model for any inter-regional or statewide analysis of water in the Central Valley of California.

C.2.2.2 DSM2

C.2.2.2.1 DSM2- General Background Information

DSM2 is a one-dimensional (1-D) hydrodynamic and water quality simulation model used to represent conditions in the Delta. The model was developed by DWR and is frequently used to model impacts associated with projects in the Delta, such as changes in exports, diversions, or channel geometries associated with dredging in Delta channels. It is frequently used in conjunction with CalSim II in planning studies – CalSim II hydrological output and specification of the operation of in-Delta gates and barriers are used to set the appropriate DSM2 boundary conditions. DSM2 has been used extensively to model hydrodynamics and salinity in the Delta, as well as Dissolved Organic Carbon (DOC). Salinity is modeled as EC, which is assumed to behave as a conservative constituent. DOC is also modeled as a conservative constituent in a water quality module (QUAL).

DSM2 contains three separate modules, a hydrodynamic module (HYDRO), a QUAL, and a particle tracking module (PTM). HYDRO was developed from the USGS FOURPT model (USGS 1997). DWR adapted the model to the Delta, accounting for such features as operable gates, open water areas, and export pumps. The water quality module, QUAL, is based on the Branched Lagrangian Transport Model (Jobson 1997), also developed by the USGS. QUAL uses the hydrodynamics simulated in HYDRO as the basis for its transport calculations. PTM, which was not used in the current study, also uses hydrodynamic results from HYDRO to track the fate of particles released at user-defined points in space and in time.

Detailed descriptions of the mathematical formulation implemented in the hydrodynamic module, DSM2-HYDRO and for EC in the water quality module, DSM2-QUAL, the data required for simulation, calibration of HYDRO and QUAL, and past applications of the DSM2 Historical model are documented in a series of reports available at:
http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/annualreports.cfm.

Documentation on the calibration and validation of the HYDRO module and the QUAL module for EC used in the current implementation of DSM2 is available at that website. The calibration of DSM2 has generally focused on hydrodynamics and the conservative transport of salinity, modeled as EC. Changes to the network of the DSM2 model were implemented in 2009 (Chilmakuri 2009), and the updated grid was used for the HYDRO hydrodynamic and QUAL simulations in this study. The major changes are the inclusion of the Liberty Island open water area (this is modeled as a “reservoir” in DSM2 terminology) and an extension and refinement in the grid at the northern boundary of the model. Figure C-1 shows the earlier DSM2 Version 6 grid with channels, nodes and open water areas other than Liberty Island.

C.2.2.2.2 Astronomical Tide

In addition to CalSim II’s monthly time series inflows, diversions, operations, and water quality data, DSM2 planning studies also require stage data at Martinez, which is the downstream boundary of the model. The Martinez boundary stage used in planning studies is a continuous time series of stage data known as the “adjusted astronomical” tide. This tide is based on historical Martinez stage data with missing data synthesized through the development and application of a statistical model using available stage data, astronomical cycles and hydrologic variations (Ateljevich 2001). The astronomical tides are calibrated to both San Francisco and Martinez observed data.

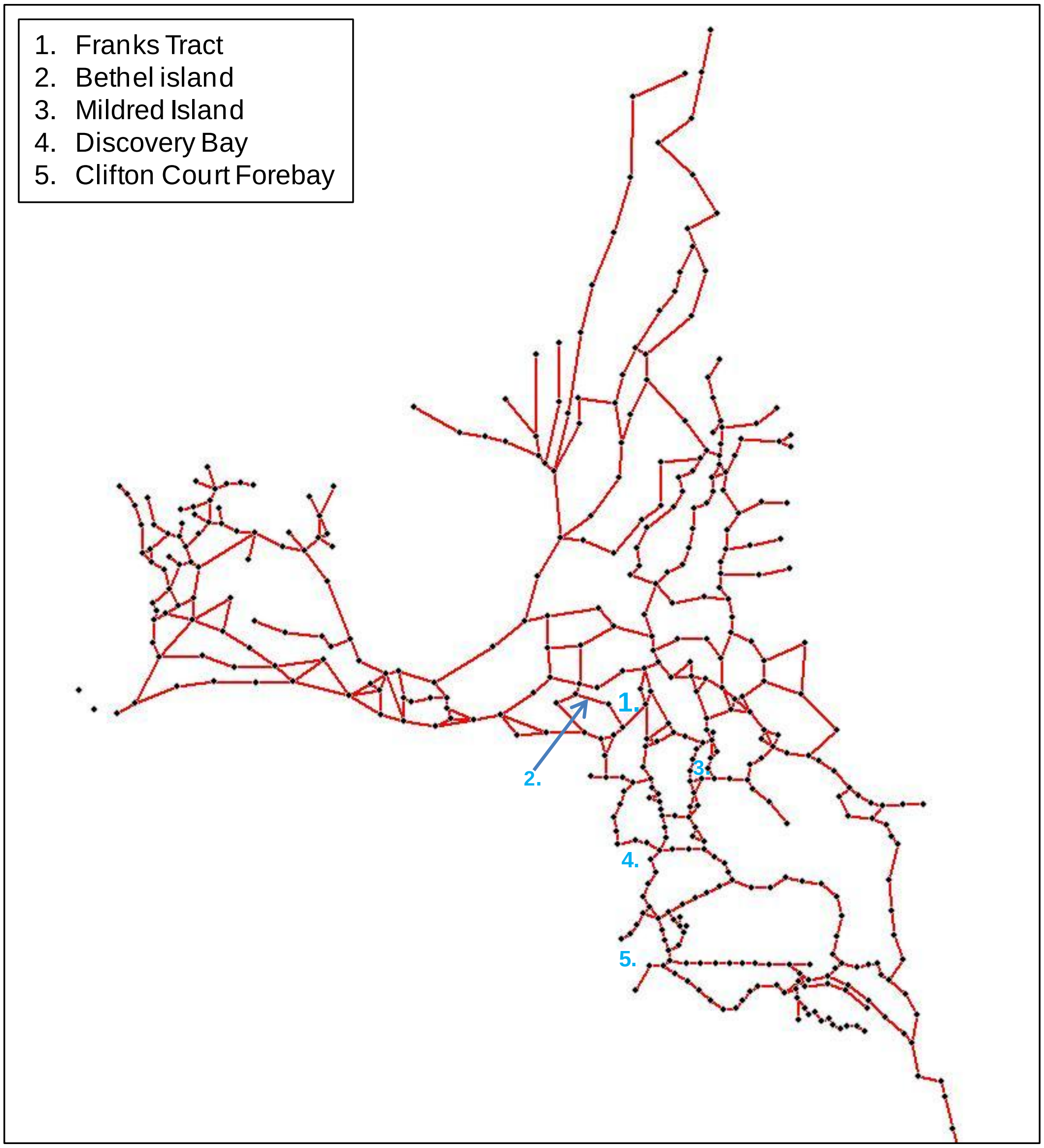


Figure C-1. DSM2 Version 6 model grid showing channels (red), reservoirs (blue numbers), and nodes (black)

C.2.2.2.3 Gates, Barriers and Exports

Permanent gates and temporary barriers represented in the model include the Delta Cross Channel (DCC), Old River near Tracy (DMC) barrier, Old River at Head barrier, Middle River barrier, Montezuma Slough salinity control gates (SMSCG), Grant Line Canal barrier, and Lawler buffer ditch culvert. The SMSCG control season is from early October through the end of May.

Delta exports applied in the model include SWP, CVP, North Bay Aqueduct, and CCWD exports or diversions at Rock Slough, Victoria Canal and Old River intake locations. (See also Chapter C.3.1).

C.2.2.3 DICU

C.2.2.3.1 DICU Background Information

The DICU[2] model was developed by DWR's Planning Division to estimate agricultural diversions and return flows to Delta channels. The DICU model is used in DSM2 both to estimate historical agricultural flows and to estimate project planning model agricultural volumes, and to assign these volumes and associated concentration of water quality parameters to DSM2 nodes. In this report, the term "DICU" is used to refer both to the conceptual model and to the associated computer program.

The values calculated for consumptive use in the conceptual model include the following parameters:

- Evapotranspiration – includes climatic conditions, soil type and plant type and associated acreage
- Precipitation – spatially distributed using Delta weather station values
- Surface runoff
- Soil moisture
- Irrigation – water diverted from channels, estimated by season
- Seepage – water used by plants flows from channels to Delta islands
- Drainage – return flows from irrigation and leaching to channels from Delta islands
- Leach water – heavy applications of water in winter months used to leach salts from soils.

The DICU model calculations for water diversions and returns are most sensitive to changes in efficiency of irrigation (a factor applied to irrigation withdrawals)

[2] http://modeling.water.ca.gov/delta/reports/misc/EstDICU.pdf

and in evapotranspiration. Changes in seepage values can cause changes in irrigation demands or in return flows, but only have a small impact on return flows. Studies have indicated that DICU seepage estimates are probably low. The model as a whole is most sensitive to changes in irrigation efficiency (a constant value) and to leaching water estimates.

The DICU model provides time series of values that are applied as boundary conditions on a monthly average basis[3,4] (DWR 1995; DWR 2002) in DSM2 at 257[5] locations throughout the Delta – these locations are subdivided into 142 regions. There are three components to DICU flows – diversion, drainage and seepage. The total monthly diversions incorporate agricultural use, evaporation and precipitation, drains incorporate agricultural returns, and seeps incorporate channel depletions. These flows are distributed as boundary conditions that vary by region and by WY type. Acreages for land use categories and crop type are varied by two categories of WY type, critical and non-critical. The critical years in the DICU model include the D-1485 (same as D-1641) WY types of Critical and Dry; non-critical years include the remaining WY types.

Similarly, the concentration of EC in agricultural return flows, the drain flows in DSM2, are also applied on a monthly average basis, but using the same monthly averages in every year regardless of WY type. The estimation of water quality concentrations in return flows in the DICU model is documented in another DWR publication, available online[6].

There is considerable uncertainty in the estimates of DICU inflow, outflow and constituent concentrations. During periods of low inflow, for example during Critical WYs, errors in volumes ascribed to DICU boundaries may dominate model results at some locations.

C.2.2.3.2 The ADICU program

Because the CalSim II model calculations used in the alternatives in this project also include the capability to change consumptive use in the Delta and these values were changed for the current project, an executable program, ADICU, and a set of input and output files incorporated in a fixed directory structure were obtained from staff at DWR Delta Modeling Section (DMS). The program required a set of four CalSim II demand time series that incorporate Delta consumptive use – D404, D410, D412 and D413. ADICU then disaggregates CalSim II demands into the nodes used in DSM2 withdrawal and return flows. The use of ADICU is documented in Chapter 5 of the 2004 Annual Report[7] prepared by the Delta Modeling Section in DWR.

---

[3] http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dicu/dicu.cfm
[4] http://www.iep.ca.gov/dsm2pwt/reports/DSM2FinalReport_v07-19-02.pdf, http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dicu/DICU_Dec2000.pdf
[5] Note that Byron-Bethany Irrigation District is included as a DICU flow in Clifton Court Forebay, so there are actually 258 DICU nodes.
[6] http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dicu/DICU_Dec2000.pdf
[7] http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/annualreports.cfm

C.3 Modeling Set-up and Methodology

The DWR DMS has developed a series of computer applications to automate the generation of DSM2 model inputs and boundary conditions. These applications produce input time series for DSM2 flows from CalSim II output, as well as time series for the timing of operations for certain gates and barriers, for example, the gates at the entry of Clifton Court Forebay (CCFB) and the gates in the DCC. The time series are copied into a single input file that is read directly into DSM2. These applications also produce time series for the DICU flows and constituent concentrations for EC using standardized Planning Study model inputs. The DICU time series are also copied into the input file that is read directly into DSM2.

The DICU time series used in this project for the three scenarios were each generated using the ADICU executable with input from the set of four CalSim II time series discussed in Chapter C.2.2.3.2.

C.3.1 Inflow and Export Boundary Conditions

Boundaries that define the movement of water into and out of the Delta, and thus also the transport of water quality constituents, consist of inflow boundaries, outflow boundaries and a stage boundary set at Martinez. The plots of these boundary flows that follow are split into two plots, with the upper plot showing a range of the early modeled years, and the lower plot presenting (fewer of) the later modeled years.

In Figure C-2, the main inflow boundary locations are denoted by blue dots as is the stage boundary at Martinez. The inflow boundaries are found at the each of the major rivers (Sacramento, San Joaquin, Calaveras, Mokelumne and Cosumnes), and at the Yolo Bypass. Martinez is also an outflow boundary. In Figure C-3, the approximate positions of Delta export locations (water intakes) are shown. Figure C-4 through Figure C-8 document the No Action Alternative export values and the change from base for the two action alternatives at the five export locations in the central and south Delta considered in this study. Figure C-9 and Figure C-10 document Sacramento and San Joaquin River inflow, respectively, for the No Action Alternative and changes from these inflow values for the two action alternatives.

CalSim II files were converted to DSM2 input, such as boundary inflows, exports and gate operations, by running the preprocessors for DSM2 developed by staff at the DMS for Planning run applications. Similarly, the stage boundary at Martinez was obtained from a standardized time series developed by the DMS under direction of the preprocessor logic.

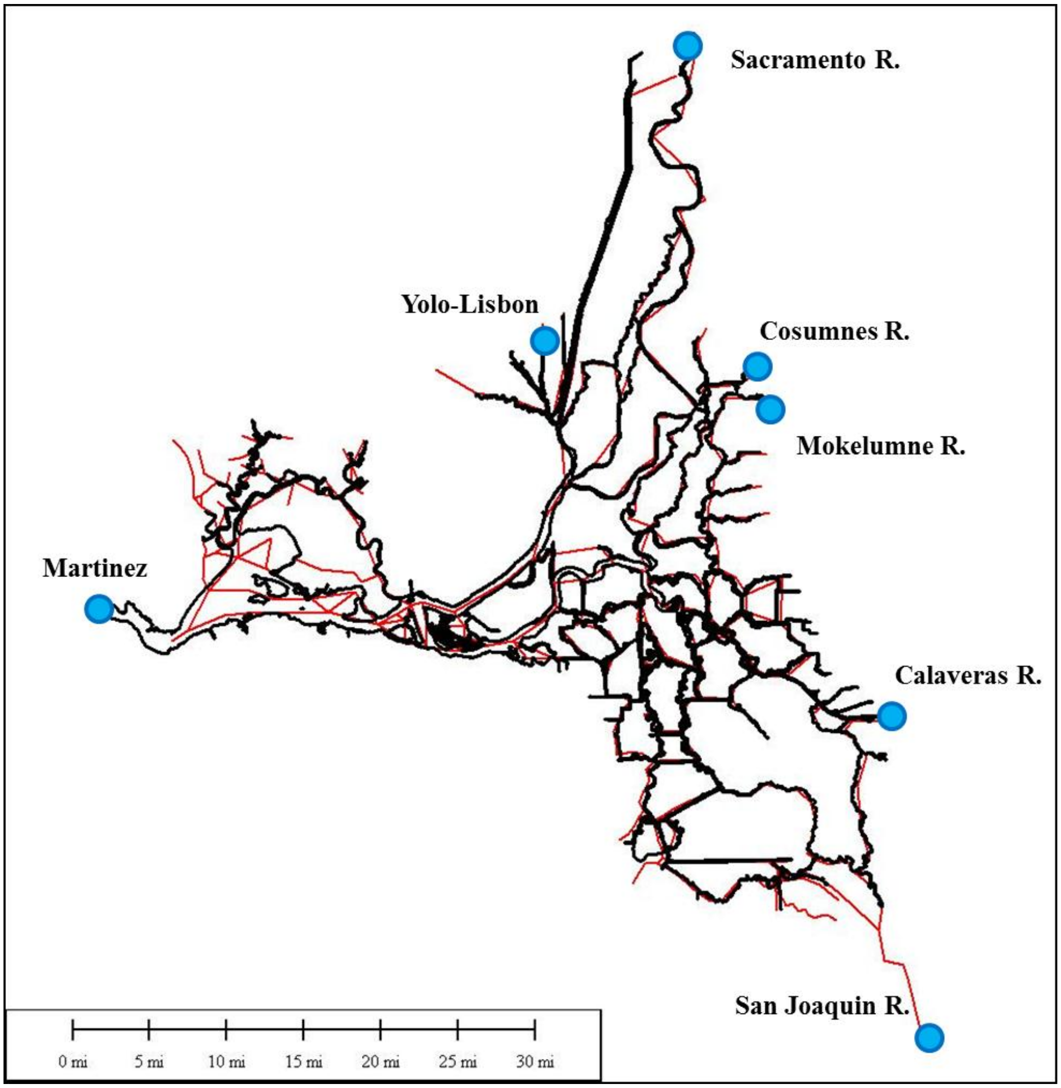


Figure C-2. Approximate location (blue circles) of the main model inflow boundaries and the stage boundary at Martinez, which is also an outflow boundary

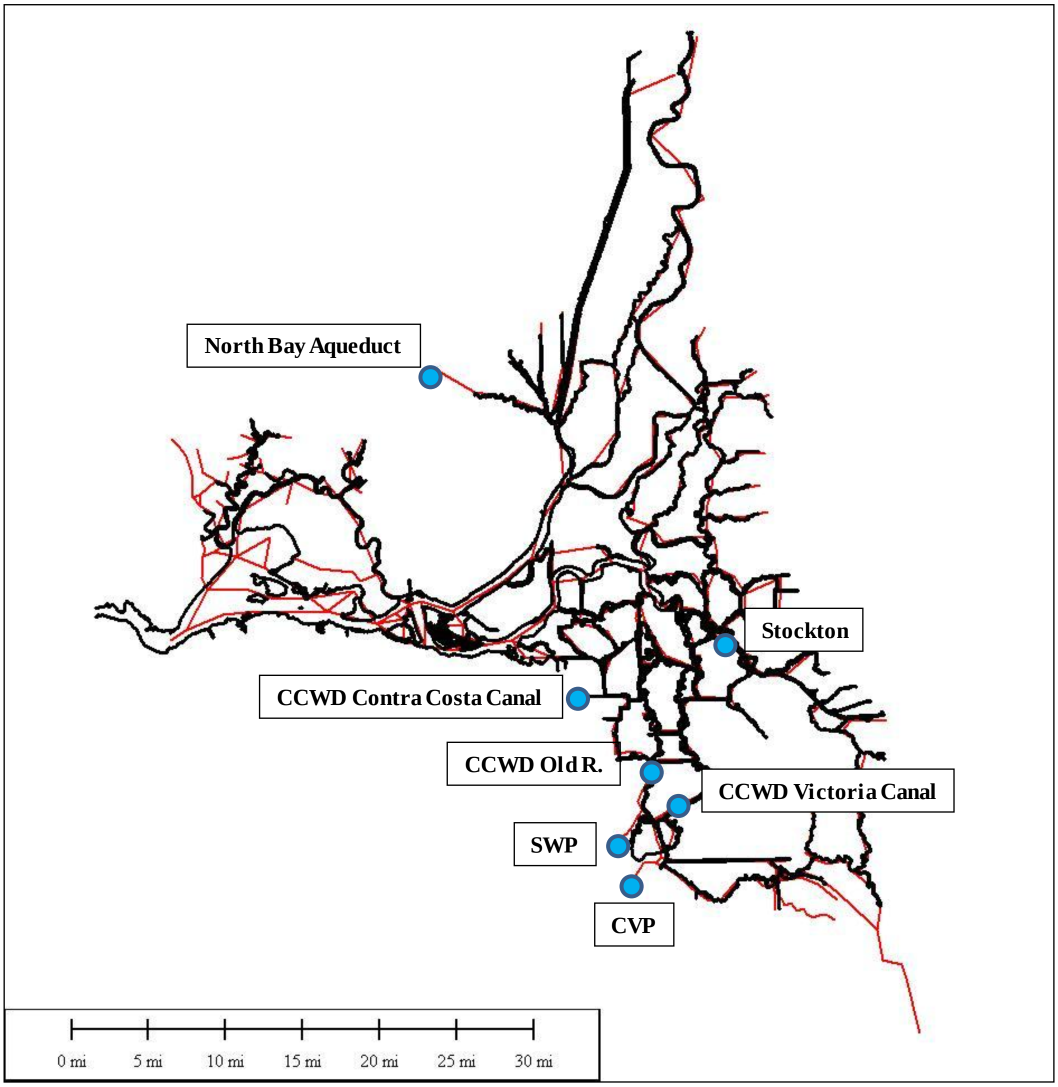


Figure C-3. Approximate location of water intakes (export locations)

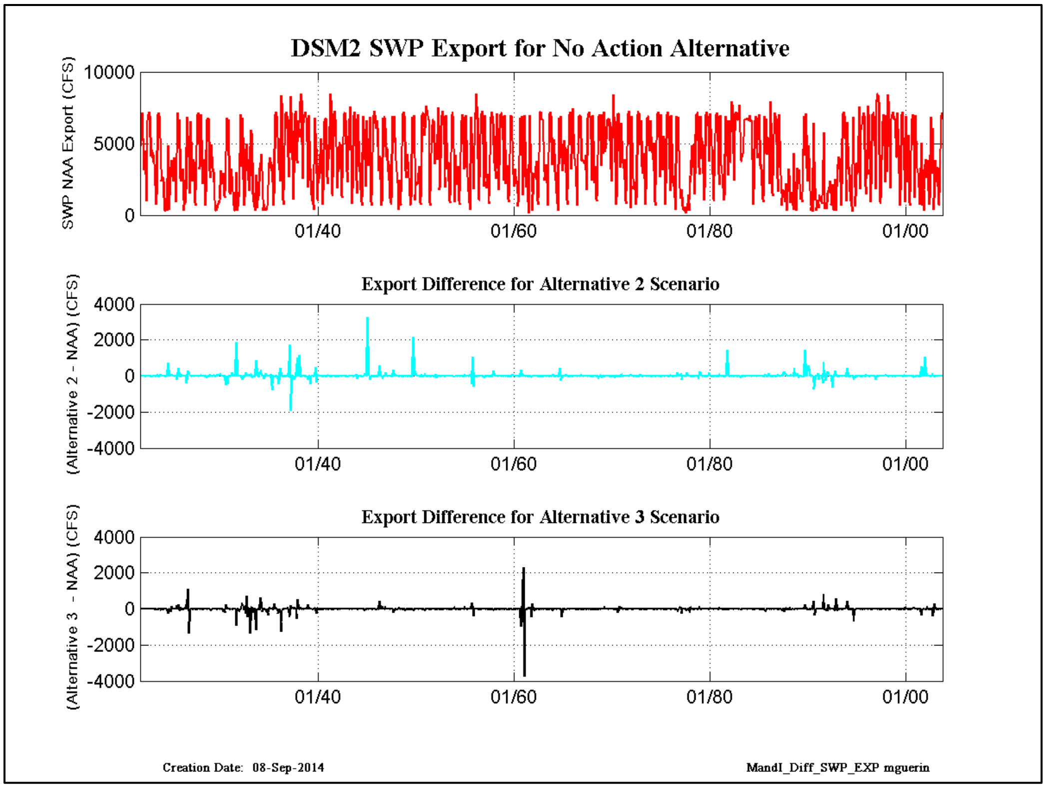


Figure C-4. SWP monthly-average exports for the No Action Alternative, and change from No Action Alternative exports for the two action alternatives

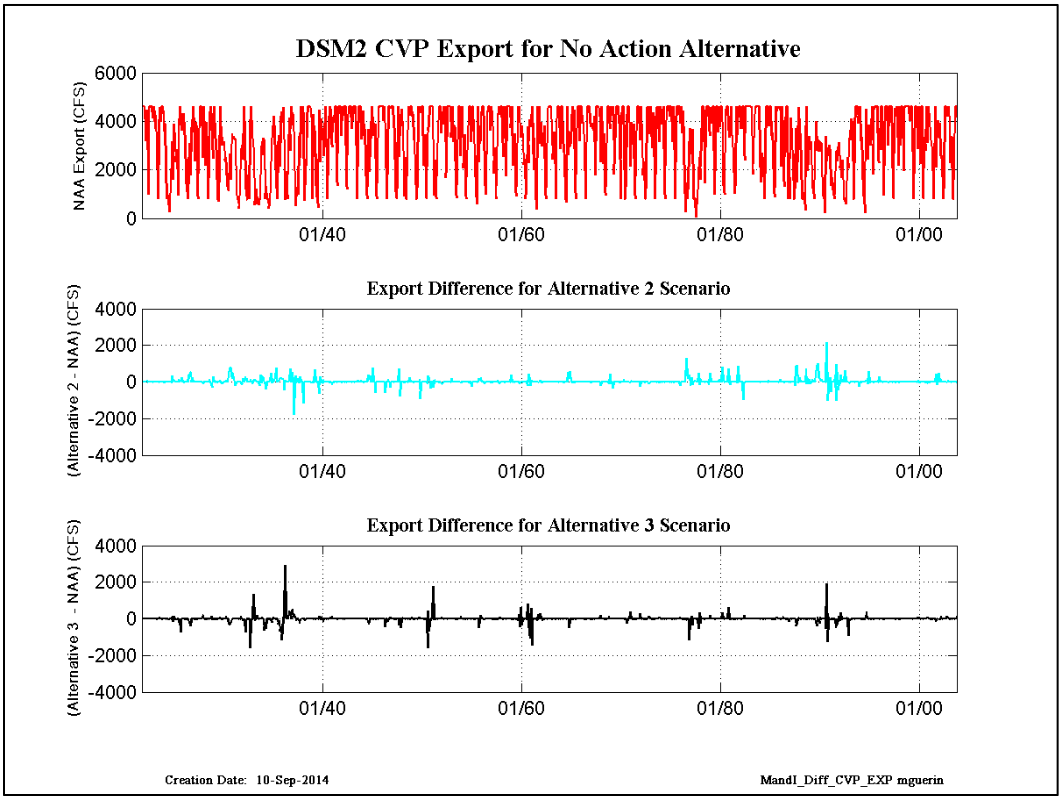


Figure C-5. CVP monthly-average exports for the No Action Alternative and change from No Action Alternative exports for the two action alternatives

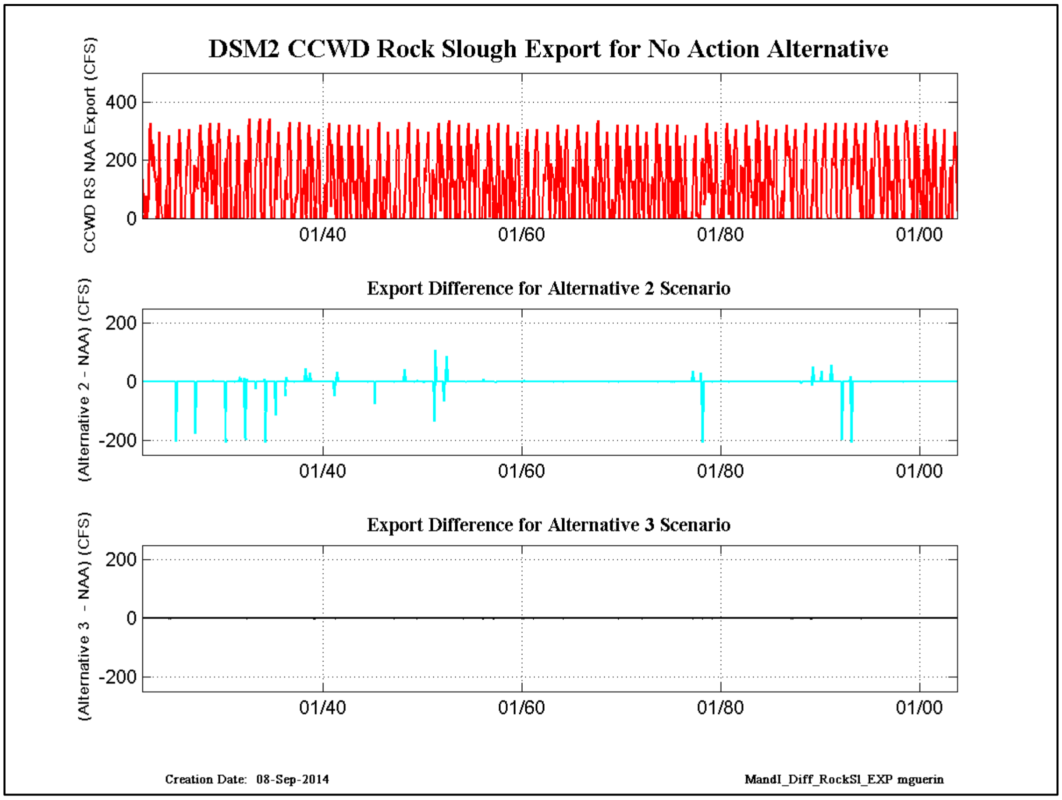


Figure C-6. CCWD Rock Slough monthly-average exports for the No Action Alternative, and change from No Action Alternative exports for the two action alternatives

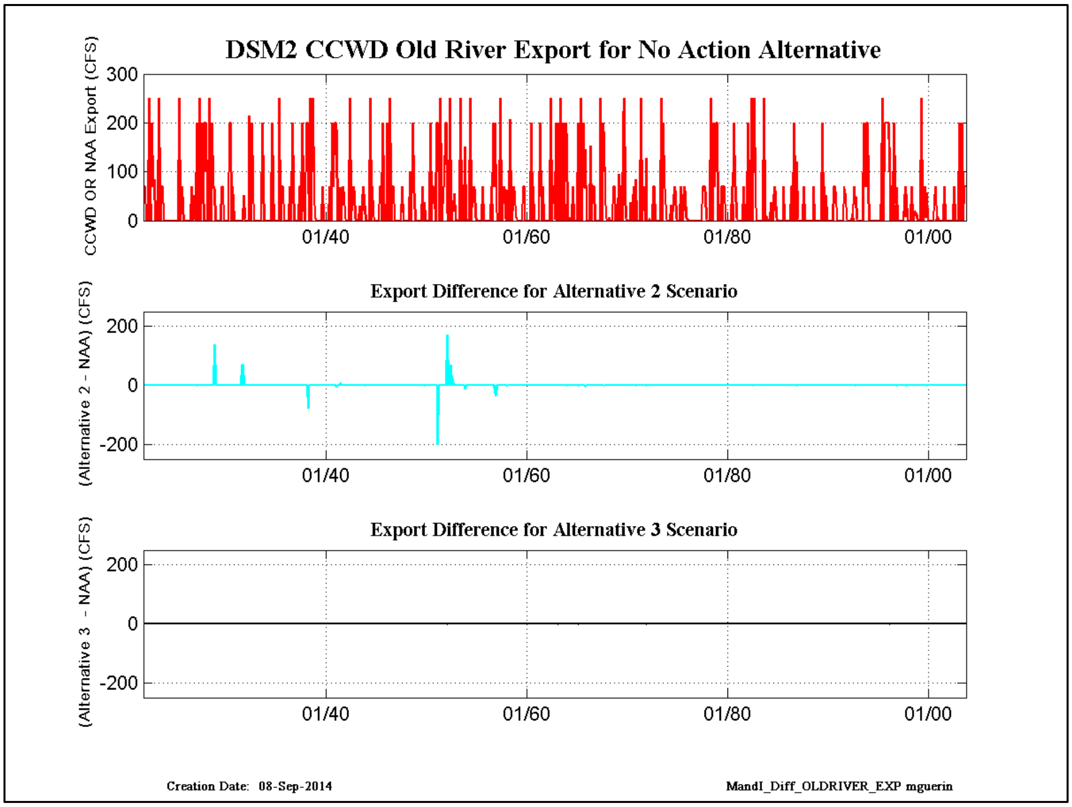


Figure C-7. CCWD-Old River monthly-average exports for the No Action Alternative, and change from No Action Alternative exports for the two action alternatives

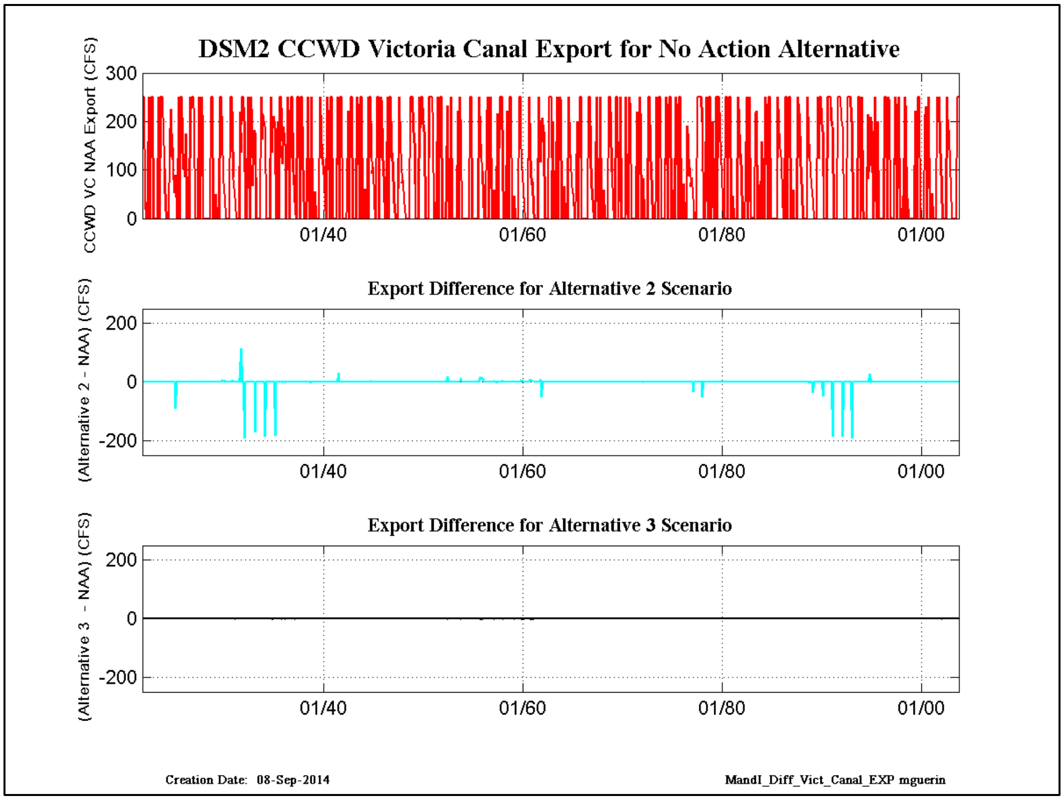


Figure C-8. CCWD-Victoria Canal monthly-average exports for the No Action Alternative, and change from No Action Alternative exports for the two action alternatives

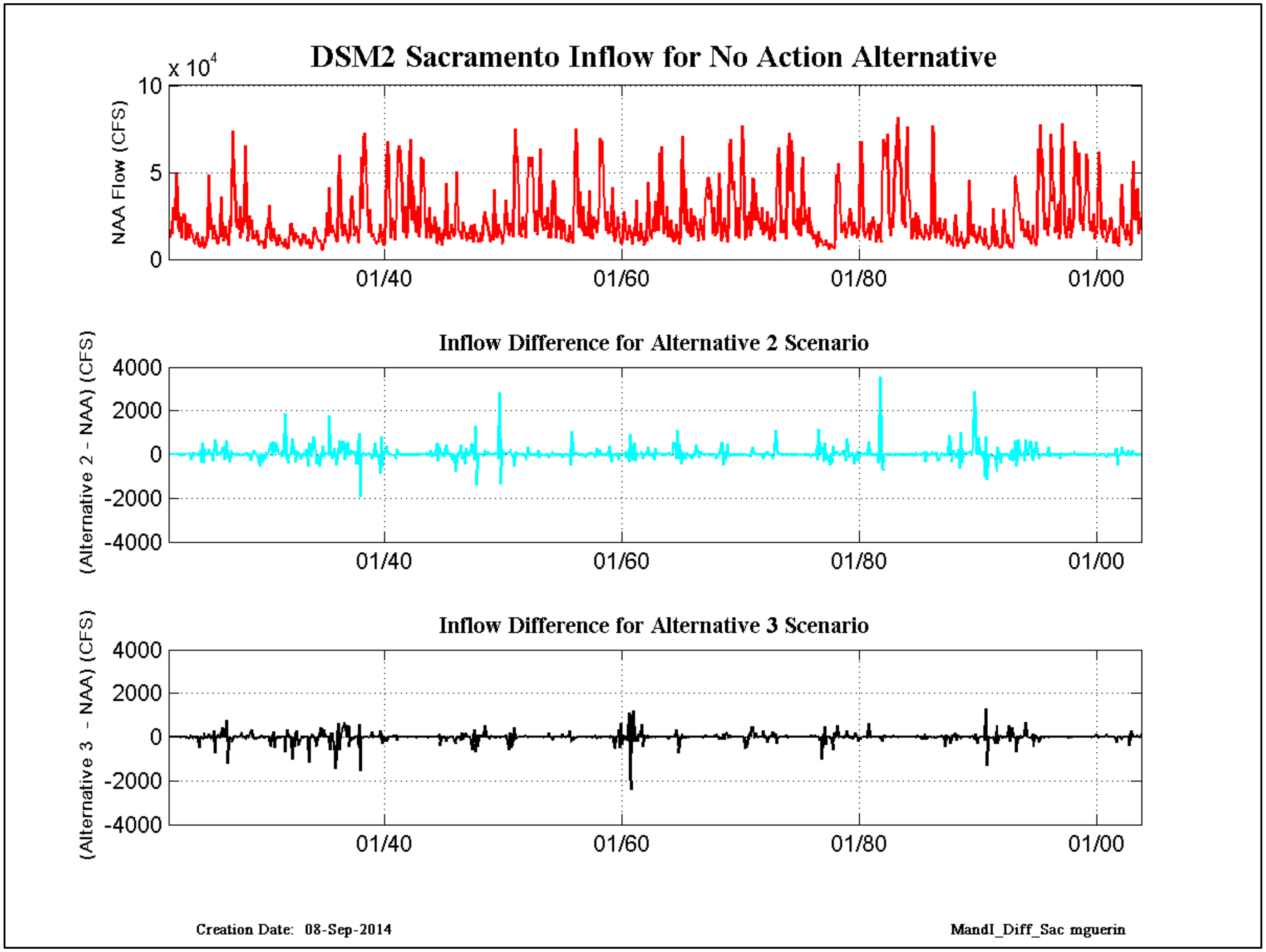


Figure C-9. Monthly average Sacramento River inflow for No Action Alternative and change from No Action Alternative inflow for the two action alternatives

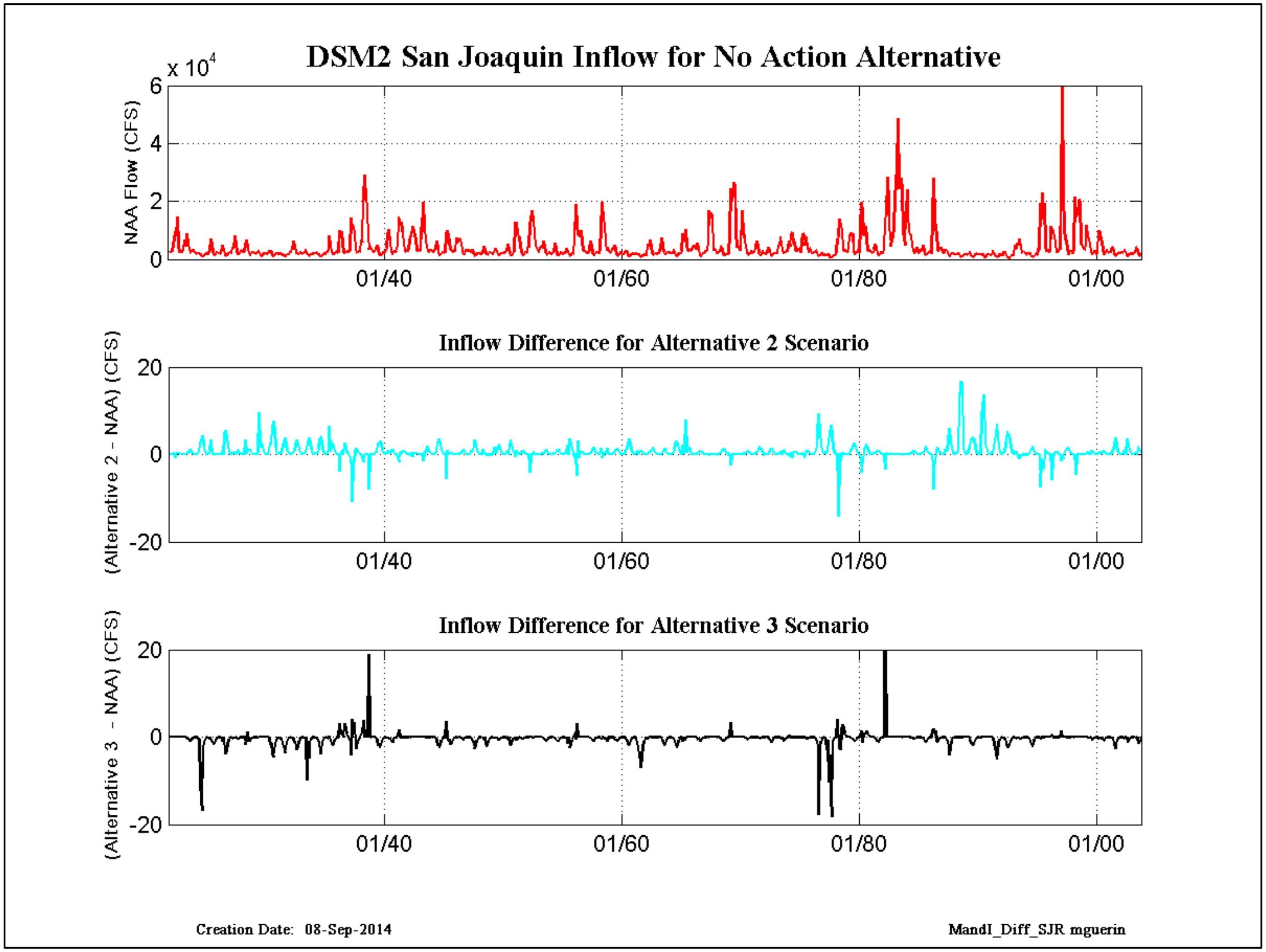


Figure C-10. Monthly average San Joaquin River inflow for No Action Alternative and change from No Action Alternative inflow for the two action alternatives

C.3.2 EC Boundary Conditions

The EC boundary condition at Martinez is calculated using the NDO (Net Delta Outflow) value from CalSim II output as input into an executable program developed by the DMS. The NDO is used as input into a DSM2 preprocessor equation defining an NDO-EC relationship at Martinez.

The EC time series at the San Joaquin River location at Vernalis is also calculated in a DMS preprocessing program using a linear relationship between San Joaquin River flow and EC. EC at the other major inflow boundaries is set as constant for use in QUAL.

C.3.3 DICU Development

Modeled agricultural influences in DSM2 are handled by the DICU program - they consist of withdrawals, seepage and return flows, as well as the EC concentration of the return flows. EC boundary conditions for DICU are generated from a standardized input set for the future condition planning models using DMS preprocessing software for DSM2. The ADICU program produces flow time series that are used by HYDRO as DICU flow boundary conditions for cases where the DICU flows assumed in CalSim II need to be modified.

For the No Action Alternative, the four CalSim II Delta consumptive demand time series (D404, D410, D412 and D413) needed for ADICU were used as specified in the No Action Alternative CalSim II "DV' file to produce a set of DICU flows for this scenario.

For the two action alternative scenarios, several modifications were required. Scale changes were applied on an annual basis to the net of the four CalSim II demands, which altered the distribution of consumptive use demands monthly, but maintained the annual demand volume (on a calendar year basis). Thus, the DICU flow time series were different for each of the three scenarios while the EC time series are the same for the three scenarios.

Note that this scale change introduces a discrepancy between the NDO calculated initially by CalSim II and the NDO defined by inputs to DSM2. Thus, the NDO value in the CalSim II "DV" file used to generate DSM2 inputs was updated to reflect the change due to the altered monthly DICU flow distribution. This altered NDO was then used to generate a Martinez EC boundary condition, as described in Chapter C.3.2, that best reflects the conditions as modified.

Note on DICU changes and CalSim II *vs.* DSM2 NDO – Note that the changes in the pattern of DICU flows due to the reallocation of annual consumptive use flow implements changes to the DSM2 inflow and outflow patterns that are not reflected in CalSim II NDO. To assess the magnitude of the changes in the pattern of consumptive demand, DSM2 NDO (calculated as a tidally-averaged, monthly-averaged flow at Martinez) was compared to the updated CalSim II-generated NDO to confirm that there was a difference in the magnitude of these flows originating from several sources: there are timing differences between CalSim II and DSM2 as CalSim II does not account for the travel time between the inflow and outflow boundaries as implemented in DSM2; DSM2 tributary inflows at Freeport and Vernalis are smoothed at the beginning of each month to produce a more natural flow pattern than the step changes seen in CalSim II; and, the change in the pattern of agricultural demands in the scenarios.

As a sensitivity test, the QUAL model was run for the two Alternative scenarios both with and without the updated NDO calculation and subsequent changes to Martinez EC boundary, and the results compared. The EC differences between the two implementations were deemed to be of minor consequence to the model results, in part because they are assessed using the "comparative analysis" approach described in Chapter C.2.2.

C.3.4 Model set-up and QA/QC

DSM2 was run with the Mini-calibration set-up and V8.0.6 of HYDRO and QUAL. Inflow boundary conditions and SWP and CVP export flows were compared with model output and plots were generated for each of the three scenarios as a primary check for appropriate implementation. Martinez EC calculated by DSM2 was visually compared with the input time series. ADICU program input and output were compared to ensure the appropriate time series were being used to calculate DICU flows. As discussed in Chapter C.2.2.3.2, CalSim II and DSM2 NDO and calculated Martinez EC values were assessed to ensure the modification to seasonal agricultural diversion patterns produced sensible EC values as calculated in DSM2.

C.3.5 Analysis Methodology

For the water quality analyses in this project, DSM2 was used primarily to determine differences in EC patterns in the Delta due to two project alternatives in comparison to the No Action Alternative case, as well as differences in bromide load at export locations and the change in the location of X2, the location of the 2 ppt salinity isohaline. Hydrodynamic changes of interest to potential stakeholder groups were also calculated, i.e., stage changes at south Delta barrier locations and the change in OMR flow.

C.3.5.1 EC calculations

The effect of changes in water quality constituents at Delta locations due to the two alternative operational scenarios is generally presented as the percent change from Monthly Average No Action Alternative model results or as change from Average Monthly No Action Alternative. The results consist of an average value calculated for each month over the 82 years in the simulation. In this analysis, results are also split out by WY type, and the combined results are presented in tables for each scenario as a percent difference from the No Action Alternative. Monthly Average results are also calculated, but are not discussed. These results, consisting of large tables of results with an average monthly value calculated for each month in the simulation, are found in Chapter C.8.

C.3.5.2 Bromide Calculations

DSM2 QUAL output was used to estimate bromide concentrations at SWP Banks Pumping Plant, CVP Jones Pumping Plant, Old River at Highway 4 (CCWD Los Vaqueros Intake), Old River at Rock Slough, ROLD024 (CCWD Rock Slough Intake) and at VICT_Intake (CCWD Victoria Canal Intake). A combination of predicted EC and results of a volumetric fingerprinting analysis were used along with a conversion equation, shown below. The calculated bromide concentrations were then used to determine monthly mass loads at each export location.

The following equation is used in computing constituent concentrations from the EC values generated by DSM2 QUAL:

$$Constituent\ (mg/L) = \mathrm{A}*EC\ (\mu mhos\ cm^{-1}) + \mathrm{B} \qquad (1)$$

where EC is the DSM2-simulated electrical conductivity at any given location in μScm^{-1} ($\mu mhos\ cm^{-1}$), and coefficients A and B are listed below for various constituents depending on the Martinez volumetric fingerprint value calculated in DSM2. The same method can be used to calculate mass loads for chloride and total dissolved solids (TDS), as shown in the table below. Coefficients for bromide calculations are highlight in bold font below:

Constituent	Martinez Volumetric Fingerprint	A	B
TDS	< 0.4%	0.567	3.9
TDS	≥ 0.4%	0.540	5.7
Clorine	< 0.4%	0.173	-19.2
Clorine	≥ 0.4%	0.252	-34.6
Bromine	**< 0.4%**	**0.000552**	**-0.073**
Bromine	**≥ 0.4%**	**0.000827**	**-0.112**

The EC-based correlations for the constituents TDS, bromide and chloride listed above were developed based on whether the water at any given location is riverine or seawater dominant. Hutton (2006) found that a discernible mineral signature was found for both seawater and the riverine water. For instance, the chloride-to-sulfate ratio was found to be approximately 7.0 for seawater and approximately 1.0 for the Sacramento and San Joaquin Rivers.

At any given location in the Delta the proportion of seawater (seawater ratio) can be determined by simulating Martinez volumetric fingerprinting using DSM2. At high seawater ratios (≥ 0.4%), the chloride-to-sulfate ratio increases and approaches 7, which is the ratio found in seawater. At low seawater ratios (< 0.4 percent), the chloride-to-sulfate ratio is approximately 1.0, which is similar to the ratio found in Sacramento and San Joaquin River waters. Therefore, the 0.4 percent seawater ratio was used as the demarcation between riverine and seawater influences and in developing the coefficients A and B.

C.3.5.3 X2 calculations

X2 is defined as the distance in km from Golden Gate to the position of 2.0 ppt bottom salinity. Using EC data analysis at stations throughout the Delta, regression relationships were developed relating NDO to EC measurements (Jassby et.al. 1995). Using these data, it was also found that 2.0 ppt corresponds to 2640 micro Siemens per centimeter ($\mu S\ cm^{-1}$) surface EC and to 3000 $\mu S\ cm^{-1}$ bottom EC.

The position of X2 is regulated from February to June each year by the 1995 Bay/Delta Plan (SWRCB 1995). The compliance standard for the position of X2 can be met either with flow objectives specified by the Net Delta Outflow Index (NDOI) or as an equivalent EC standard, each of which vary with the Sacramento WY type[8]. Compliance is met by a 3-day NDOI for a X2 location at Collinsville (81 km, NDOI = 7,100 cubic feet per second [cfs]), Chipps (75 km, NDOI = 11,400 cfs) or at Port Chicago (64 km, NDOI = 29,200 cfs). Equivalently, compliance can also be met at these locations using surface EC of 2640 $\mu S\ cm^{-1}$ on a daily basis or on a 14-day running average basis.

DSM2 is depth-averaged EC, so as a proxy for X2, the methodology developed to use DSM2 EC output for the calculation of X2 assumed that the average of the top and bottom EC values for X2, 2820 µmhos cm^{-1} was the *de facto* location of X2. Using this estimate, the monthly average DSM2 EC output at six River Kilometer Index (RKI)[9] locations in the western Delta – RSAC054, RSAC064, RSAC075, RSAC077, RSAC081, RSAC084, RSAC092 and RSAC101 – were used to calculate X2 (see Figure C-11). Eastward movement of X2 is less desirable from a fish habitat standpoint.

[8]Sacramento R. Water Year Index = 0.4 * Current Apr-Jul Runoff Forecast (MAF) + 0.3 * Current Oct-Mar Runoff (MAF) + 0.3 * Previous Water Year's Index (if it exceeds 10.0, then 10.0 is used)
[9]RKI, the River Kilometer Index, is the distance from the Golden Gate in km.

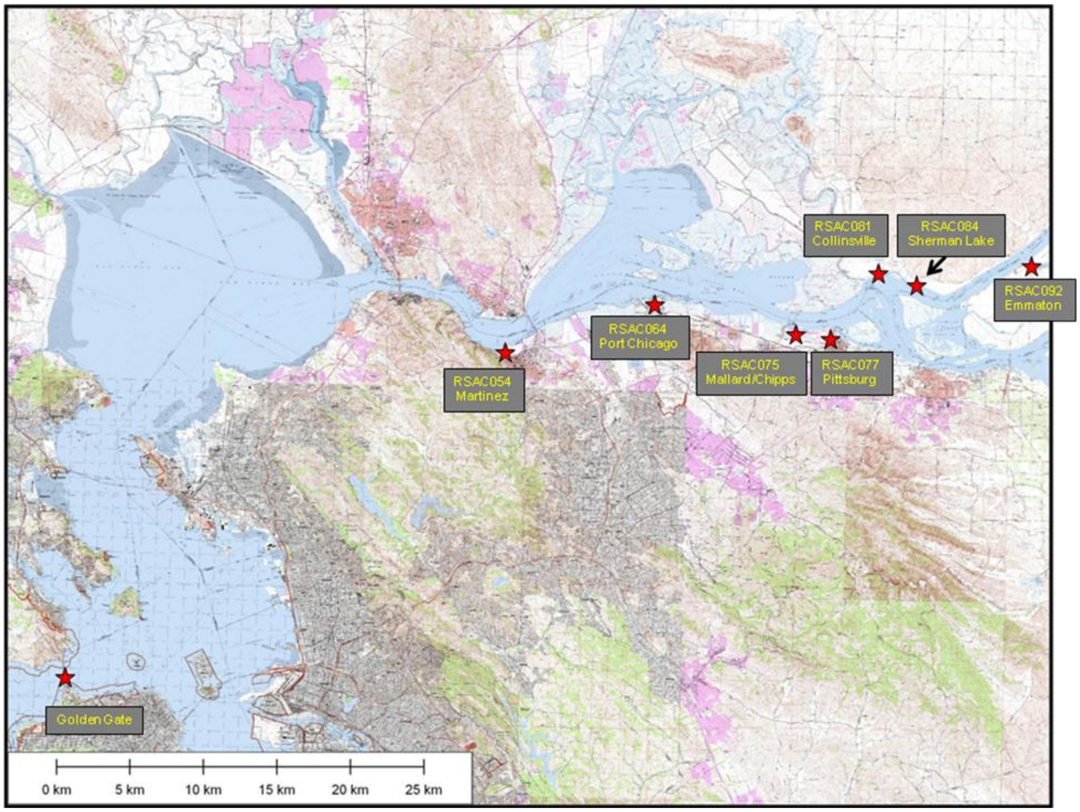


Figure C-11. DSM2 Output locations used in the calculation of X2 are on the Sacramento River from Rio Vista (upstream of Emmaton) to Martinez

Linear interpolation was used to estimate the location of X2 between successive points. Two exceptions occurred: if EC at RSAC054 (Martinez boundary) EC was less than 2820 µmhos cm^{-1}, X2 was set to be 54 km, or if EC at RSAC101 was greater than 2820 µmhos cm^{-1}, X2 was set to be 101 km – the latter case did not occur. When 2820 µmhos cm^{-1} occurred between two adjacent RKI locations, RKI_1 and RKI_2 (in km), the average change in EC per km between the points, delta_X2, was used to calculate the position of X2 as follows, where EC (RKI_1) is the EC at RKI_1:

$$X2 = RKI_1 + (2820 - EC\ (RKI_1))/delta\_X2$$

For each scenario, the position of X2 was calculated from February through June using the linear interpolation method. Plots of monthly average of X2 position for the three scenarios are presented as the change in X2, (action alternative minus No Action Alternative).

C.3.5.4 Stage calculations

For changes in water level upstream and downstream of south Delta barriers, the minimum stage was calculated monthly for the three scenarios from the 15-minute model output. The final calculation, as presented in this document, is the change from the No Action Alternative stage on a Monthly Average basis. In addition, the largest decreases in minimum monthly stage change from No Action Alternative were recorded. These methods combine to give a conservative estimate of the potential for stage changes in the Alternative scenarios to negatively affect agricultural operations.

C.3.5.5 OMR calculations

The 15-minute DSM2 flow results at ROLD024 and at RMID015 were daily averaged, added together then smoothed with a 14-day running average – the final step was to monthly average the running average results and then calculate the percent change between each action alternative and the No Action Alternative. Percent change from No Action Alternative of the monthly averaged OMR flow for the alternatives was used as an estimate for the effect of alternative Delta operations found in the scenarios. Note that negative percent difference numbers indicate that a negative OMR flow in the alternative was smaller in magnitude than the No Action Alternative – i.e., this is a good result as negative OMR flows pull delta smelt toward the SWP and CVP export locations. Thus, a positive percent difference number indicates a result that the alternatives would prefer to avoid.

C.4 Model Results

Results for EC concentrations and bromide load were calculated at five export locations – SWP, CVP, CCWD-Rock Slough (calculated at the DSM2 grid ROLD024 location), CCWD-Old River and CCWD-Victoria Canal. The calculations in this section are presented as tabular results for percent change from No Action Alternative on an Average Monthly basis. In addition, plots are shown comparing EC for the No Action Alternative and each of the action alternatives at eleven locations in the Delta to illustrate the distribution of EC (see Figure C-12 through Figure C-37). The plots are split with the upper year showing a range of the early modeled years, and the lower plot presenting fewer of the later modeled years to give a better view of the types of changes from the No Action Alternative.

In this section, tabular results are presented as Average Monthly values (one value for each month averaged over the 82 year model time frame) that are also split out by Water Year (WY) Type (Wet, Above Average, Below Average, Dry and Critical). In Chapter C.8.1, the more detailed Average Monthly (one value for each month in every modeled water year) tables are presented for EC percent difference at the five south Delta export locations.

The location of X2 is part of the D-1641 compliance standards, so the location was calculated for the three scenarios, as the change in inflow and export operations between the scenarios will result in a change in X2 location. According to the criteria specified in (SWRCB 1999), eastward changes in Monthly Average X2 position (positive values in our analysis) of 1.1 km are not significant in general, and in Critically Dry years an eastward movement of 3.0 km is not significant.

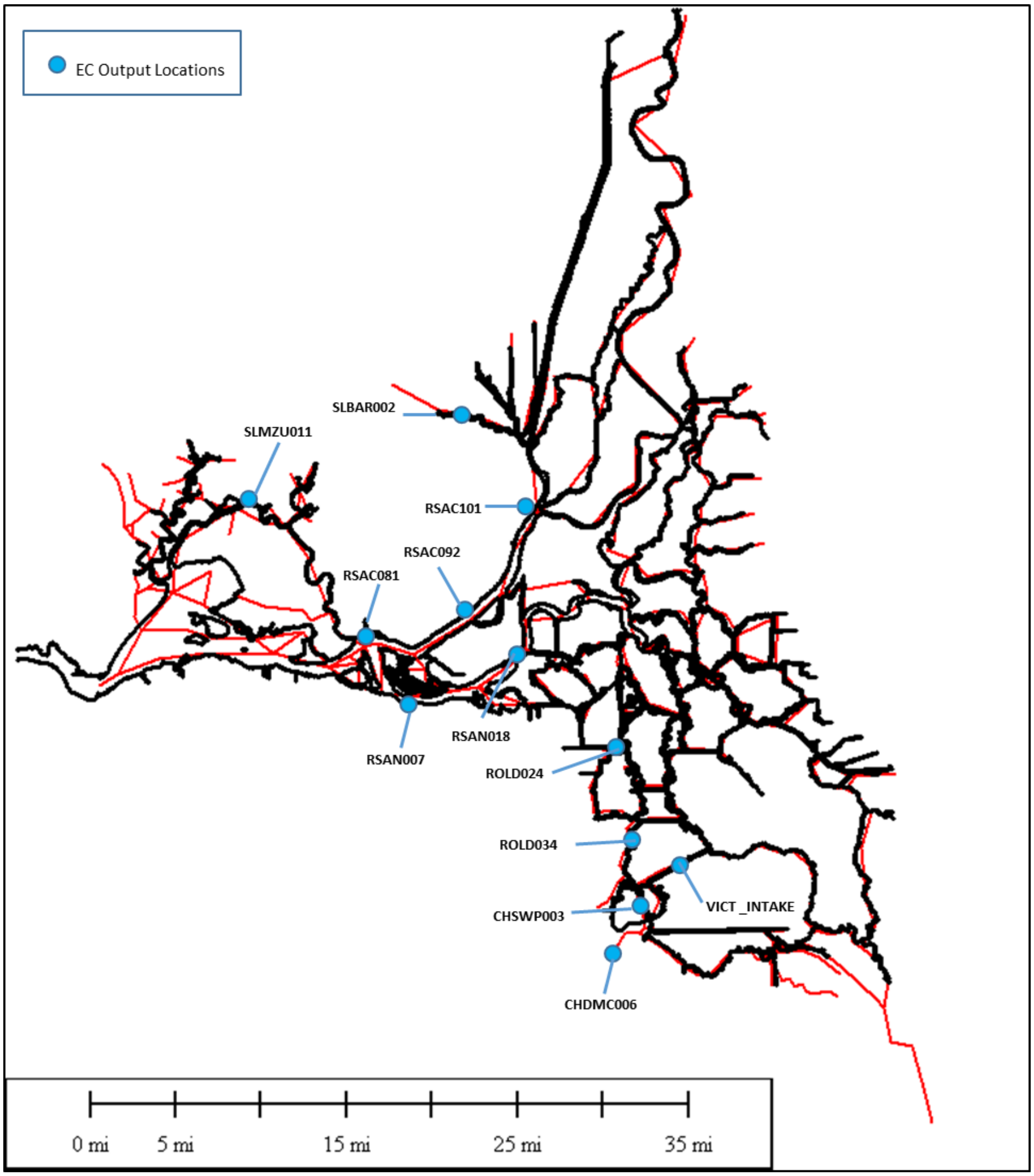
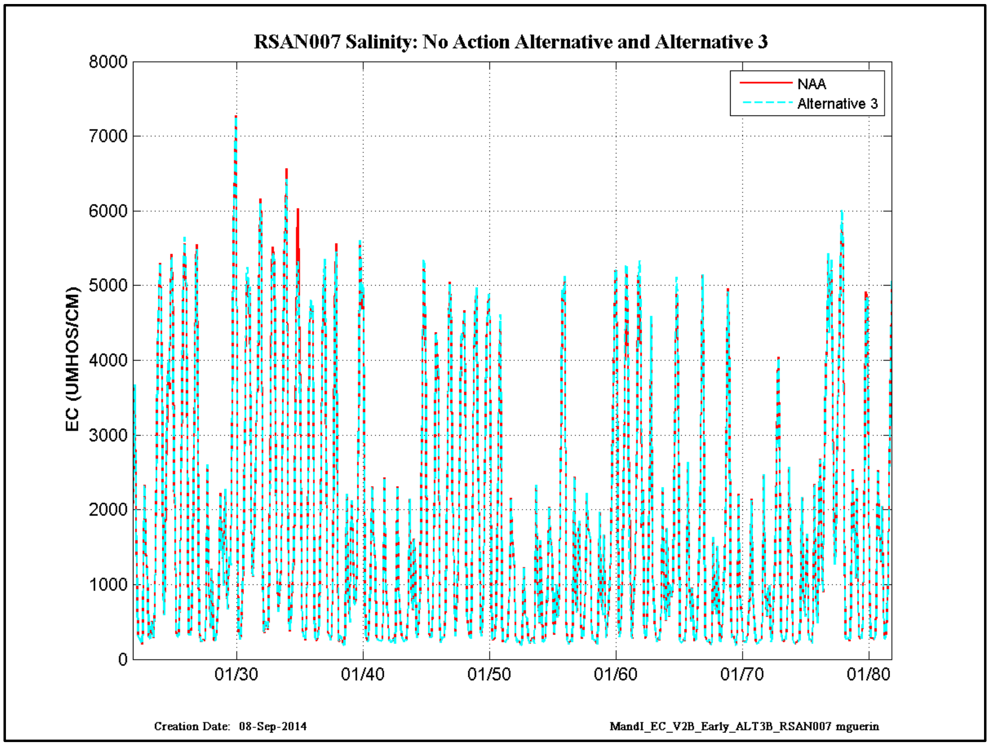


Figure C-12. DSM2 model output locations (approximate) analyzed for EC



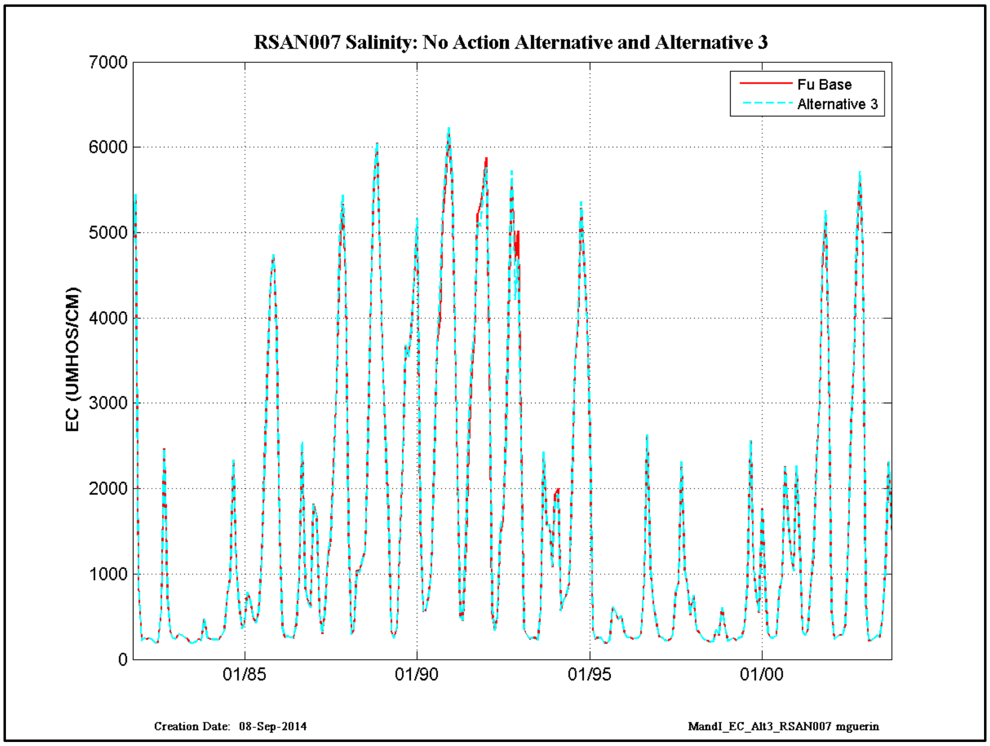
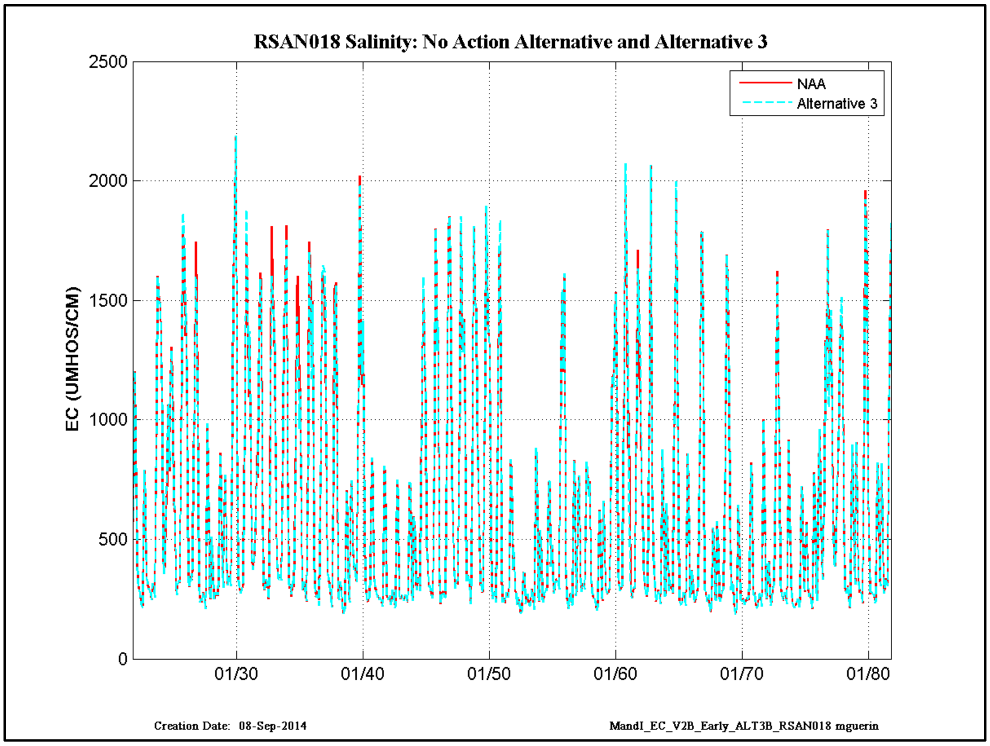


Figure C-13. RSAN007 (Antioch) EC results for the No Action Alternative and Alternative 3, for early (1921 -1980) and late (1981 – 2003) time frames



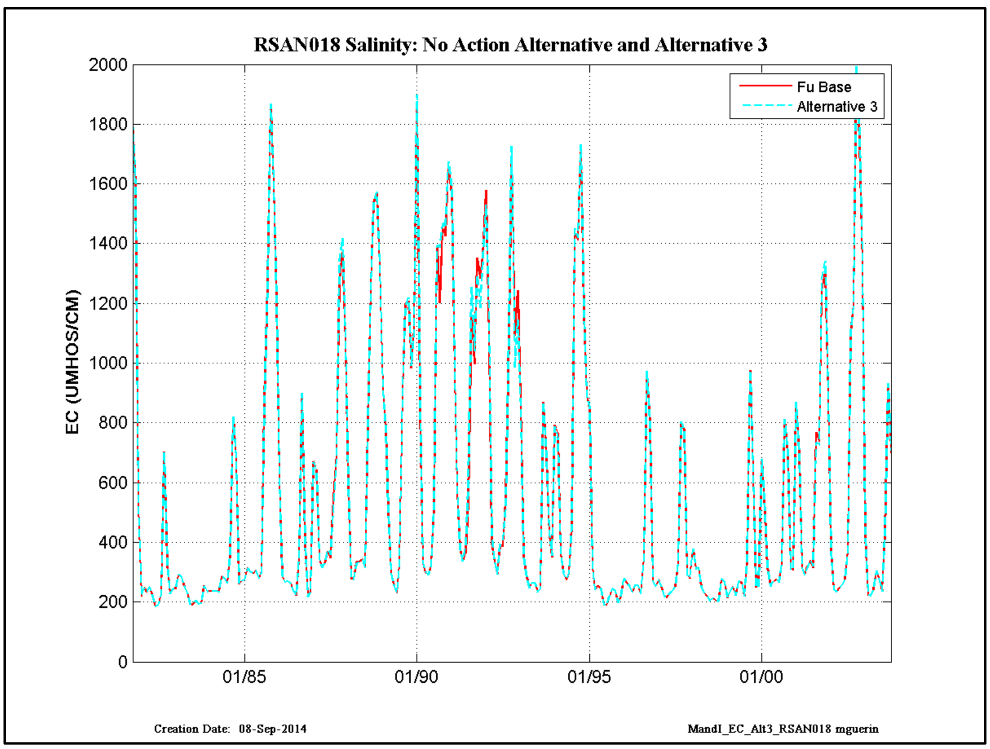
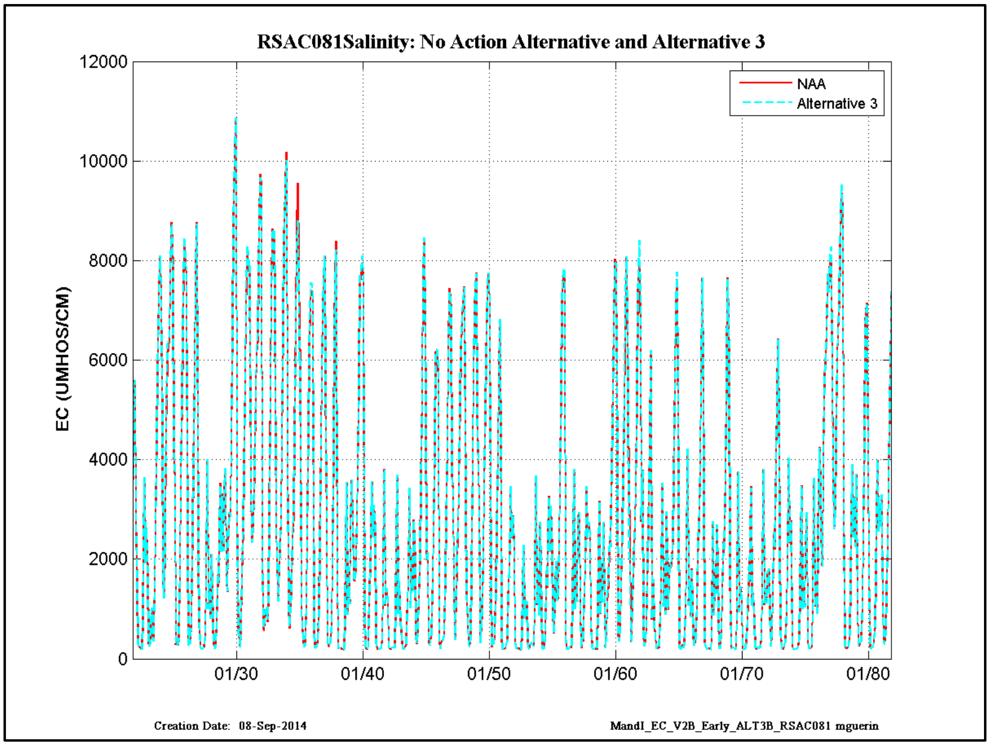


Figure C-14. RSAN018 (Jersey Point) EC results for the No Action Alternative and Alternative 3, for early (1921 -1980) and late (1981 – 2003) time frames



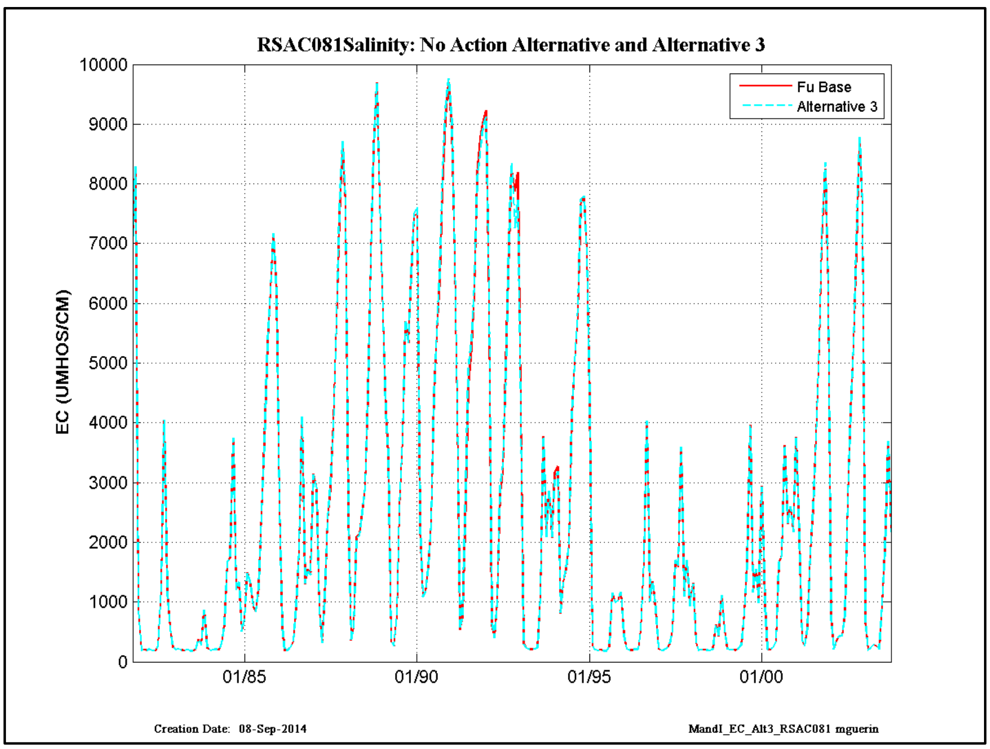
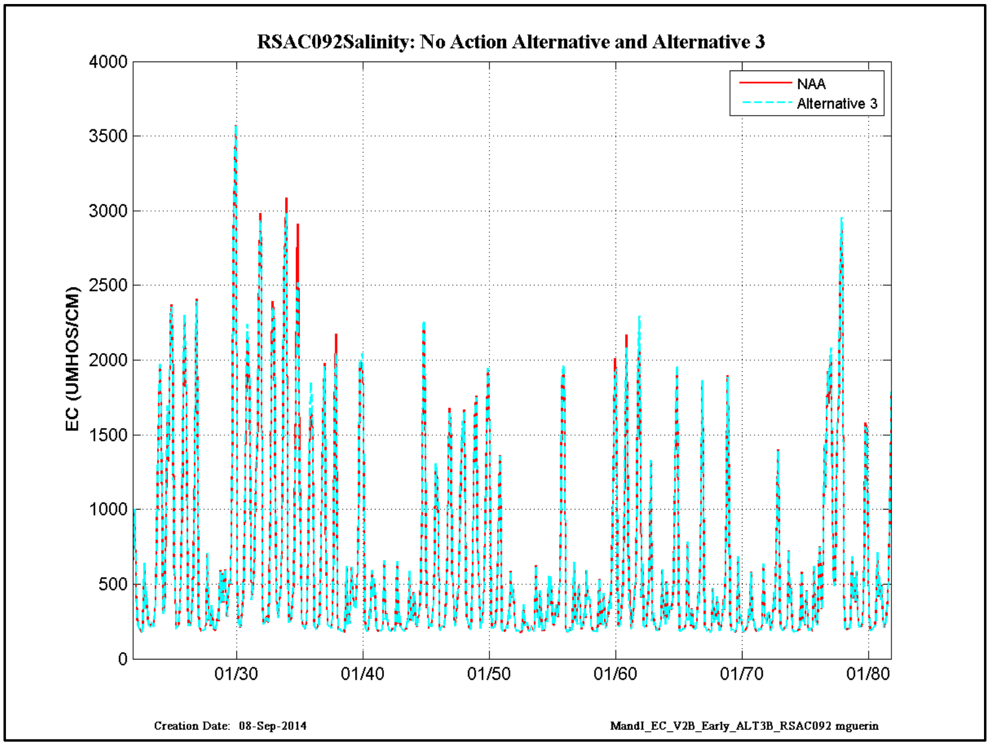


Figure C-15. RSAC081 (Collinsville) EC results for the No Action Alternative and Alternative 3, for early (1921 -1980) and late (1981 – 2003) time frames



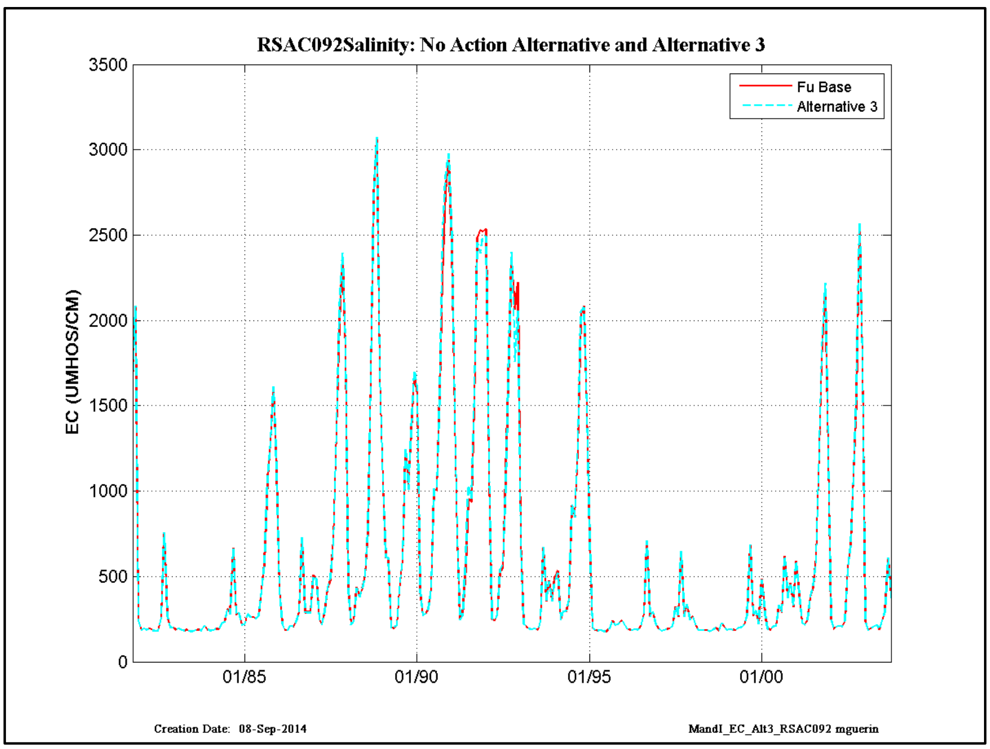
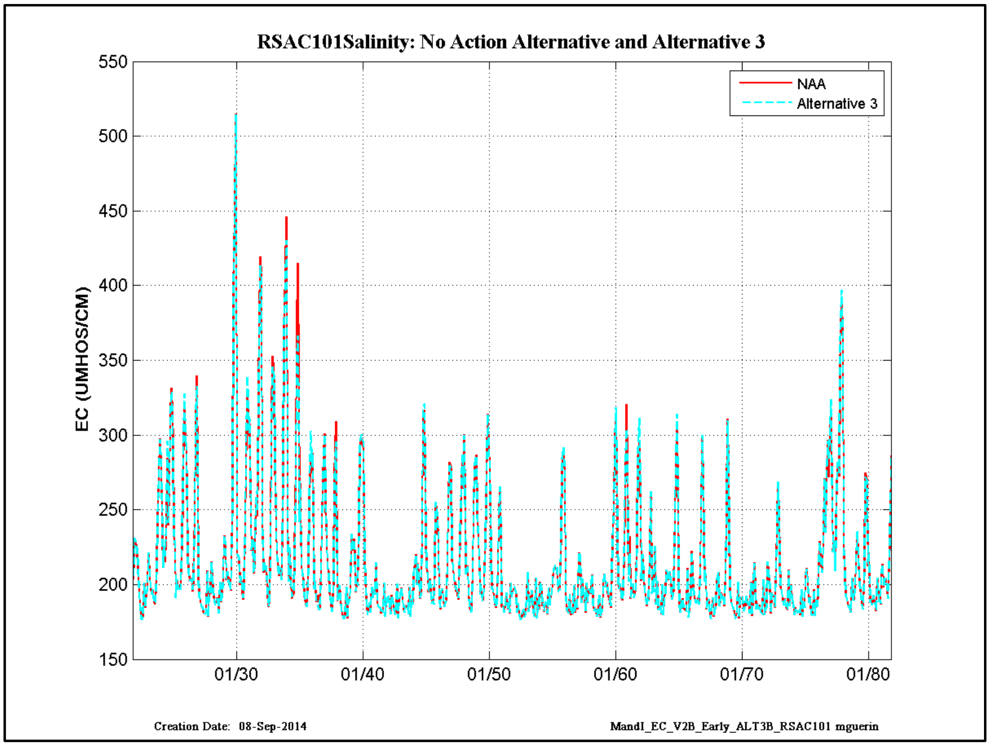


Figure C-16. RSAC092 (Emmaton) EC results for the No Action Alternative and Alternative 3, for early (1921 -1980) and late (1981 – 2003) time frames



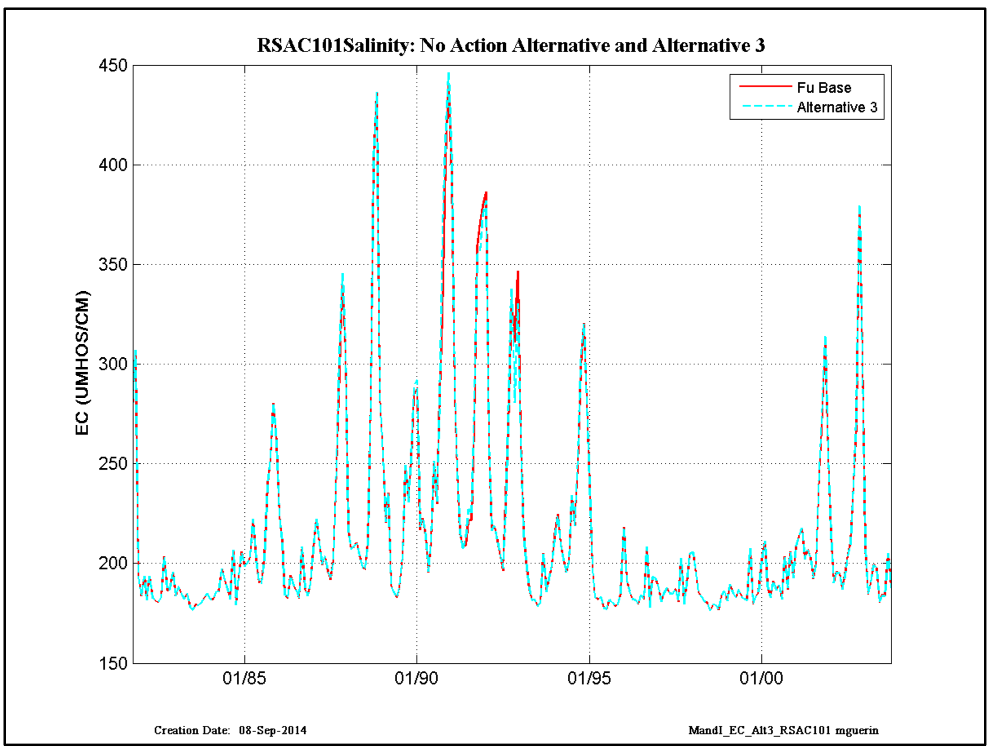
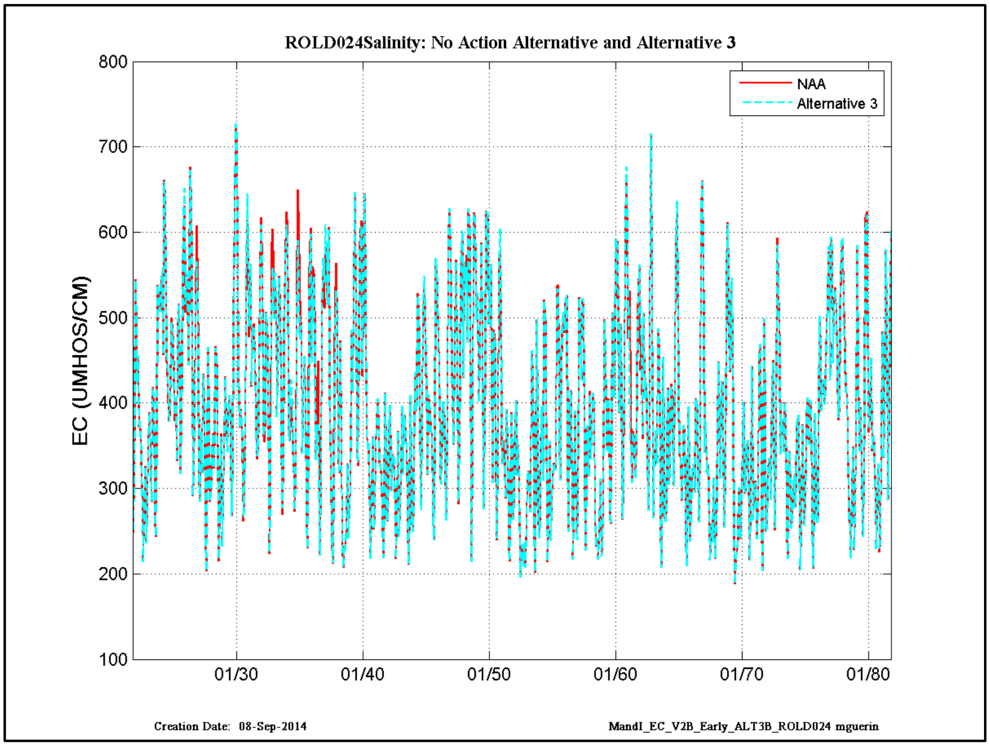


Figure C-17. RSAC101 (Rio Vista) EC results for the No Action Alternative and Alternative 3, for early (1921 -1980) and late (1981 – 2003) time frames



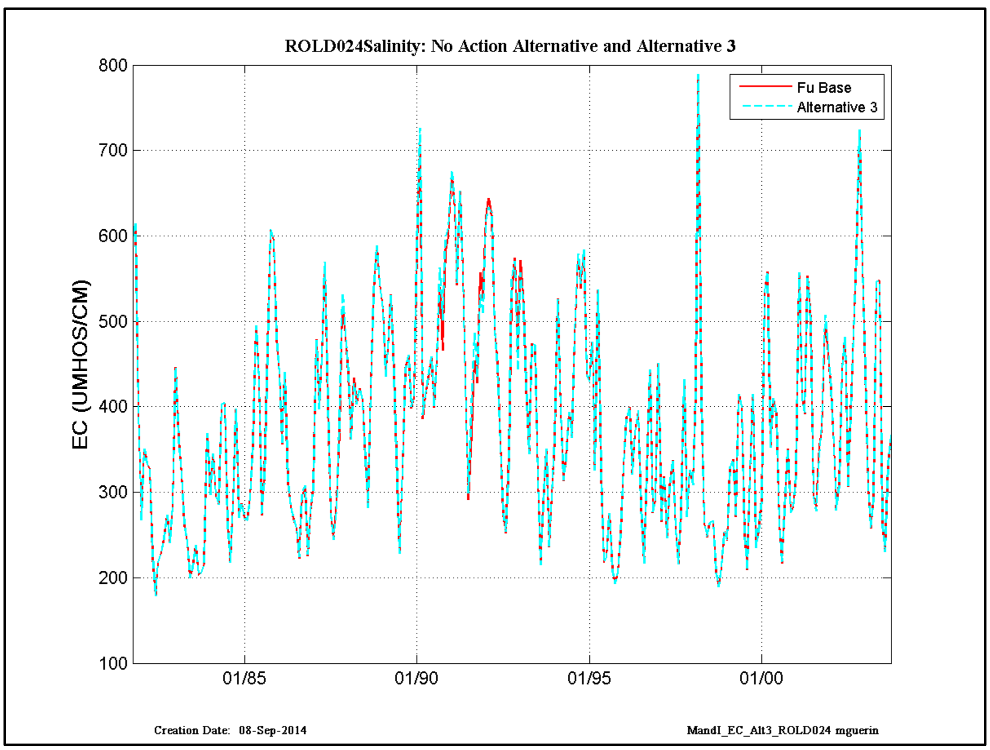
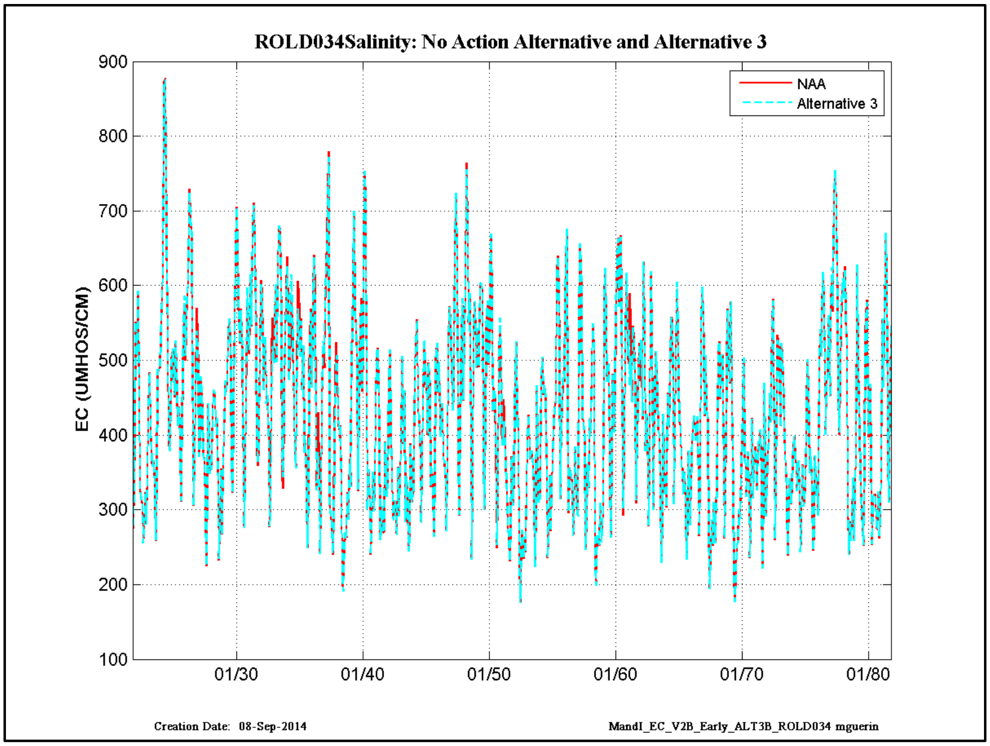


Figure C-18. ROLD024 (Old River at Bacon, CCWD Rock Slough location) EC results for the No Action Alternative and Alternative 3, for early (1921 - 1980) and late (1981 – 2003) time frames



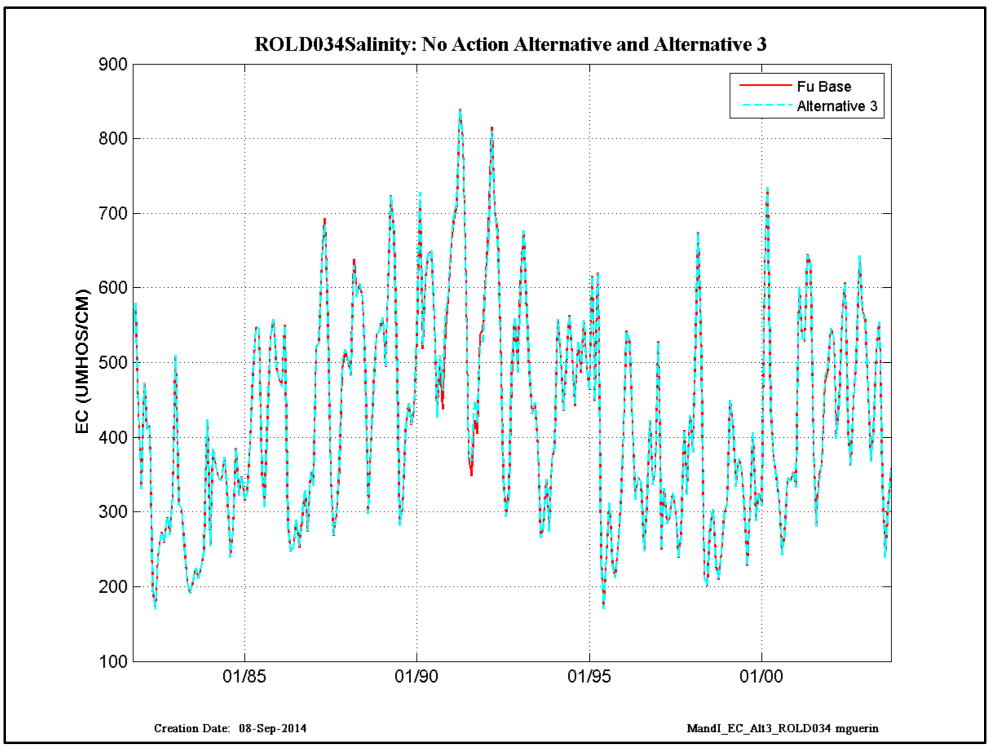
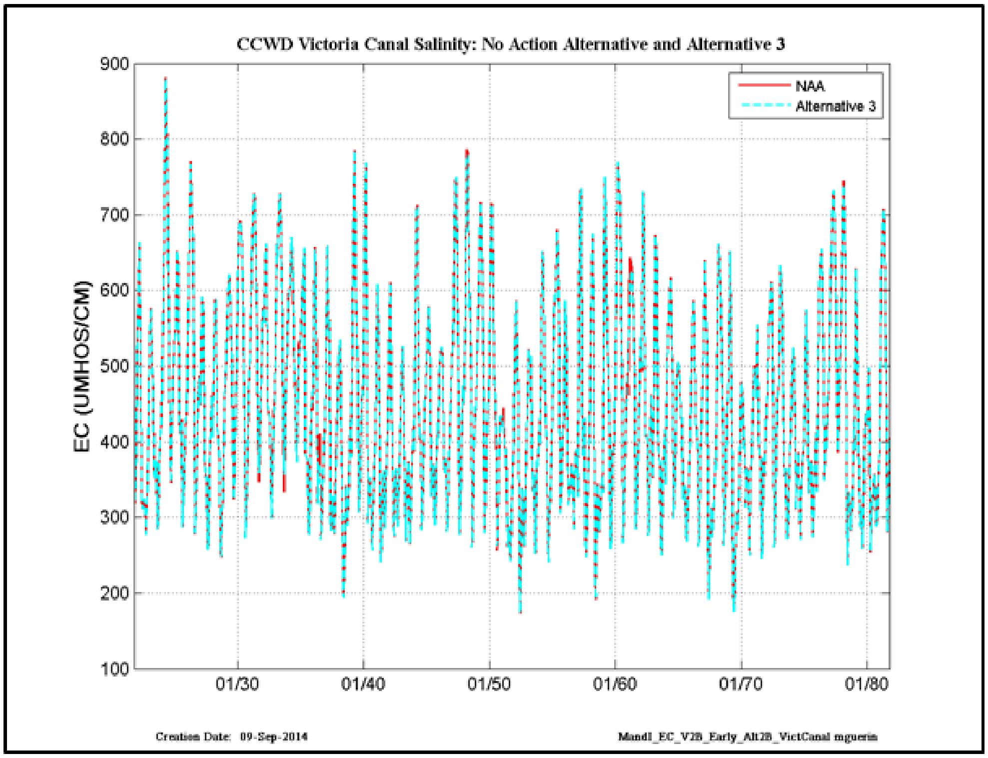


Figure C-19. ROLD034 (Old River near Byron, CCWD intake location) EC results for the No Action Alternative and Alternative 3, for early (1921 -1980) and late (1981 – 2003) time frames



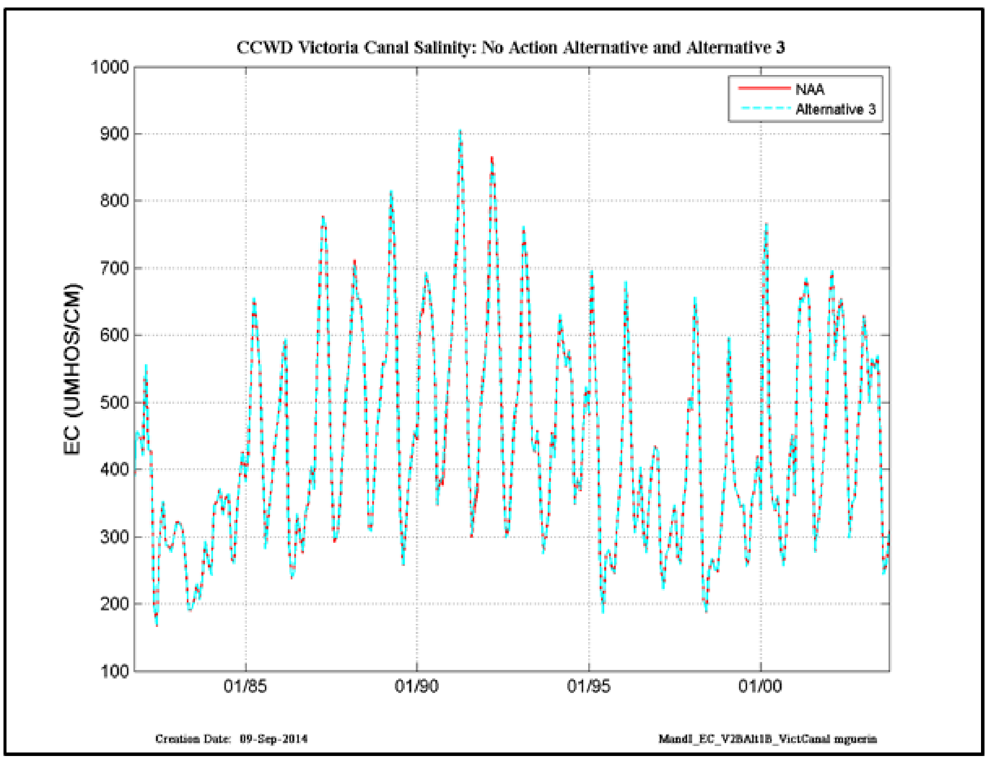
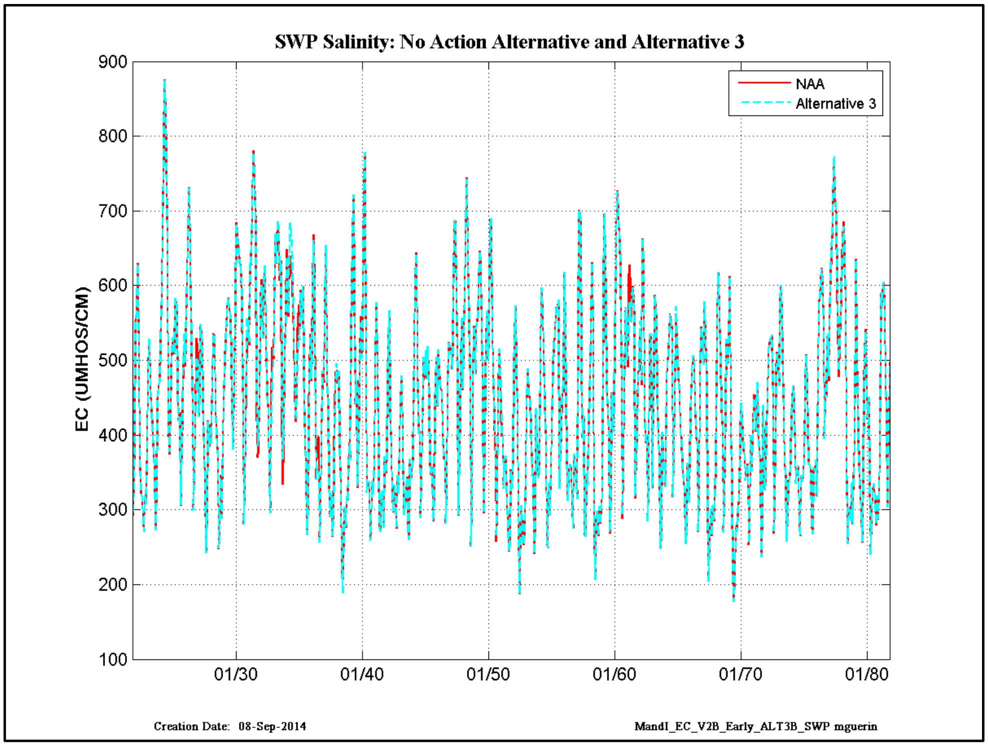


Figure C-20. VICT_INTAKE (Victoria Canal, CCWD intake location) EC results for the No Action Alternative and Alternative 3, for early (1921 -1980) and late (1981 – 2003) time frames



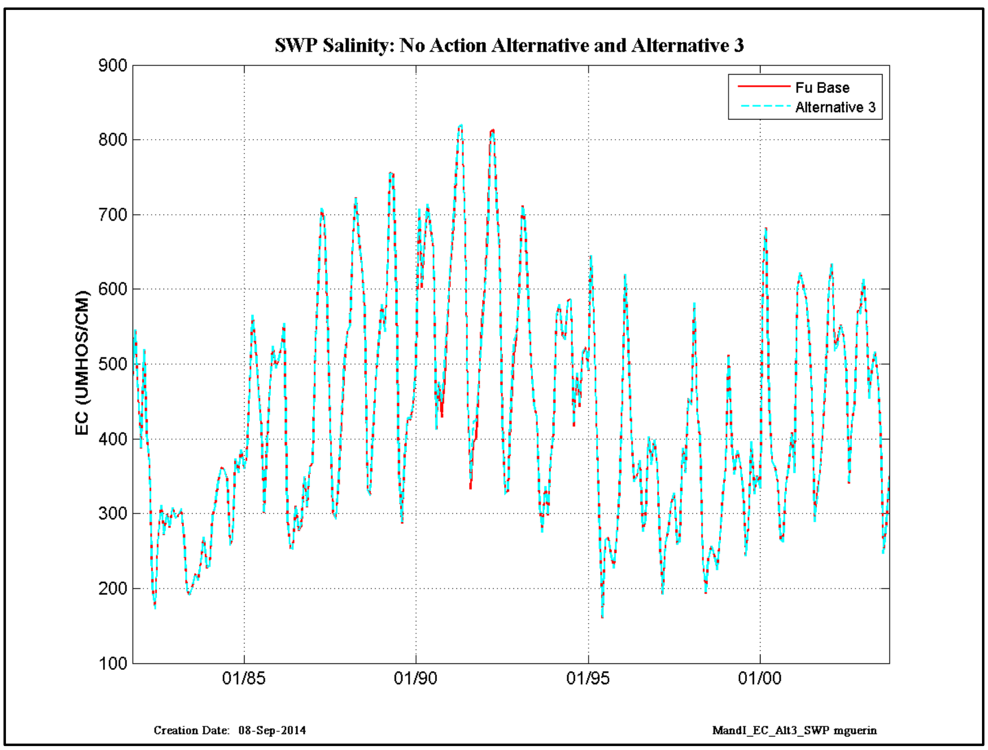
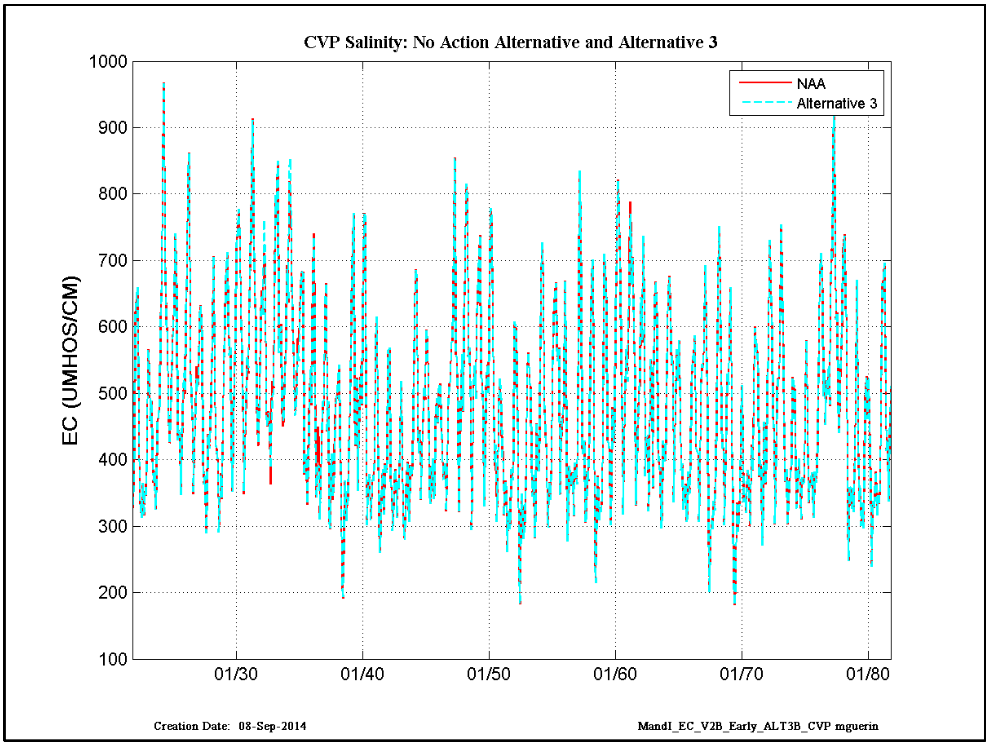


Figure C-21. CHSWPOO3 (SWP intake EC) EC results for the No Action Alternative and Alternative 3, for early (1921 -1980) and late (1981 – 2003) time frames



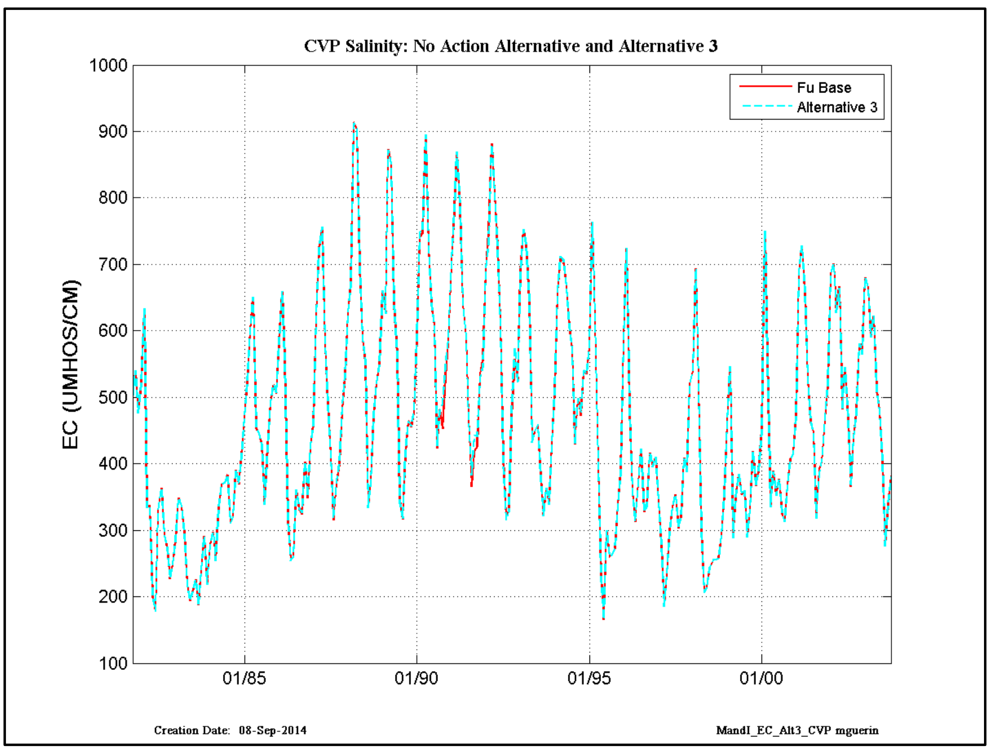
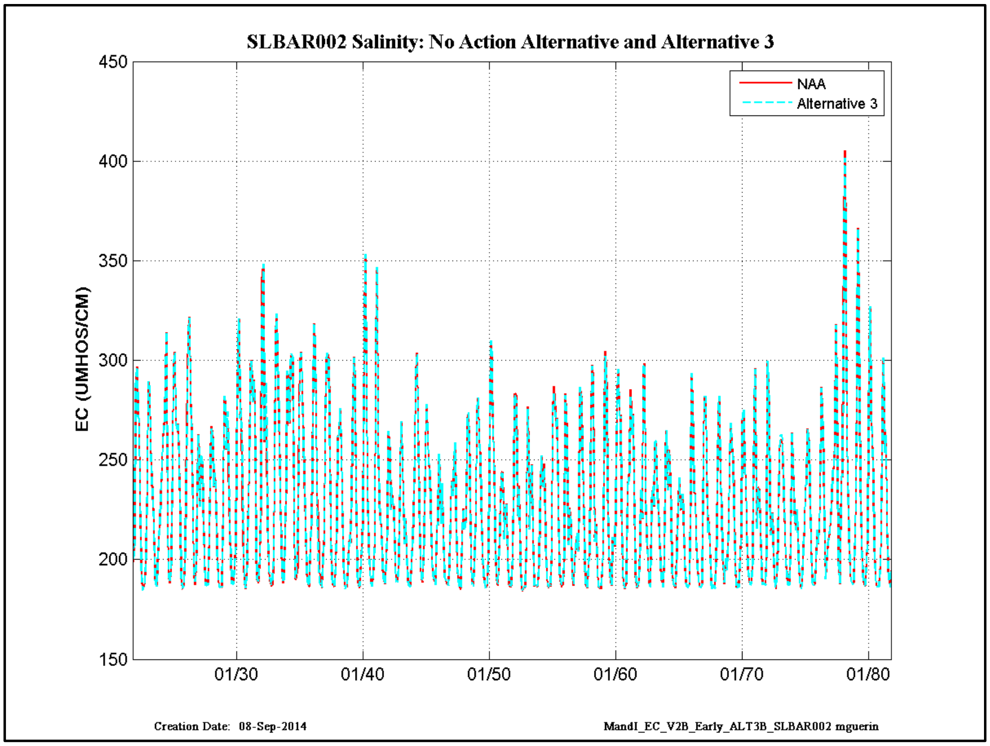


Figure C-22. CHDMC006 (entrance to CVP water intake) EC results for the No Action Alternative and Alternative 3, for early (1921 -1980) and late (1981 – 2003) time frames



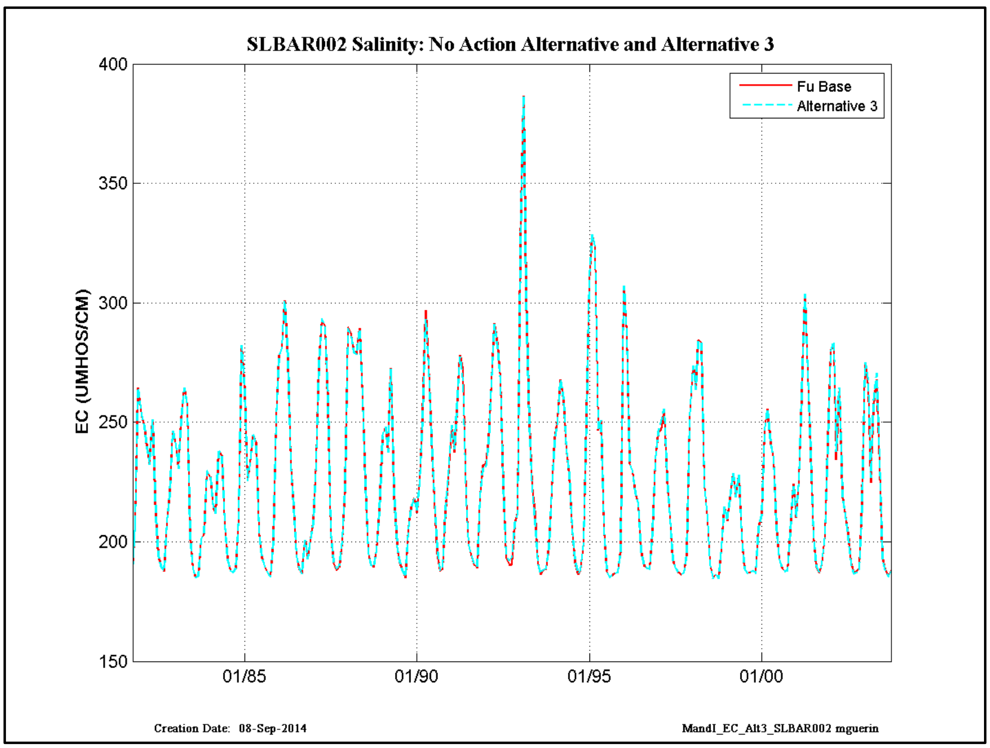
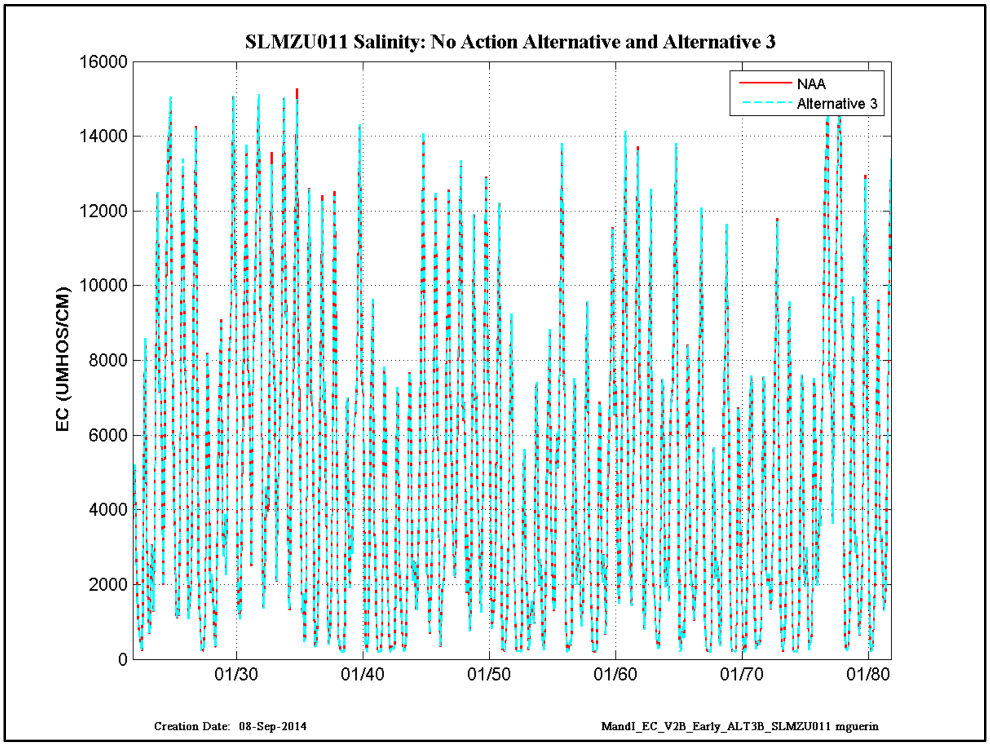


Figure C-23. SLBAR002 (Barker Slough) EC results for the No Action Alternative and Alternative 3, for early (1921 -1980) and late (1981 – 2003) time frames



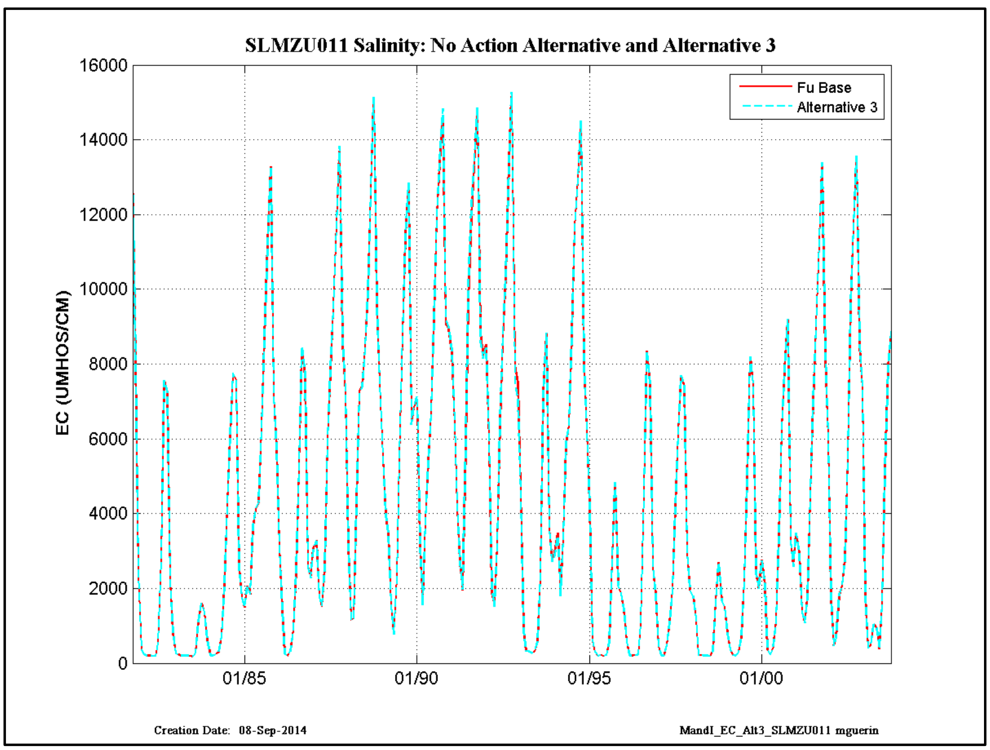
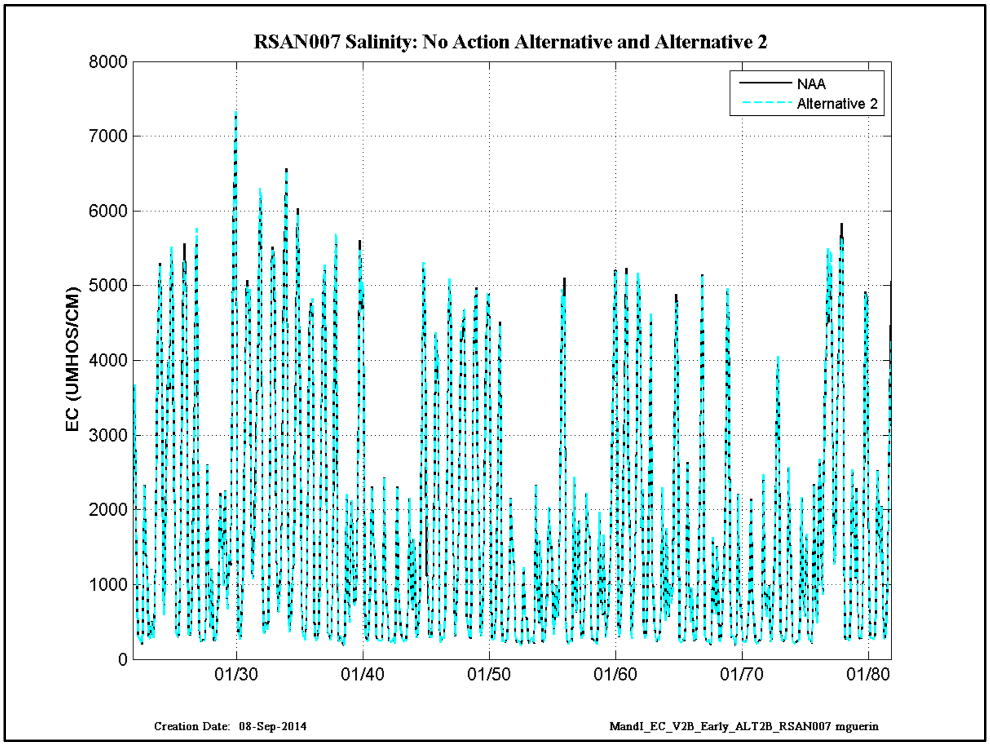


Figure C-24. SLMZU011 (Montezuma Slough at Beldon's Landing) EC results for the No Action Alternative and Alternative 3, for early (1921 -1980) and late (1981 – 2003) time frames



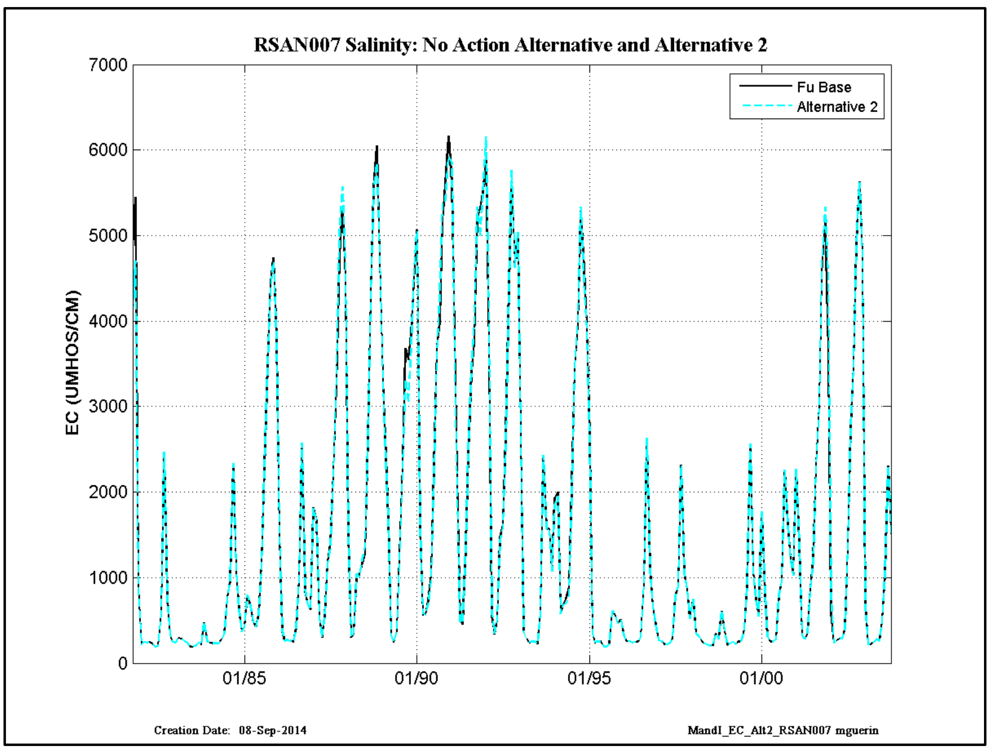
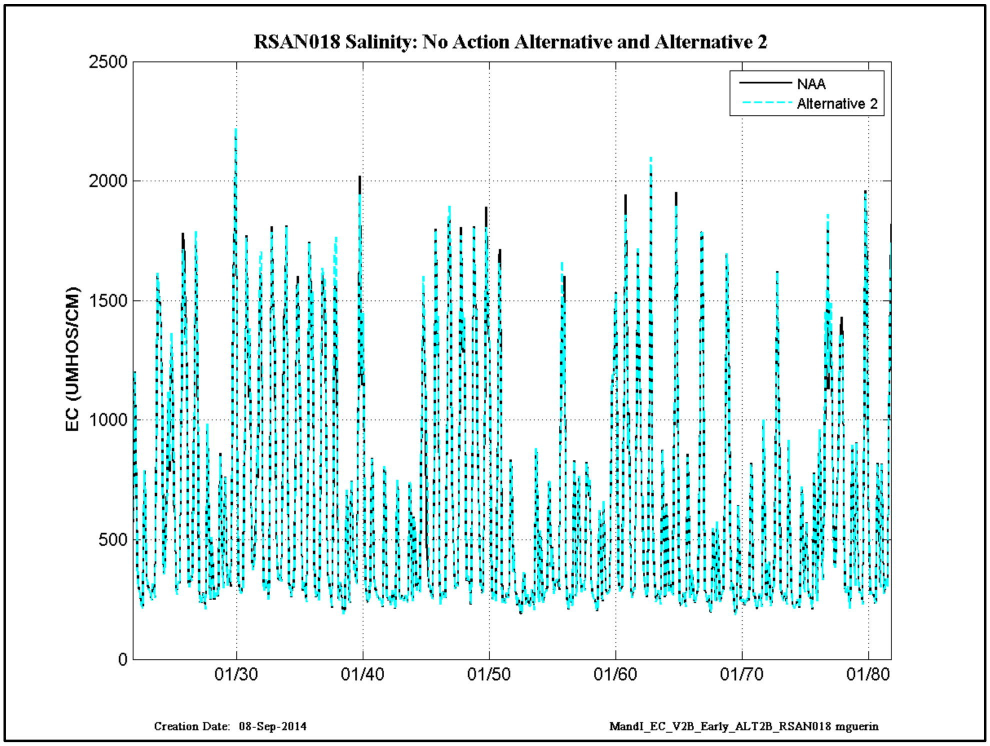


Figure C-25. RSAN007 (Antioch) EC results for the No Action Alternative and Alternative 2, for early (1921 -1980) and late (1981 – 2003) time frames



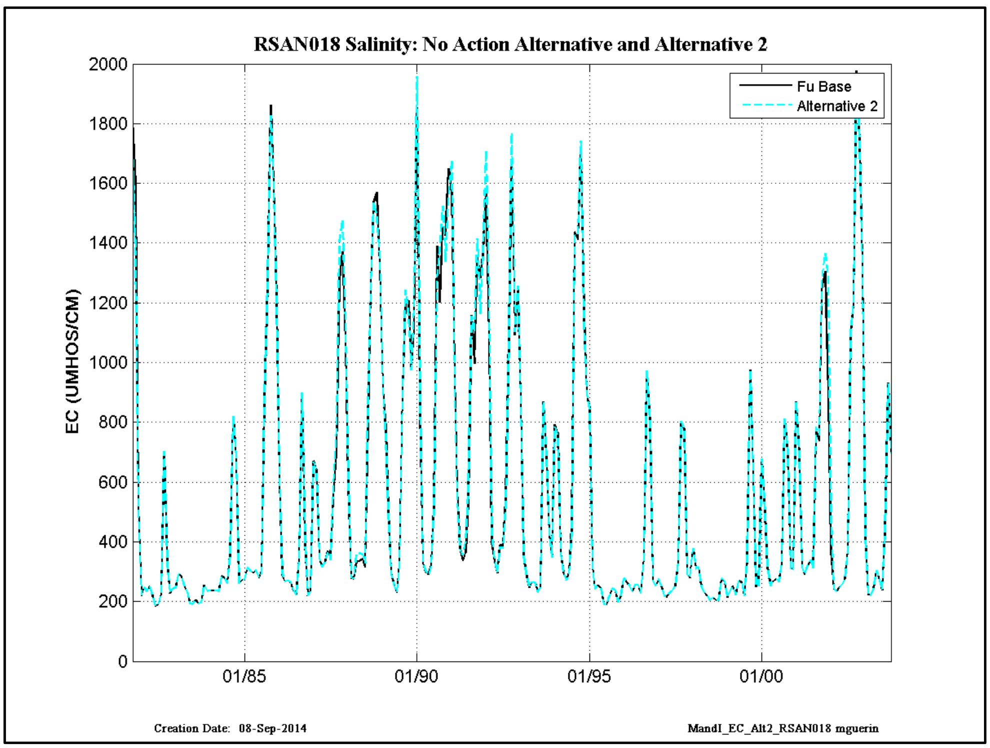
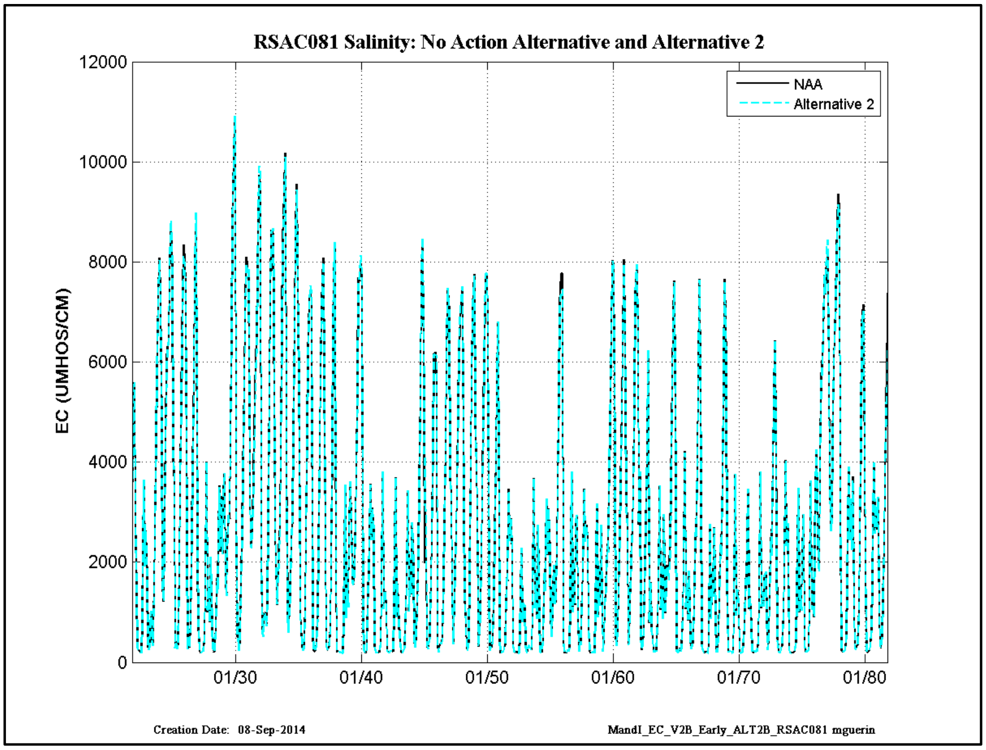


Figure C-26. RSAN018 (Jersey Point) EC results for the No Action Alternative and Alternative 2, for early (1921 -1980) and late (1981 – 2003) time frames



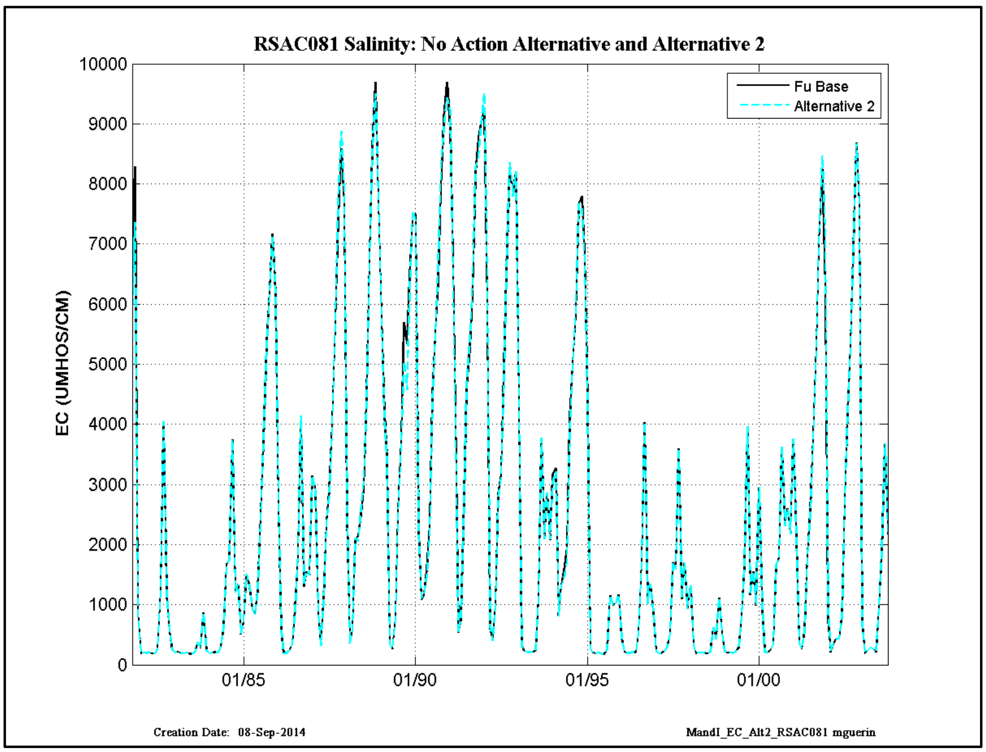
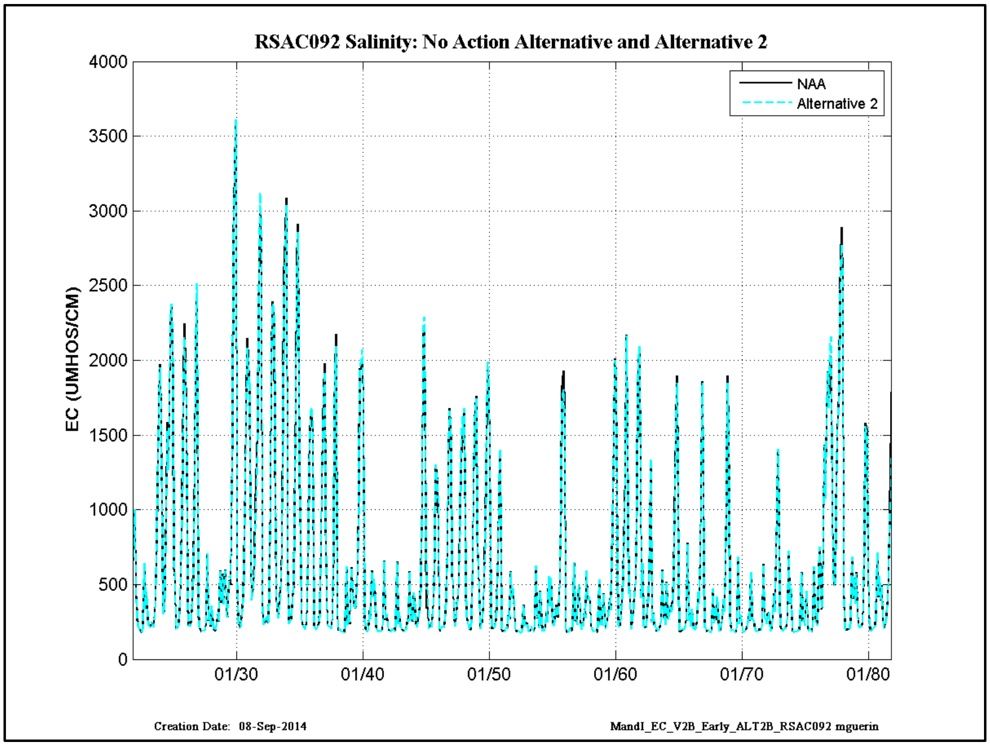


Figure C-27. RSAC081 (Collinsville) EC results for the No Action Alternative and Alternative 2, for early (1921 -1980) and late (1981 – 2003) time frames



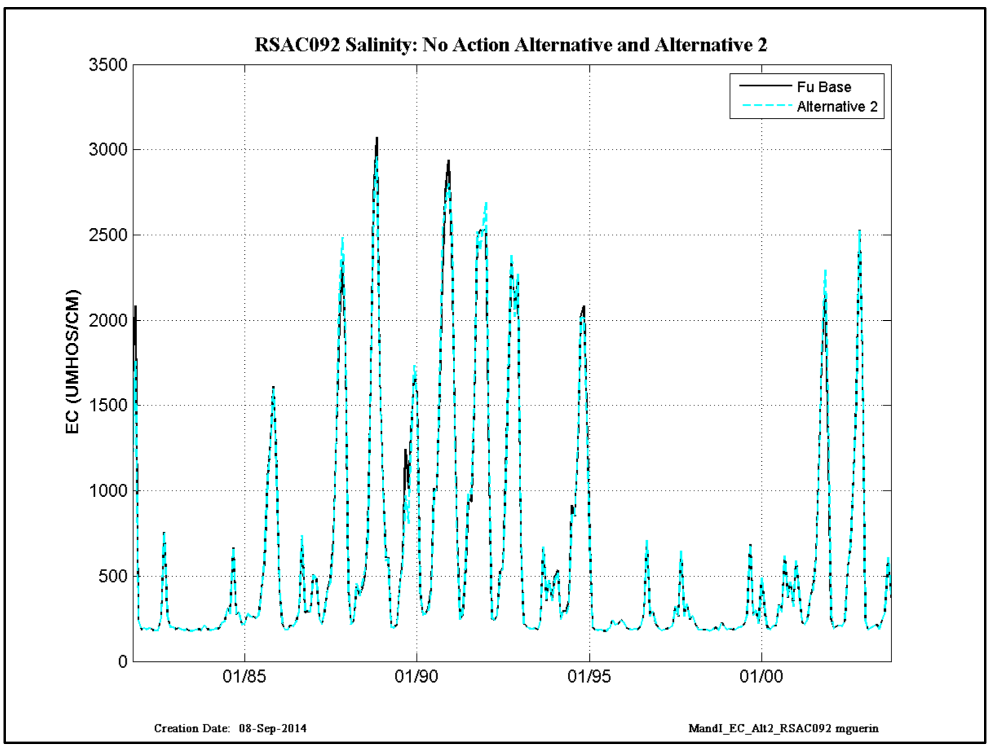
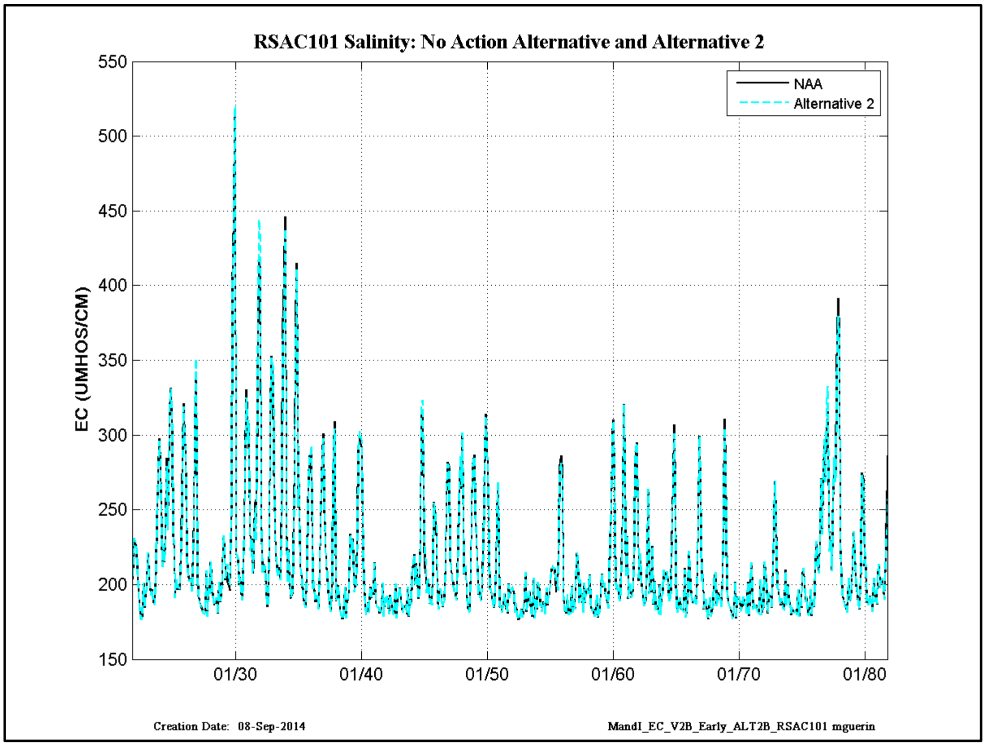


Figure C-28. RSAC092 (Emmaton) EC results for the No Action Alternative and Alternative 2, for early (1921 -1980) and late (1981 – 2003) time frames



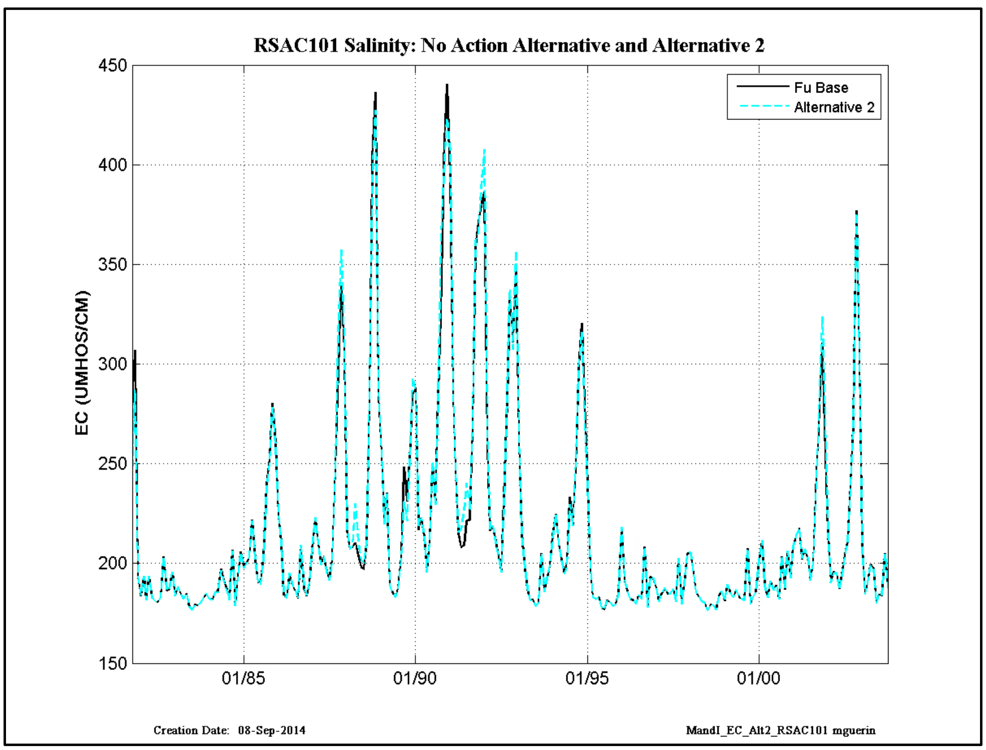
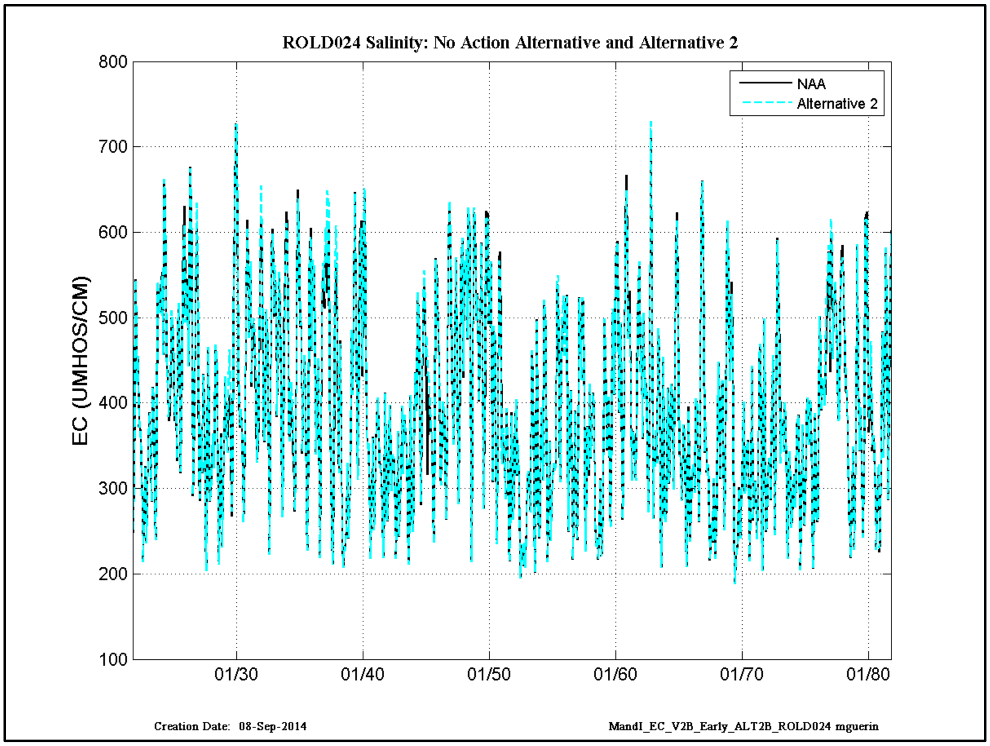


Figure C-29. RSAC101 (Rio Vista) EC results for the No Action Alternative and Alternative 2, for early (1921 -1980) and late (1981 – 2003) time frames



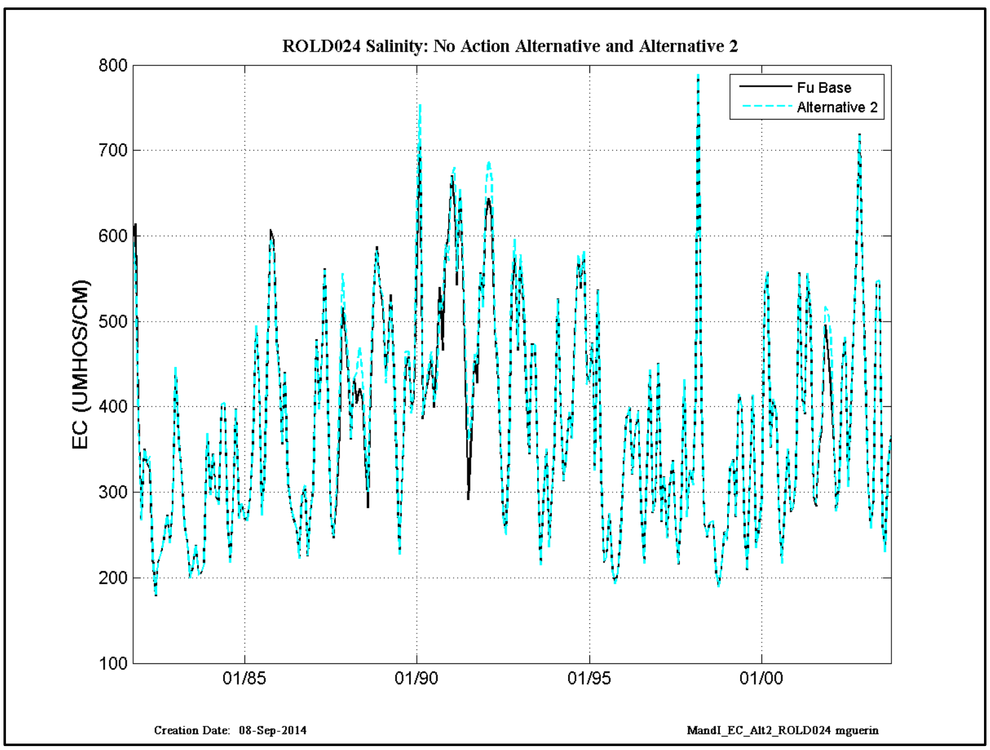
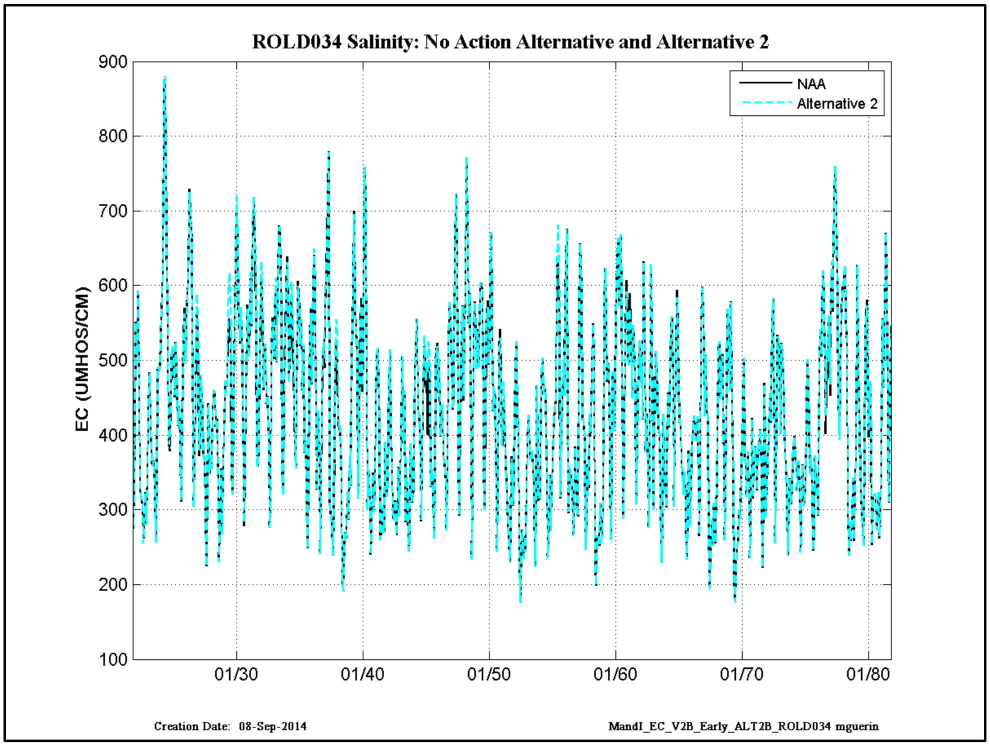


Figure C-30. ROLD024 (Old River at Bacon, CCWD intake) EC results for the No Action Alternative and Alternative 2, for early (1921 -1980) and late (1981 – 2003) time frames



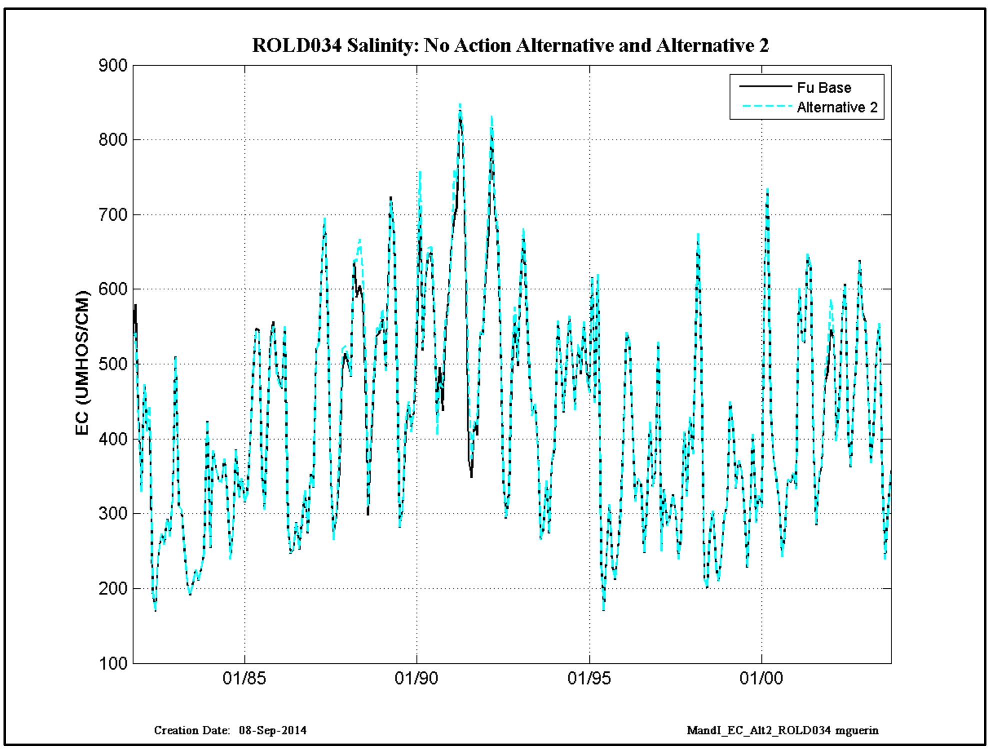
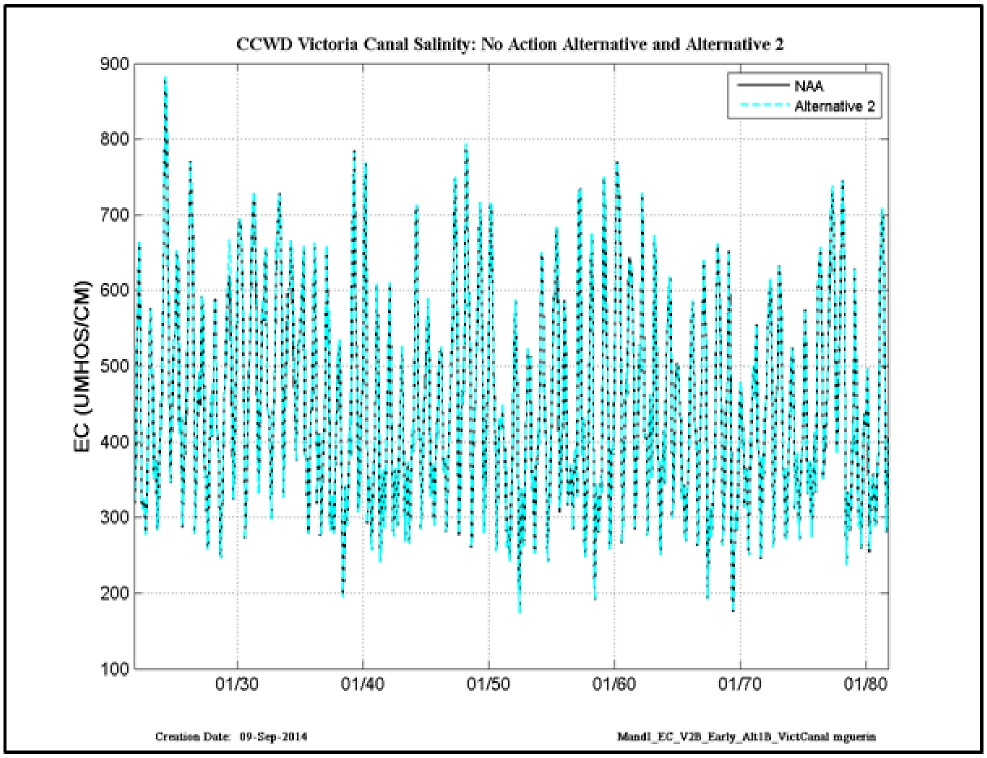


Figure C-31. ROLD034 (Old River at Byron, CCWD intake) EC results for the No Action Alternative and Alternative 2, for early (1921 -1980) and late (1981 – 2003) time frames



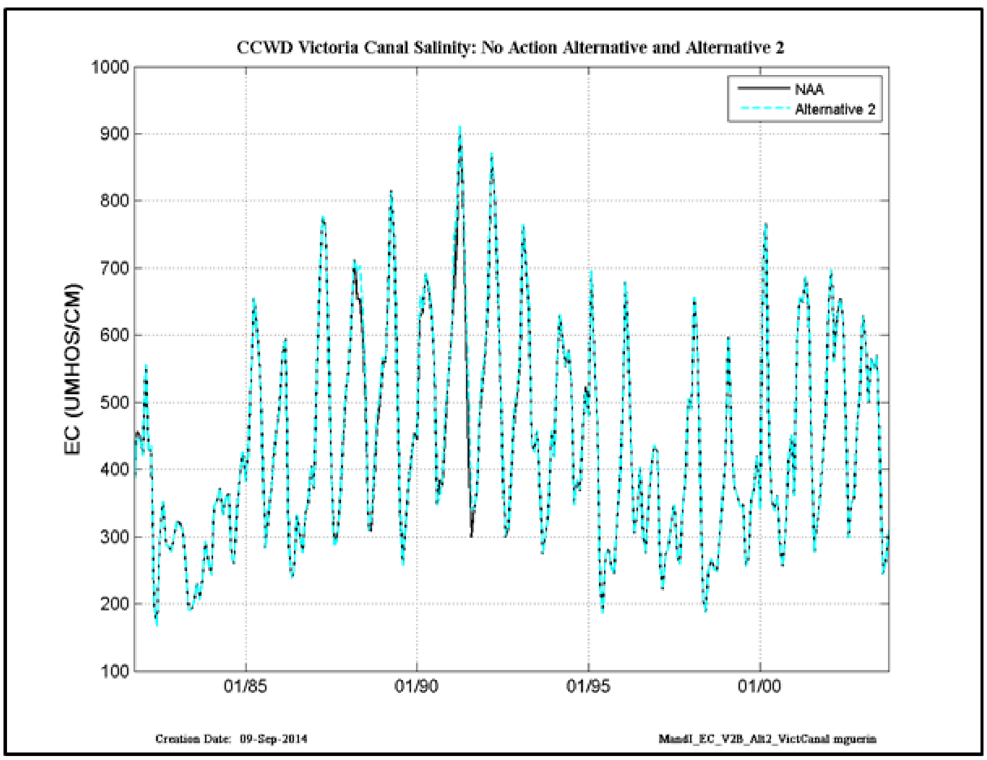
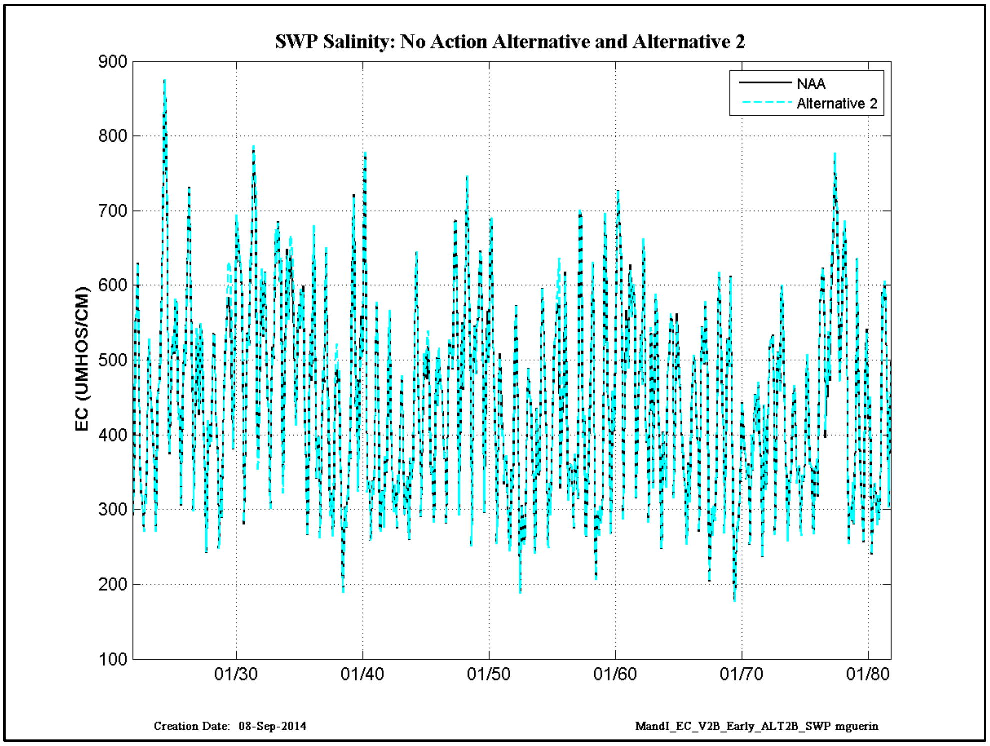


Figure C-32. VICT_INTAKE (CCWD intake in Victoria Canal) EC results for the No Action Alternative and Alternative 2, for early (1921 -1980) and late (1981 – 2003) time frames



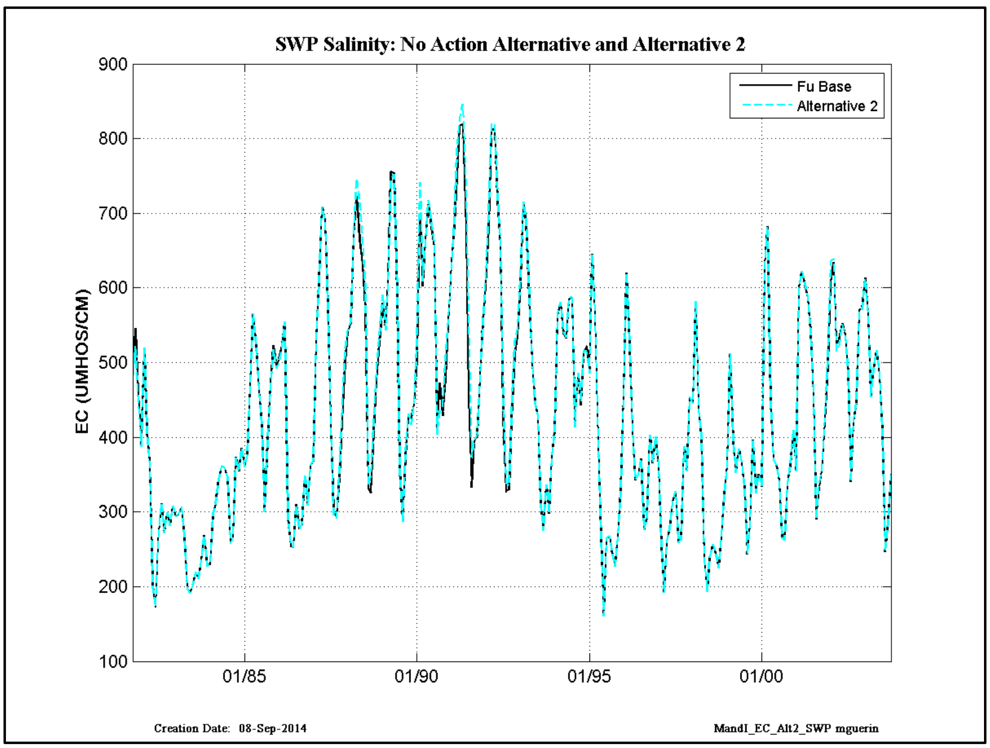
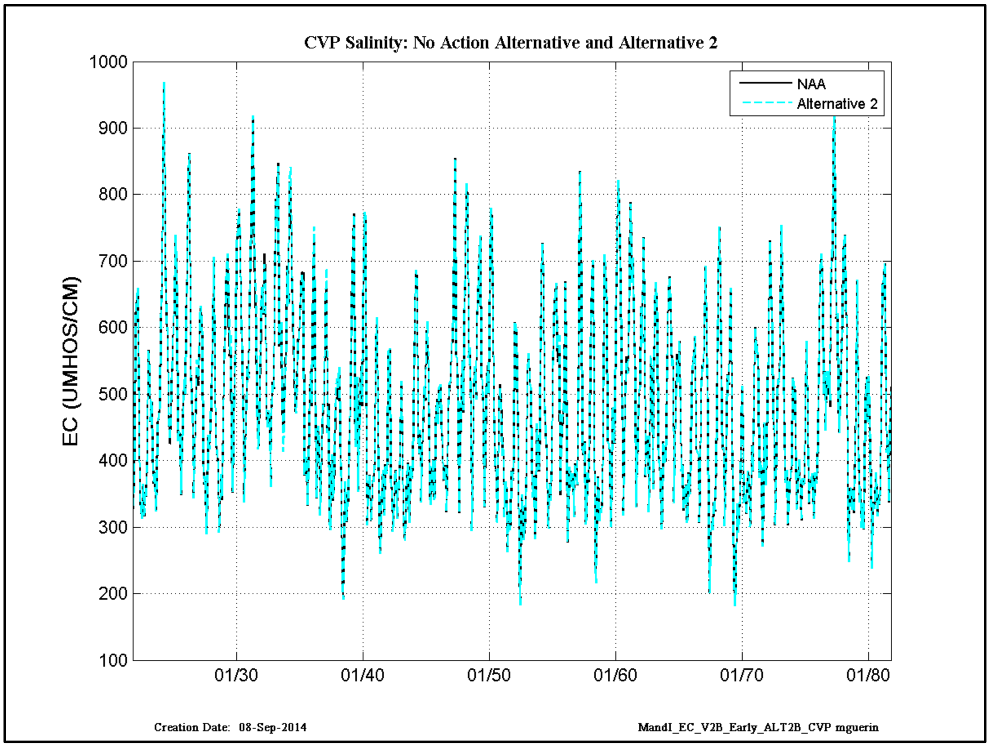


Figure C-33. CHSWP003 (SWP intake) EC results for the No Action Alternative and Alternative 2, for early (1921 -1980) and late (1981 – 2003) time frames



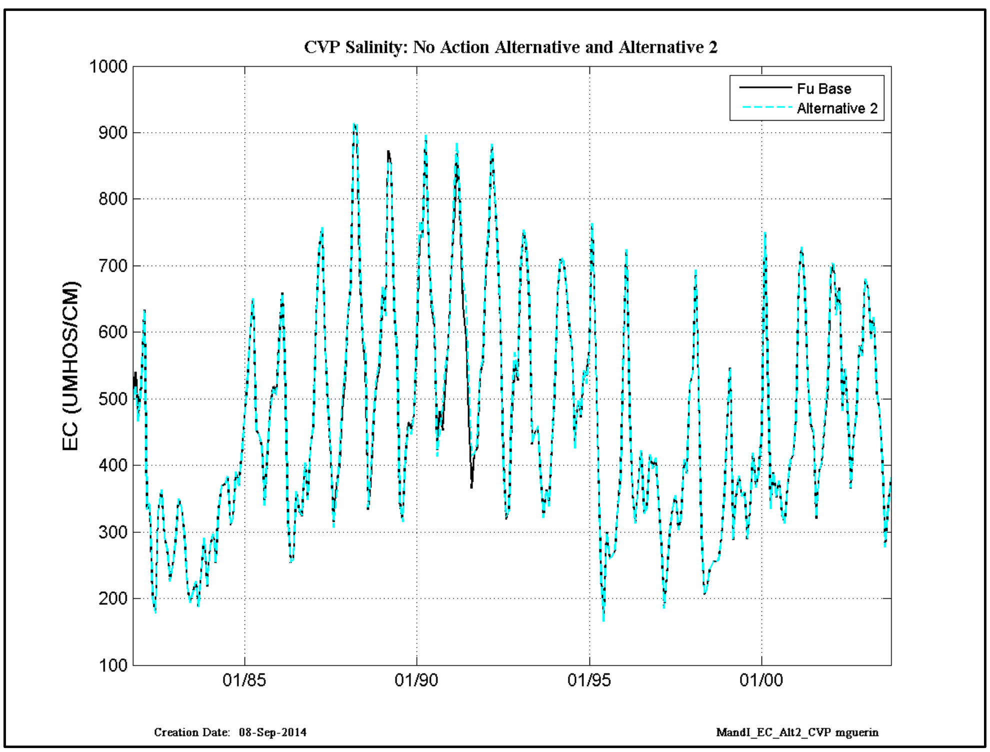
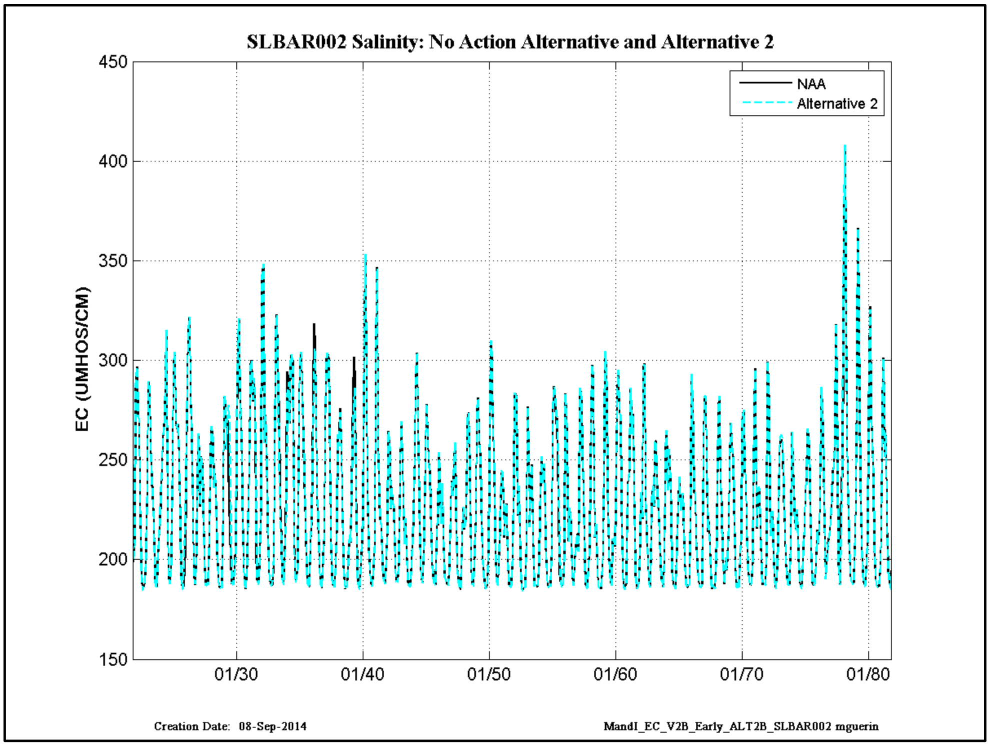


Figure C-34. CHDMC006 (CVP intake) EC results for the No Action Alternative and Alternative 2, for early (1921 -1980) and late (1981 – 2003) time frames



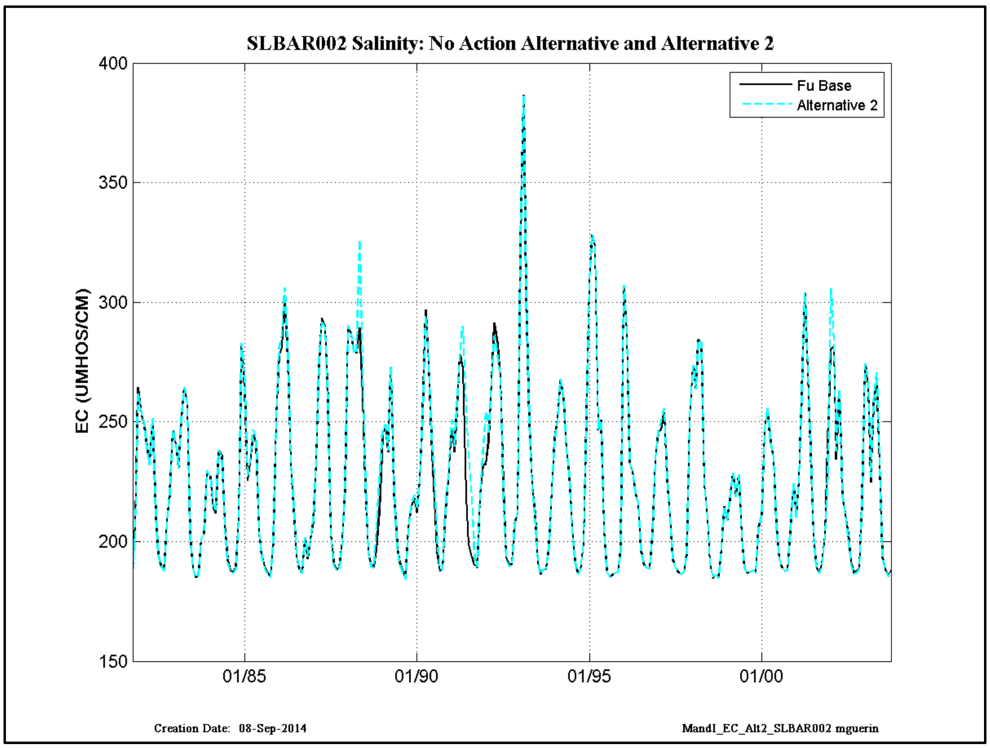


Figure C-35. SLBAR002 (Barker Slough) EC results for the No Action Alternative and Alternative 2, for early (1921 -1980) and late (1981 – 2003) time frames

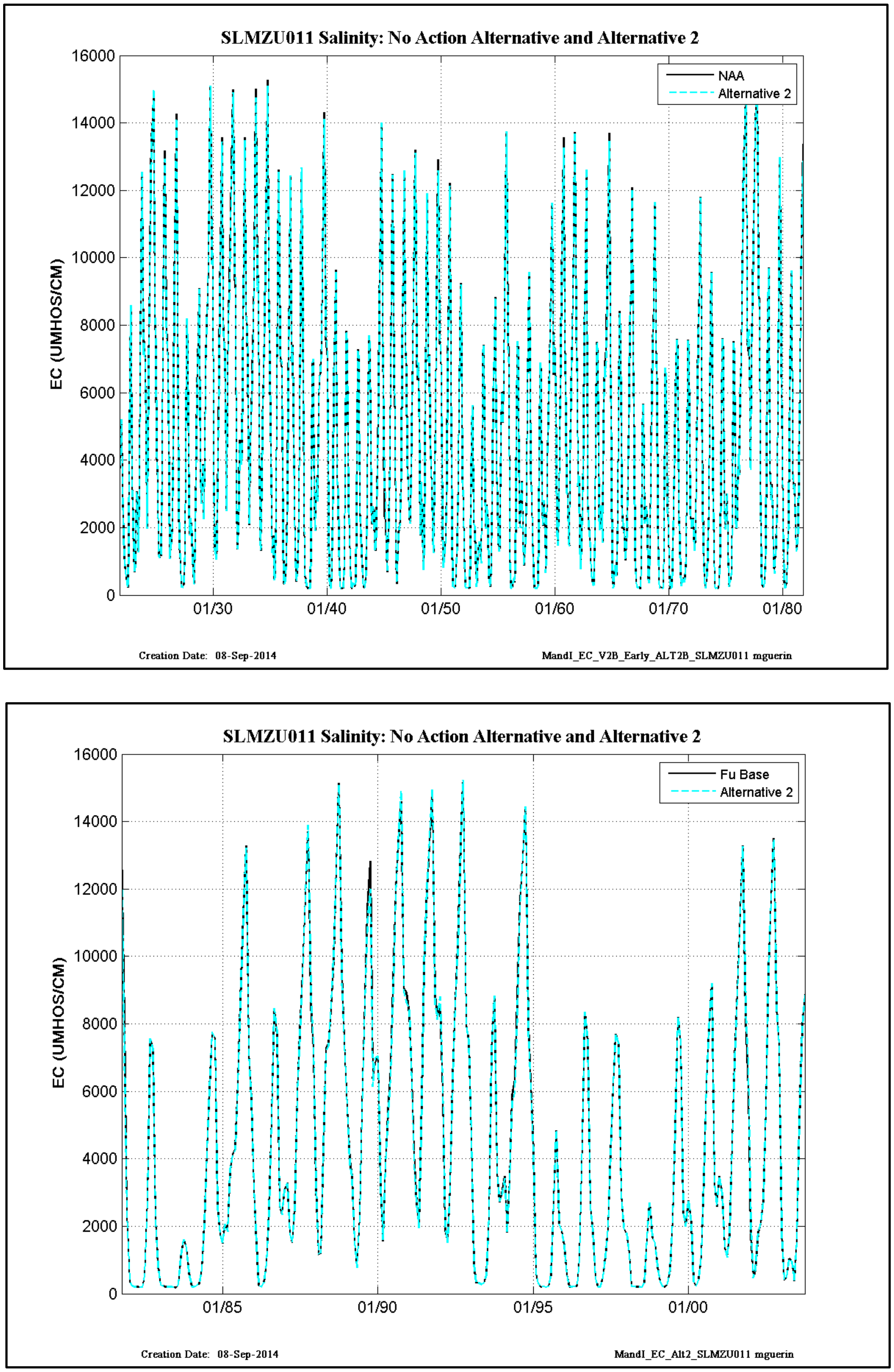


Figure C-36. SLMZU011 (Montezuma Slough at Beldon's Landing) EC results for the No Action Alternative and Alternative 2, for early (1921 -1980) and late (1981 – 2003) time frames

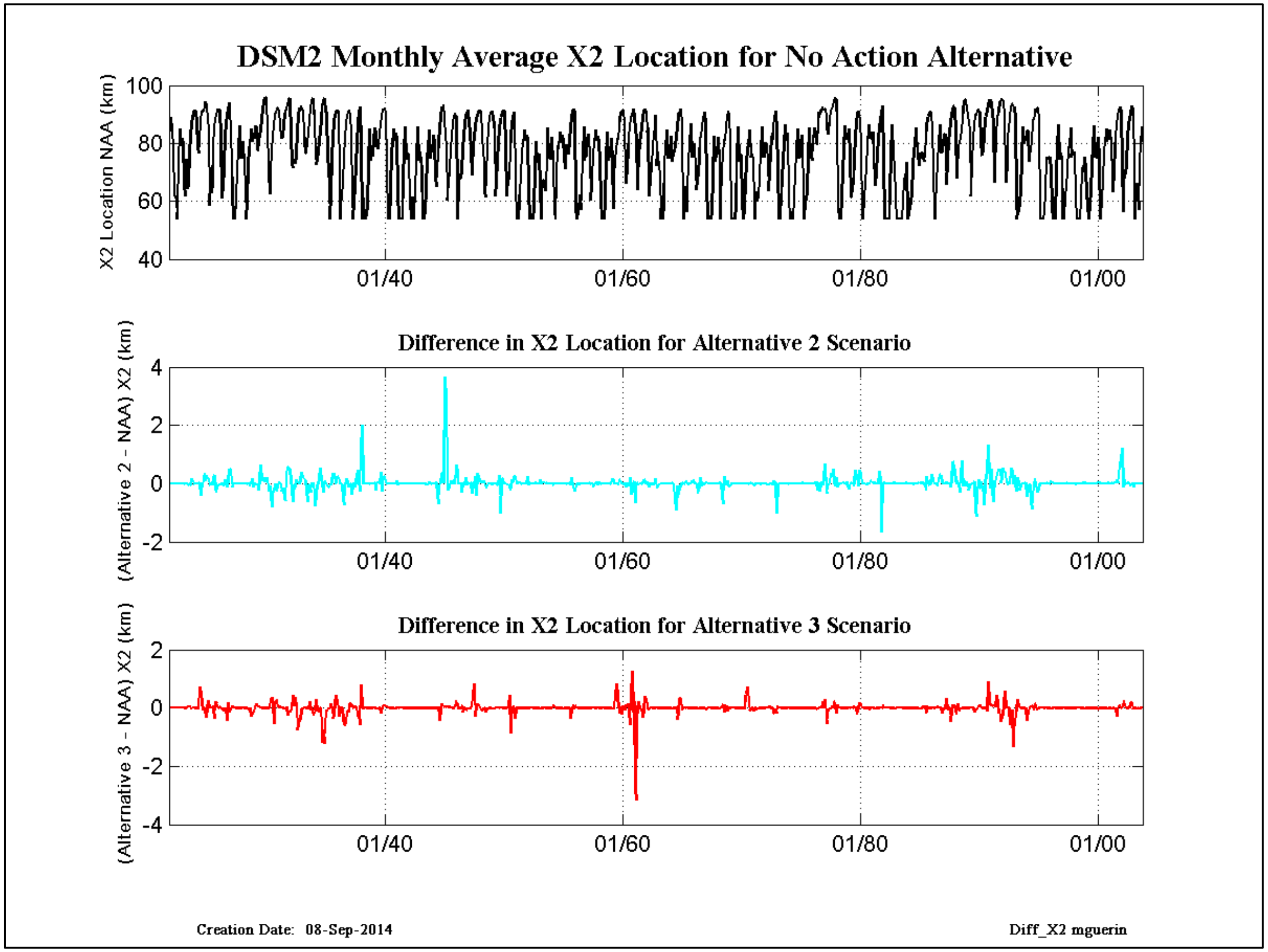


Figure C-37. DSM2 model output calculations for X2 location for the No Action Alternative (upper) and X2 change from No Action Alternative for Alternative 2 (Center) and Alternative 3 (lower)

An additional D-1641 compliance standard for modeled water level was also considered for completeness, as the Alternative operations may have changed stages near barriers in the south Delta. Decreases in stage can negatively affect agricultural operations if stage falls below agricultural intake levels. As mentioned in Chapter C.2.2, to monitor changes in water level upstream and downstream of south Delta barriers in the action alternatives, the minimum stage was calculated monthly for the three scenarios from the 15-minute model output. Results are presented in this document as the change from No Action Alternative stage. This gives a conservative estimate of the potential for stage changes in the action alternatives to negatively affect agricultural operations.

Finally, OMR flow results are presented are Monthly Average percent change from No Action Alternative.

C.4.1 EC results

C.4.1.1 SWP Export location

SWP export EC (Table C-4) for the action alternatives showed the following trends for increases in EC by WY type:

- The largest percent change from No Action Alternative increases in EC for Alternative 2 occurred April to June in Critical WYs (+2.25 percent to 4.8 percent). There were also notable average increases in a few Dry and Below Normal months.

- The largest percent change from No Action Alternative increases in EC for Alternative 3 occurred July to September in Critical WYs (+1.71 percent to 2.59 percent).

The SWP export EC for the action alternatives (Table C-4) showed the following trends for decreases in EC:

- Decreases in EC were scattered over WY types and months for Alternative 2, but were small in comparison with EC increases, as they were all less than 1 percent. For the Average of all WY types, EC decreased in July and August (-0.02 percent to -0.12 percent) in comparison with No Action Alternative.

- Decreases in EC were scattered over WY types and months for Alternative 3, although they were somewhat greater in magnitude for this scenario. For the Average of all WY types, EC decreased in January, February, May and June (-0.05 percent to -0.13 percent) in comparison with No Action Alternative.

C.4.1.2 CVP Export location

At the CVP export location (Table C-5), the following trends for increases in EC were observed:

- The largest percent change from No Action Alternative increases in EC for Alternative 2 occurred April to July in critical WYs (+1.48 percent to 2.52 percent).

- The largest percent change from No Action Alternative increases in EC for Alternative 3 were all less than 1 percent when viewed on average by WY type.

The CVP export EC for the action alternatives (Table C-5) showed the following trends for decreases in EC:

- Decreases in EC were scattered over WY types and months for Alternative 2, but were small in comparison with EC increases, as they were all less than 1 percent. For the Average of all WY types, EC decreased in February and August (-0.06 percent to -0.38 percent) in comparison with the No Action Alternative.

- Decreases in EC were scattered overall WY types and months for Alternative 3, although they were somewhat greater and more common for this scenario. For the Average of all WY types, EC decreased in January, April, May, June, September and November (-0.05 percent to -0.19 percent) in comparison with the No Action Alternative.

C.4.1.3 CCWD Export Locations

C.4.1.3.1 Old River

At the CCWD Old River export location (Table C-6), EC for the action alternatives showed the following trends for increases in EC:

- The largest percent change from No Action Alternative increases in EC for Alternative 2 occurred January and April to June in Critical WYs (+2.07 to 4.91 percent). There were also notable average increases in a few Dry and Below Normal months.

- The largest percent change from the No Action Alternative increases in EC for Alternative 3 occurred July – September in Critical WYs (+1.00 to 1.69 percent).

CCWD Old River export location (Table C-6) showed the following trends for decreases in EC:

- Decreases in EC were scattered over WY types and months for Alternative 2, but were fewer and smaller in magnitude in comparison with EC increases, as they were all less than 1 percent. For the Average of all WY types, EC decreased in July (-0.14 percent) in comparison with the No Action Alternative.

- Decreases in EC were scattered over WY types and months for Alternative 3, and they were somewhat greater and occurred more frequently for this scenario. For the Average of all WY types, EC decreased in January, February, April, May, June, August and September (-0.01 to -0.35 percent) in comparison with the No Action Alternative.

C.4.1.3.2 Rock Slough

At the CCWD Rock Slough export location (Table C-7), in this case calculated at the ROLD024 location in DSM2, EC for the action alternatives showed the following trends for increases in EC:

- The largest percent change from the No Action Alternative increases in EC for Alternative 2 occurred January, April – June, September, and December in Critical WYs (+2.01 to 4.08 percent). There were also notable average increases in a few Dry and Below Normal months.

- The largest percent change from No Action Alternative increases in EC for Alternative 3 occurred in July in Critical WYs (+1.35 percent).

CCWD Rock Slough export location (Table C-7) showed the following trends for decreases in EC:

- Decreases in EC were scattered over WY types and months for Alternative 2, but were fewer and smaller in magnitude in comparison with EC increases, as they were all less than 1 percent. For the Average of all WY types, EC decreased in July (-0.19 percent) in comparison with the No Action Alternative.

- Decreases in EC were scattered over WY types and months for Alternative 3, and they were somewhat greater and occurred more frequently for this scenario. The largest decreases occurred in Dry WYs. For the Average of all WY types, EC decreased in October, January, February, April, May, August and September (-0.01 percent to -0.42 percent) in comparison with the No Action Alternative.

C.4.1.3.3 Victoria Canal

At the CCWD Victoria Canal export location (Table C-8), EC for the action alternatives showed the following trends for increases in EC:

- The largest percent change from No Action Alternative increases in EC for Alternative 2 occurred April to June in Critical WYs (+2.10 percent to 4.27 percent)

- The largest percent change from No Action Alternative increases in EC for Alternative 3 occurred in August in Critical WYs (+1.11 percent)

CCWD Victoria Canal export location (Table C-8) showed the following trends for decreases in EC:

- Decreases in EC were scattered over WY types and months for Alternative 2, but were small in comparison with EC increases, as they were all less than 1 percent. For the Average of all WY types, EC decreased in August (-0.20 percent) in comparison with the No Action Alternative.

- Decreases in EC were scattered over WY types and months for Alternative 3, and they were somewhat greater and occurred more frequently for this scenario. For the Average of all WY types, EC decreased in November, January, February, March, May, June and September (-0.02 percent to -0.13 percent) in comparison with the No Action Alternative.

C.4.1.4 D-1641 EC compliance locations

C.4.1.4.1 Rio Vista

Table C-9 documents the percent change from No Action Alternative EC for the two action alternatives at Rio Vista on the Sacramento River. Changes are generally small at this location for Alternative 2, with the largest increase in EC occurring in Critical December (1.13 percent) and the largest decrease in Dry August (-1.70 percent). For most other months and WY types, changes are less than +/- 0.5 percent (in magnitude). For Alternative 3, all changes are less than +/- 0.55 percent except for June in Critical WYs at 0.88 percent increase.

C.4.1.4.2 Collinsville

Table C-10 documents the percent change from No Action Alternative EC for the two action alternatives at Collinsville on the lower Sacramento River. EC changes showed the following trends:

- The largest changes in EC occurred in Critical, Dry and Below Normal WY types for Alternative 2, with the general trend for most months being a decrease in EC. Below Normal WYs showed the greatest variation with December showing a 5.09 percent increase and June showing a -2.36 percent decrease. For the Average of all WY types, changes were in the range -1.12 percent and 0.79 percent or less.

- The largest changes in EC occurred in Critical, Dry and Below Normal WY types for Alternative 3, although in this case the split was not pronounced for either increase or decrease in EC. Below Normal WYs showed the greatest variation with May showing a 2.24 percent increase and December showing a -1.88 percent decrease. For the Average of all WY types, changes were all +/- 1.0 percent or less in magnitude.

C.4.1.4.3 Emmaton

Table C-11 documents the percent change from No Action Alternative EC for the two action alternatives at Emmaton on the Sacramento River. EC changes showed the following trends:

- The largest changes in EC occurred in Critical, Dry and Below Normal WY types for Alternative 2, with the general trend for most months and WYs being a decrease in EC. Dry WYs showed the greatest variation with November showing a 1.57 percent increase and August showing a -5.52 percent decrease. For the Average of all WY types, changes were all +/- 1.12 percent or less in magnitude.

- The largest changes in EC occurred in Critical and Dry WY types for Alternative 3, although in this case the split was not pronounced for either increase or decrease in EC. Dry WYs showed the greatest variation with September showing a 4.41 percent increase and July showing a -1.86 percent decrease. For the Average of all WY types, changes were all +/- 1.0 percent or less in magnitude.

C.4.1.4.4 Jersey Point

Table C-12 documents the percent change from No Action Alternative EC for the two action alternatives at Jersey Point on the lower San Joaquin River. EC changes showed the following trends:

- The largest changes in EC occurred in Critical, Dry and Below Normal WY types for Alternative 2, with the general trend for most months and WYs being an increase in EC. Below Normal WYs showed the greatest variation with December showing a 6.40 percent increase and July showing a -2.46 percent decrease. For the Average of all WY types, December showed a 2.05 percent increase and in June a small decrease at -0.53 percent.

- The largest changes in EC occurred in Critical and Dry WY types for Alternative 3, although in this case the split was not pronounced for either increase or decrease in EC. Dry WYs showed the greatest variation with November showing a 2.41 percent increase and January showing a -2.33 percent decrease. For the Average of all WY types, changes were all +/- 1.0 percent or less in magnitude.

C.4.1.4.5 Antioch

Table C-13 documents the percent change from No Action Alternative EC for the two action alternatives at Antioch on the lower San Joaquin River. EC changes showed the following trends:

- The largest changes in EC occurred in the months of April through July in Critical through Below Normal WY types, with EC generally decreasing for Alternative 2. Below Normal WYs showed the greatest variation with December showing a 6.24 percent increase and June showing a -2.26 percent decrease. For the Average of all WY types, December showed the largest increase at 1.68 percent and June a decrease of -1.41 percent.

- The largest changes in EC occurred in Critical and Dry WY types for Alternative 3, although in this case the split was not pronounced for either increase or decrease in EC and the percentages were smaller for this scenario. In Dry WYs, Alternative 2 showed the largest percent changes in EC from -2.15 percent in January to 2.48 percent in June. For the Average of all WY types, changes were all +/- 0.96 percent or less in magnitude.

C.4.1.4.6 Barker Slough

Table C-14 documents the percent change from No Action Alternative EC for the two action alternatives at Barker Slough. Changes in EC are minor for both the alternatives, although there is a small percent increase in EC in April through July of Critical WYs for Alternative 2. For the Average of all WY types in Alternative 2, EC changes ranged from -0.12 percent to 0.62 percent. For the Average of all WY types in the For the Average of all WY types in Alternative 2, EC changes ranged from -0.17 percent to 0.12 percent.

C.4.1.4.7 Montezuma Slough

Table C-15 documents the percent change from No Action Alternative EC for the two action alternatives in Montezuma Slough. For Alternative 2, EC decreased in Critical through Below Normal WY types in the spring months. For the Average of all WY types in Alternative 2, EC changes ranged from -1.06 percent to 1.03 percent. For Alternative 3, the changes were both increases and decreases in EC and they were generally smaller in magnitude. For the Average of all WY types in Alternative 2, EC changes ranged from -0.15 percent to 0.67 percent.

C.4.1.4.8 Rock Slough

Table C-16 documents the percent change from No Action Alternative EC for the two action alternatives in Rock Slough. This is the DSM2 location CHCC006 in DSM2, which occurs at the end of the slough and which tends be heavily influenced by changes in DICU flows, so is less indicative of overall changes due to the alternatives than the ROLD024 location. For Alternative 2, there were large increases in EC in January and February of Dry WYs and Feb to Jun of Critical WYs. EC percent changes in Alternative 3 were small and were generally decreases.

C.4.2 Bromide

Bromide load at export locations is presented on Annual Average Basis, and also split by WY Type in Table C-17 for the SWP and CVP exports locations and in Table C-18 for CCWD export locations at Rock Slough, Old River and Victoria Canal. The annual load is calculated as average tons bromide/year. Note that the bromide source is mainly from waters entering the Delta at Martinez.

For SWP exports, as an annual average Alternative 2 results in a 1.2 percent increase in bromide load – with the largest percent increase occurring in Critical WYs followed by Below Normal and Dry WYs. Alternative 3 results in a 0.4 percent decrease in annual average bromide load, with the largest percentages occurring in Dry and Below Normal WYs.

For CVP exports, as an annual average Alternative 2 results in a 1.3 percent increase in bromide load – with the largest percent increases occurring in Critical and Dry WYs. Alternative 3 results in a 0.5 percent decrease in annual average bromide load, which occurs mainly in Dry and Critical WYs.

For CCWD Old River exports, as an annual average Alternative 2 results in a 0.3 percent increase in bromide load – with the largest percent increase occurring in Critical WYs and a large percent annual decrease occurring in Above Normal WYs. Alternative 3 results in a 0.1 percent decrease in annual average bromide load, however an increase in load occurs in Critical WYs and offsetting decreases in load occurs in Dry, Below Normal and Above Normal WYs.

For CCWD Victoria Canal exports, as an annual average Alternative 2 results in a 2.6 percent decrease in bromide load – with the largest percent decrease occurring in Critical and Above Normal WYs. Alternative 3 results in a 0.3 percent decrease in annual average bromide load, with the largest decrease in load occurring in Above Normal WYs.

For CCWD Rock Slough exports (calculated at the ROLD024 DSM2 location), as an annual average Alternative 2 results in a 2.2 percent decrease in bromide load – with the largest percent decrease occurring in Critical and Above Normal WYs. Alternative 3 results in a 0.3 percent decrease in annual average bromide load, with the largest decrease in load occurring in Dry and Below Normal WYs.

C.4.3 X2

Table C-19 presents the monthly average change from No Action Alternative X2 position in km for the compliance months February through June, while Table C-20 presents X2 position as percent change from No Action Alternative for all months split by WY. Note that in no month did the X2 position change by more than 0.32 km for Alternative 2, or by more than 0.18 km for Alternative 3. As a percent change from No Action Alternative over all months, for Alternative 2 the largest decrease in X2 position of -0.38 percent occurred in Critical June and the largest increase occurred in Below Normal December, while for Alternative 3 the largest decrease in X2 position of -0.19 percent occurred in Dry December and the largest increase occurred in Critical and Dry May. Table C-1 documents the months when the change from No Action Alternative X2 position was greater than 1.0 km.

Table C-1. Months where the change in X2 position was greater than 1.0 km (bold font) for Alternatives 2 and 3

	Alternative 2	Alternative 3
November-1937	**1.2**	0.8
December-1937	**2.0**	0.0
December-1944	**3.7**	0.1
January-1945	**2.9**	0.0
September-1960	-0.3	**1.2**
September-1990	**1.3**	0.9
December-2001	**1.2**	0.0

C.4.4 Stage

As the alternatives changed inflow, export and DICU volumes and timing, the main consideration for agricultural interests was the change from No Action Alternative stage at the south Delta barrier locations. A conservative estimate of decrease in stage was used – the difference in minimum stage calculated from 15-minute model output on a monthly basis. The results, indicate that decreases in stage both upstream and downstream of the south Delta barriers were 0.2 feet (or greater) in only a few months out of a possible 984 months for the three barriers, calculated upstream and downstream of the barrier, for the two action alternatives over 82 years. In all other months, decreases in stage at these locations were less. These results are documented in Table C-2.

Table C-2. Months in the simulation period when the change in minimum stage from No Action Alternative was -0.2 ft (or greater)

Scenario	Barrier Location	Upstream/Downstream	WY/Month
Alternative 2	Grant Line Canal	Downstream	1945/Dec.
		Upstream	1945/Dec.
	Old River	Downstream	1990/Aug.
		Upstream	1945/Dec.
	Middle River	Upstream	1991/Jun
Alternative 3	Old River	Downstream	1936/Feb.
	Old River	Downstream	1951/Jan
	Old River	Downstream	1990/Aug.
	Old River	Upstream	1936/Feb.
	Old River	Upstream	1951/Jan

C.4.5 OMR Flow

The 15-minute DSM2 flow results at ROLD024 and at RMID015 were daily averaged, added together then smoothed with a 14-day running average – the final step was to monthly average then calculate the percent change between each alternative and the No Action Alternative. Percent change from No Action Alternative of the monthly averaged OMR flow for the alternatives was used as an estimate for the effect of alternative Delta operations found in the scenarios, with results shown in Table C-3 The range of percent changes for the average for all WYs was much smaller than the ranges for specific WYs and months - for Alternative 2, from -1.04 percent to +22.40 percent. For Alternative 3, the range was -3.26 percent to 21.96 percent. Note that negative percent difference numbers indicate that a negative OMR flow in the alternative was smaller in magnitude than the No Action Alternative – i.e., this is a good result as negative OMR flows pull delta smelt toward the SWP and CVP export locations. Thus a positive percent difference number indicates a result that the alternatives would prefer to avoid. The results in indicate that both alternative scenarios tend to increase the magnitude of negative OMR flow, and the range of effects are similar.

Table C-3. Percent change from the No Action Alternative in monthly averaged OMR flow for the two action alternatives for the regulated months

OMR Percent Change from NAA Alternative 2							
WY	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**
Average	6.04	3.63	4.02	9.50	-1.04	16.02	22.40
Critical	7.83	2.47	8.31	18.55	50.26	71.81	48.05
Dry	4.20	3.84	6.24	13.32	27.02	126.82	25.78
BN	7.31	5.50	2.61	8.27	32.58	-29.58	16.21
AN	4.47	3.88	3.45	5.58	-92.32	-58.93	17.10
Wet	6.52	2.90	1.53	5.14	-20.11	-27.28	14.01

OMR Percent Change from NAA Alternative 3							
WY	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**
Average	4.29	4.33	5.75	9.96	-3.26	15.84	21.96
Critical	4.17	5.36	9.38	16.72	49.33	72.19	48.29
Dry	1.96	2.83	5.38	12.50	25.62	125.64	25.69
BN	3.28	4.03	11.67	12.05	22.68	-29.59	13.78
AN	4.41	9.20	6.37	5.80	-92.16	-58.94	17.07
Wet	6.45	2.81	0.86	5.86	-20.47	-27.21	13.89

Table C-4. EC percent change from No Action Alternative for Alternative 2 and Alternative 3 at the SWP export location

SWP Alternative 2

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.19	0.14	0.30	0.36	0.02	0.12	0.36	0.50	0.87	-0.02	-0.12	0.29
Critical	0.51	0.20	0.68	1.21	0.75	0.98	2.25	2.97	4.80	0.83	-0.48	0.65
Dry	0.34	0.43	0.58	-0.05	-0.33	-0.12	-0.05	0.29	0.81	-0.24	0.41	0.25
BN	-0.15	0.15	0.23	1.00	-0.29	0.05	0.16	-0.04	-0.05	-0.44	-0.60	0.92
AN	-0.18	-0.42	0.18	0.15	0.18	0.06	0.04	0.03	0.02	-0.06	-0.18	-0.14
Wet	0.28	0.18	0.03	0.01	0.01	-0.03	0.02	0.00	-0.01	-0.02	-0.02	0.00

SWP Alternative 3

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.03	0.04	0.12	-0.13	-0.09	0.02	0.11	-0.05	-0.12	0.40	0.24	0.00
Critical	0.35	0.22	-0.26	0.29	0.28	0.72	1.05	0.38	-0.03	2.30	2.59	1.71
Dry	0.27	-0.23	0.71	-0.74	-0.40	-0.15	-0.03	0.11	-0.14	0.16	-0.67	-0.38
BN	-0.31	-0.07	0.13	0.01	-0.11	-0.31	-0.17	-0.71	-0.48	0.08	-0.02	-1.03
AN	0.26	0.53	-0.14	-0.08	-0.15	-0.01	-0.01	0.00	-0.01	0.03	0.06	0.00
Wet	-0.20	-0.03	-0.01	-0.01	0.00	-0.01	0.00	-0.01	-0.01	0.04	0.00	0.02

Table C-5. EC percent change from No Action Alternative for Alternative 2 and Alternative 3 at the CVP export location

CVP Alternative 2

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.18	0.07	0.15	0.26	-0.06	0.08	0.29	0.29	0.52	0.12	-0.38	0.27
Critical	0.46	-0.01	0.38	0.79	0.25	0.63	1.59	1.53	2.52	1.48	-0.59	1.01
Dry	0.33	0.34	0.33	-0.06	-0.39	-0.04	0.12	0.35	0.46	-0.33	-0.76	0.05
BN	-0.05	0.12	0.02	0.81	0.03	-0.21	0.18	-0.04	0.23	-0.15	-0.68	0.73
AN	-0.10	-0.33	0.09	0.13	-0.18	0.01	0.07	0.00	0.08	0.01	-0.09	-0.12
Wet	0.20	0.07	0.03	0.01	0.02	0.10	-0.02	-0.01	-0.01	0.02	0.01	0.01

CVP Alternative 3

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.06	-0.09	0.09	-0.15	0.02	0.05	-0.06	-0.19	-0.05	0.07	0.22	-0.05
Critical	0.30	-0.05	-0.22	0.12	0.46	0.55	-0.16	-0.18	-0.55	0.50	0.35	1.14
Dry	0.24	-0.21	0.57	-0.44	0.18	-0.08	-0.09	0.00	-0.09	0.06	0.64	-0.21
BN	-0.12	-0.22	0.08	-0.03	-0.37	-0.06	-0.06	-0.95	0.34	-0.13	0.18	-0.82
AN	0.30	0.23	-0.09	-0.44	-0.13	-0.01	-0.02	-0.03	-0.03	-0.02	0.02	-0.20
Wet	-0.19	-0.10	-0.01	0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.04	-0.01	0.00

Table C-6. EC percent change from No Action Alternative for Alternative 2 and Alternative 3 at CCWD's Old River intake location

CCWD-OR Alternative 2

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.18	0.15	0.55	0.66	0.17	0.37	0.42	0.54	0.90	-0.14	0.17	0.50
Critical	0.33	0.08	1.21	2.07	0.75	1.40	2.58	3.40	4.91	0.63	0.52	1.68
Dry	0.33	0.58	0.79	-0.12	-0.30	-0.05	0.04	0.37	0.75	-0.33	0.93	0.40
BN	0.00	0.25	0.85	1.68	0.27	0.38	0.12	-0.16	0.09	-0.76	-0.40	1.06
AN	-0.24	-0.60	0.29	0.62	0.62	0.09	0.01	-0.06	0.03	-0.13	-0.25	-0.12
Wet	0.31	0.16	0.05	0.02	-0.04	0.31	0.03	-0.01	-0.01	-0.03	-0.02	0.01

CCWD-OR Alternative 3

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.00	0.01	0.14	-0.35	-0.25	0.01	-0.01	-0.16	-0.08	0.31	-0.13	-0.08
Critical	0.16	-0.13	0.08	0.29	0.09	0.63	0.36	-0.15	-0.11	1.69	1.19	1.00
Dry	0.25	-0.04	0.52	-1.15	-0.46	-0.11	-0.23	0.03	-0.17	0.14	-1.20	-0.21
BN	-0.16	-0.12	0.24	0.01	-0.93	-0.33	-0.09	-0.84	-0.15	0.09	-0.30	-1.19
AN	0.22	0.42	-0.22	-0.92	-0.15	0.00	0.01	0.03	-0.01	0.06	0.07	0.07
Wet	-0.26	-0.01	0.02	-0.01	0.06	0.00	0.00	-0.01	0.00	0.03	0.00	0.04

Table C-7. EC percent change from No Action Alternative for Alternative 2 and Alternative 3 at CCWD's Rock Slough location (model output from the ROLD024 location)

CCWD-RS Alternative 2

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.13	0.22	0.95	0.92	0.61	0.40	0.55	0.72	0.72	-0.19	0.41	0.65
Critical	0.12	0.15	2.01	2.43	0.98	1.49	3.10	4.03	4.08	0.85	1.07	2.23
Dry	0.23	0.90	1.18	-0.17	-0.12	-0.06	0.18	0.48	0.54	-0.33	1.53	0.59
BN	0.06	0.37	1.83	2.88	2.21	0.58	0.21	0.19	0.04	-1.14	-0.19	1.19
AN	-0.40	-0.90	0.39	0.64	0.94	0.26	0.07	0.02	0.02	-0.21	-0.31	-0.09
Wet	0.36	0.22	0.08	0.06	-0.07	0.19	0.05	-0.02	-0.01	-0.05	-0.02	0.01

CCWD-RS Alternative 3

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	-0.02	0.12	0.12	-0.42	-0.23	0.03	-0.01	-0.26	0.02	0.24	-0.36	-0.06
Critical	0.03	-0.23	0.31	0.48	0.03	0.54	0.27	-0.09	0.46	1.35	0.59	1.02
Dry	0.25	0.30	0.20	-1.76	-0.56	-0.09	-0.14	-0.16	0.00	0.01	-1.66	-0.06
BN	-0.21	0.00	0.34	-0.03	-0.79	-0.26	-0.14	-1.23	-0.28	0.10	-0.51	-1.36
AN	0.38	0.49	-0.31	-0.63	0.03	0.08	-0.01	0.00	-0.01	0.10	0.07	0.14
Wet	-0.31	0.04	0.05	-0.01	0.05	0.01	0.01	0.00	0.01	0.03	0.00	0.05

Table C-8. EC percent change from No Action Alternative for Alternative 2 and Alternative 3 at CCWD's Victoria Canal intake location

CCWD-VC Alternative 2

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.13	0.08	0.04	0.29	0.14	0.23	0.33	0.49	0.80	0.11	-0.20	0.10
Critical	0.37	0.08	0.18	1.58	0.57	0.85	2.10	3.24	4.27	0.76	-0.38	0.51
Dry	0.41	0.27	0.29	-0.03	-0.25	-0.02	-0.01	0.25	0.68	-0.06	-0.26	-0.21
BN	-0.12	-0.02	-0.38	0.30	-0.10	0.35	0.10	-0.20	0.11	-0.01	-0.46	0.51
AN	-0.06	-0.07	0.14	0.20	1.28	0.14	0.02	-0.05	0.06	0.04	-0.06	-0.12
Wet	0.03	0.06	0.00	-0.03	-0.20	0.08	0.01	0.01	-0.01	0.01	-0.01	0.00

CCWD-VC Alternative 3

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.07	-0.11	0.12	-0.13	-0.10	-0.02	0.00	-0.09	-0.13	0.15	0.11	-0.04
Critical	0.39	0.03	-0.14	0.04	0.08	0.21	0.25	0.01	-0.17	0.90	1.11	0.59
Dry	0.08	-0.41	0.72	-0.37	-0.33	-0.11	-0.12	0.05	-0.15	0.01	-0.26	-0.03
BN	-0.03	-0.09	0.04	0.05	-0.46	-0.17	-0.06	-0.62	-0.38	0.03	0.02	-0.59
AN	0.06	0.06	-0.10	-0.39	0.24	0.05	-0.01	0.04	-0.01	-0.01	0.03	-0.09
Wet	-0.04	-0.05	-0.02	-0.02	0.01	0.00	0.00	0.00	-0.02	0.04	0.00	0.00

Table C-9. EC percent change from No Action Alternative for Alternative 2 and Alternative 3 at the D-1641 compliance location at Rio Vista

Rio Vista Alternative 2

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	-0.20	0.33	0.26	0.09	-0.01	0.11	0.11	0.13	0.04	-0.27	-0.32	-0.06
Critical	-0.64	0.48	1.13	0.30	0.08	0.86	0.94	1.03	0.67	-1.26	0.21	0.13
Dry	0.32	0.83	0.00	-0.01	-0.13	-0.06	-0.08	0.02	-0.16	-0.17	-1.70	-0.60
BN	0.09	0.40	0.46	0.33	0.00	0.01	-0.04	-0.09	-0.07	-0.23	0.18	0.28
AN	-0.22	0.38	0.08	0.00	0.02	-0.02	0.00	-0.01	-0.06	-0.06	-0.07	-0.02
Wet	-0.48	-0.15	0.02	-0.01	0.00	0.01	0.00	-0.02	-0.01	0.00	0.01	0.02

Rio Vista Alternative 3

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	-0.06	-0.07	0.08	-0.02	0.03	0.02	0.06	0.09	0.17	-0.01	0.08	0.51
Critical	0.30	0.03	0.37	0.10	0.10	0.03	0.15	0.54	0.88	0.30	0.46	1.01
Dry	-0.17	-0.21	0.04	-0.22	0.02	0.03	0.07	0.15	0.20	-0.31	0.22	1.82
BN	0.24	0.17	0.07	0.00	0.00	0.02	0.05	-0.18	-0.10	0.01	-0.24	-0.26
AN	-0.50	-0.47	-0.02	0.10	0.07	0.02	0.04	0.01	0.01	0.02	0.00	-0.02
Wet	-0.10	0.05	0.01	-0.01	0.01	0.00	0.02	0.03	0.04	0.03	0.03	0.02

Table C-10. EC p1ercent change from No Action Alternative for Alternative 2 and Alternative 3 at the D-1641 compliance location at Collinsville

Collinsville Alternative 2

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	-0.35	0.56	1.18	0.28	-0.10	-0.23	-0.98	-1.61	-1.27	-0.88	-0.53	-0.32
Critical	-1.10	0.11	0.29	-1.10	-0.30	-0.52	-3.14	-3.54	-1.03	-2.03	0.21	0.24
Dry	0.04	1.10	0.99	-0.35	-0.53	-0.59	-1.60	-2.90	-2.54	-0.77	-2.74	-2.14
BN	0.32	0.81	5.09	2.97	0.31	-0.25	-1.06	-2.34	-2.36	-1.84	0.27	0.31
AN	-0.21	-0.37	-0.28	-0.01	0.06	0.05	0.01	-0.22	-0.55	-0.57	-0.17	0.05
Wet	-0.69	0.68	0.30	0.05	0.01	0.05	0.03	-0.07	-0.24	-0.04	0.07	0.16

Collinsville Alternative 3

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.01	0.21	-0.31	-0.39	0.13	0.06	0.60	1.11	0.75	-0.22	0.06	0.40
Critical	-0.01	0.06	-0.04	0.02	1.05	-0.21	0.98	1.81	1.88	0.22	0.71	0.35
Dry	-0.05	0.11	-1.88	-1.80	-0.03	0.41	1.26	2.24	2.06	-1.25	0.30	2.08
BN	0.35	0.46	0.55	-0.04	-0.06	0.01	0.69	1.39	-0.77	-0.31	-0.58	-0.37
AN	-0.19	-0.34	-0.19	-0.05	-0.03	0.02	-0.01	-0.01	0.15	0.23	-0.05	-0.34
Wet	-0.04	0.48	0.12	0.05	0.01	-0.01	0.20	0.36	0.43	0.13	0.00	0.01

Table C-11. EC percent change from No Action Alternative for Alternative 2 and Alternative 3 at the D-1641 compliance location at Emmaton

Emmaton Alternative 2

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	-0.54	0.67	0.79	0.34	-0.11	-0.01	-0.37	-0.85	-0.86	-1.12	-1.08	-0.50
Critical	-1.68	0.40	0.82	-0.21	-0.48	0.13	-1.44	-2.63	-0.50	-3.91	0.23	0.16
Dry	0.18	1.57	0.42	-0.19	-0.27	-0.19	-0.59	-1.52	-2.37	-0.98	-5.52	-2.91
BN	0.44	1.22	2.96	2.40	0.09	0.04	-0.21	-0.68	-0.99	-1.54	0.58	0.53
AN	-0.15	0.21	0.49	-0.01	0.02	0.00	0.02	-0.03	-0.38	-0.38	-0.18	-0.02
Wet	-1.22	0.10	0.02	0.02	0.00	0.02	0.01	-0.02	-0.12	-0.03	0.08	0.07

Emmaton Alternative 3

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.06	0.04	-0.16	-0.30	0.01	0.00	0.30	0.75	0.81	-0.32	0.25	1.00
Critical	0.40	0.27	0.25	0.16	0.12	-0.11	1.00	2.37	2.60	0.55	0.98	0.95
Dry	-0.13	-0.45	-1.05	-1.51	-0.03	0.09	0.37	1.42	1.92	-1.86	1.13	4.41
BN	0.90	0.63	0.49	-0.01	-0.04	-0.01	0.31	0.35	-0.65	-0.32	-0.78	-0.41
AN	-0.73	-0.49	-0.40	0.02	0.03	0.01	0.01	-0.01	0.11	0.15	-0.09	-0.32
Wet	-0.04	0.19	0.02	0.01	0.02	0.00	0.05	0.10	0.33	0.12	0.02	0.03

Table C-12. EC percent change from No Action Alternative for Alternative 2 and Alternative 3 at the D-1641 compliance location at Jersey Point

Jersey Point Alternative 2

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	-0.17	1.05	2.05	0.90	0.10	0.19	0.20	-0.05	-0.53	-0.51	1.02	0.40
Critical	-0.98	1.04	3.15	1.08	-0.25	0.86	1.16	0.02	-0.37	0.53	3.05	1.82
Dry	0.04	3.17	1.66	-0.38	0.03	-0.05	-0.04	-0.23	-1.45	-0.15	2.14	-0.22
BN	0.52	0.99	6.40	4.54	0.63	0.23	0.07	-0.07	-0.62	-2.46	0.87	0.78
AN	-0.96	-0.77	0.53	0.20	0.09	0.10	0.06	0.05	-0.23	-0.63	-0.34	0.24
Wet	0.06	0.45	0.15	0.08	0.04	0.06	0.05	0.00	-0.05	-0.12	0.03	0.04

Jersey Point Alternative 3

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	-0.17	0.74	-0.30	-0.44	-0.16	-0.03	0.08	0.30	0.63	-0.36	-0.31	0.02
Critical	-0.69	-0.09	0.46	0.79	-0.13	-0.10	0.54	1.83	2.62	-0.73	1.54	-0.36
Dry	-0.14	2.41	-1.90	-2.33	-0.48	0.01	0.00	0.48	1.49	-1.42	-1.49	0.74
BN	-0.25	0.64	0.43	-0.04	-0.21	-0.12	0.00	-0.44	-0.78	0.01	-1.21	-1.18
AN	0.54	0.18	-0.39	-0.29	-0.08	0.02	-0.01	-0.03	0.07	0.29	-0.01	0.62
Wet	-0.22	0.29	0.10	0.01	0.02	0.00	0.02	0.02	0.13	0.06	0.01	0.08

Table C-13. EC percent change from No Action Alternative for Alternative 2 and Alternative 3 at the D-1641 compliance location at Antioch

Antioch Alternative 2

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	-0.39	0.61	1.68	0.55	0.04	-0.08	-0.68	-1.37	-1.41	-0.92	-0.21	-0.22
Critical	-1.30	0.33	1.09	-0.71	-0.39	-0.39	-2.81	-3.88	-1.31	-1.76	1.04	0.66
Dry	-0.01	1.70	1.59	-0.32	-0.21	-0.35	-0.98	-2.57	-3.04	-0.73	-1.94	-2.06
BN	0.45	0.97	6.24	3.90	0.68	0.12	-0.45	-1.31	-2.26	-2.17	0.43	0.47
AN	-0.41	-0.79	0.10	0.15	0.11	0.10	0.05	-0.07	-0.60	-0.70	-0.22	0.10
Wet	-0.67	0.44	0.29	0.10	0.04	0.06	0.05	-0.03	-0.24	-0.08	0.07	0.12

Antioch Alternative 3

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	-0.05	0.37	-0.30	-0.46	-0.03	-0.03	0.42	0.96	0.90	-0.32	0.00	0.36
Critical	-0.31	0.04	0.07	0.29	0.68	-0.35	1.03	2.27	2.51	-0.14	1.03	0.12
Dry	-0.10	0.63	-1.91	-2.15	-0.43	0.18	0.76	2.04	2.48	-1.51	-0.07	2.05
BN	0.21	0.70	0.64	0.04	-0.17	-0.10	0.45	0.67	-1.10	-0.32	-0.77	-0.57
AN	0.02	0.05	-0.33	-0.28	-0.09	0.01	-0.01	-0.01	0.19	0.28	-0.05	-0.10
Wet	-0.06	0.33	0.16	0.02	0.02	0.00	0.08	0.23	0.46	0.15	0.00	0.02

Table C-14. EC percent change from No Action Alternative for Alternative 2 and Alternative 3 at the D-1641 compliance location at Barker Slough

Barker Slough Alternative 2

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.01	0.19	0.48	0.00	0.09	-0.08	0.34	0.62	0.43	0.08	-0.09	-0.12
Critical	0.03	-0.05	0.70	0.16	0.00	-0.16	1.84	3.63	3.01	1.16	-0.10	-0.35
Dry	0.63	0.44	1.10	0.17	0.20	-0.35	0.07	0.31	0.14	-0.19	-0.17	-0.25
BN	0.03	0.14	0.06	-0.64	-0.04	-0.03	0.17	0.11	-0.16	-0.21	-0.15	-0.03
AN	-0.78	0.46	0.61	0.15	0.17	0.16	0.20	0.09	-0.05	-0.07	-0.06	-0.06
Wet	-0.07	0.02	0.12	0.09	0.07	0.01	-0.03	-0.04	-0.02	-0.01	-0.01	0.01

Barker Slough Alternative 3

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.11	-0.07	-0.17	-0.09	-0.04	-0.09	0.07	0.01	0.04	0.09	0.12	0.11
Critical	0.18	0.21	-0.11	-0.10	-0.02	0.02	0.13	0.10	0.14	0.17	0.23	0.28
Dry	0.06	0.07	-0.44	-0.30	-0.05	-0.16	0.50	0.49	0.23	0.14	0.25	0.23
BN	0.54	-0.53	-0.01	0.00	-0.05	-0.09	-0.03	-0.59	-0.19	0.12	0.09	0.04
AN	-0.06	-0.09	-0.36	0.03	0.16	0.00	-0.05	0.00	-0.04	0.03	0.04	0.05
Wet	-0.04	-0.03	-0.01	-0.06	-0.11	-0.13	-0.14	-0.05	0.01	0.03	0.03	0.03

Table C-15. EC percent change from No Action Alternative for Alternative 2 and Alternative 3 at the D-1641 compliance location at Montezuma Slough

Montezuma Slough Alternative 2

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	-0.29	0.41	1.03	0.51	0.02	-0.16	-0.62	-1.14	-1.06	-0.66	-0.40	-0.23
Critical	-0.91	-0.01	0.60	-0.17	-0.23	-0.09	-1.24	-2.18	-1.42	-0.88	-0.60	0.11
Dry	0.07	0.90	0.75	0.00	-0.12	-0.56	-1.13	-1.78	-1.78	-1.02	-0.86	-1.26
BN	0.33	0.70	3.16	2.86	0.48	-0.33	-1.23	-2.09	-2.08	-1.33	-0.56	0.11
AN	-0.15	0.25	0.40	0.05	-0.06	0.13	0.07	-0.36	-0.46	-0.35	-0.23	-0.06
Wet	-0.64	0.18	0.57	0.12	0.00	0.03	0.04	-0.06	-0.14	-0.08	0.02	0.07

Montezuma Slough Alternative 3

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.07	0.02	-0.15	-0.26	0.03	0.12	0.33	0.67	0.59	0.17	-0.05	0.12
Critical	0.00	0.04	0.05	-0.02	0.36	0.17	0.25	0.85	1.00	0.62	0.24	0.38
Dry	0.14	-0.11	-1.06	-1.43	-0.13	0.33	0.75	1.27	1.38	0.28	-0.32	0.55
BN	0.27	0.38	0.48	0.13	0.01	0.13	0.49	1.11	0.30	-0.32	-0.18	-0.29
AN	-0.07	-0.39	-0.32	-0.01	-0.11	0.07	0.02	-0.01	0.05	0.12	0.05	-0.08
Wet	0.01	0.11	0.12	0.11	0.06	-0.03	0.13	0.26	0.27	0.18	0.02	0.01

Table C-16. EC percent change from No Action Alternative for Alternative 2 and Alternative 3 at the D-1641 compliance location at Rock Slough (DSM2 location CHCCC006)

CCWD-RS Alternative 2

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.55	0.23	1.00	4.27	5.03	0.44	0.54	0.58	0.84	-0.26	-0.09	0.51
Critical	1.06	0.22	0.95	0.56	3.43	1.86	3.96	4.93	5.14	0.60	0.24	0.86
Dry	1.19	0.40	1.36	10.61	10.75	2.07	0.23	0.71	0.51	-0.49	0.30	1.21
BN	-0.04	0.42	0.92	2.47	2.52	0.70	0.35	0.34	-0.07	-1.14	-0.75	0.87
AN	0.01	-0.08	2.29	7.18	13.48	-1.06	0.12	0.06	-0.01	-0.22	-0.33	-0.22
Wet	0.44	0.17	0.23	1.23	-0.76	-0.78	-0.54	-1.16	-0.05	-0.06	-0.04	0.00

CCWD-RS Alternative 3

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	-0.06	0.05	0.10	-0.19	-0.24	0.00	-0.03	-0.35	-0.02	0.29	-0.21	-0.27
Critical	0.01	-0.08	0.07	0.35	0.07	0.42	0.33	-0.19	0.28	1.21	0.80	0.97
Dry	0.52	0.22	0.15	-0.78	-0.61	-0.18	-0.18	-0.19	0.02	0.30	-1.43	-1.05
BN	-0.42	-0.04	-0.06	0.05	-0.54	-0.32	-0.23	-1.69	-0.39	0.15	-0.14	-1.06
AN	-0.18	0.34	0.12	-0.55	-0.20	0.21	-0.01	0.01	0.00	0.10	0.10	0.01
Wet	-0.26	-0.11	0.15	-0.01	0.02	0.03	-0.01	0.01	0.01	0.03	0.00	-0.01

Table C-17. SWP and CVP Annual Average bromide load (tons/year bromide) and percent change from No Action Alternative (right hand tables)

SWP Annual Average	NAA	Alternative 2	Alternative 3
Average	605	612	602
Critical	471	487	467
Dry	627	636	621
BN	703	716	696
AN	617	612	622
Wet	589	593	590

SWP % Difference	Alternative 2	Alternative 3
Average	1.2	-0.4
Critical	3.3	-0.9
Dry	1.4	-1.0
BN	1.9	-1.0
AN	-0.7	0.9
Wet	0.7	0.1

CVP Annual Average	NAA	Alternative 2	Alternative 3
Average	586	593	583
Critical	571	595	568
Dry	641	656	627
BN	638	642	641
AN	603	604	604
Wet	519	520	520

CVP % Difference	Alternative 2	Alternative 3
Average	1.3	-0.5
Critical	4.2	-0.5
Dry	2.2	-2.2
BN	0.6	0.5
AN	0.1	0.1
Wet	0.2	0.1

Table C-18. CCWD Annual Average bromide loads (tons/month bromide) and percent change from No Action Alternative (right hand tables)

Old River Annual Average Load	NAA	Alternative 2	Alternative 3
Average	3.7	3.7	3.7
Critical	2.2	2.4	2.3
Dry	2.7	2.8	2.7
BN	3.8	3.8	3.8
AN	6.1	5.8	6.1
Wet	4.0	4.1	4.0

Old River % Difference	Alternative 2	Alternative 3
Average	0.3	-0.1
Critical	8.7	2.8
Dry	1.1	-0.7
BN	-0.3	-0.4
AN	-5.0	-0.6
Wet	1.5	0.1

Vict. Canal Annual Average Load	NAA	Alternative 2	Alternative 3
Average	10.8	10.5	10.8
Critical	15.8	14.4	16.0
Dry	10.5	10.3	10.4
BN	12.8	12.5	12.6
AN	10.2	9.8	10.2
Wet	7.9	8.0	7.8

Vict. Canal % Difference	Alternative 2	Alternative 3
Average	-2.6	-0.3
Critical	-8.8	1.5
Dry	-1.3	-0.6
BN	-2.2	-1.3
AN	-3.9	0.1
Wet	2.1	-0.9

Rock Sl. Annual Average Load	NAA	Alternative 2	Alternative 3
Average	14.6	14.3	14.5
Critical	17.7	18.1	17.8
Dry	16.6	15.8	16.5
BN	13.8	14.0	13.7
AN	16.2	14.8	16.2
Wet	11.4	11.3	11.4

Rock Sl. % Difference	Alternative 2	Alternative 3
Average	-2.2	-0.3
Critical	2.0	0.3
Dry	-4.9	-0.7
BN	1.1	-0.7
AN	-8.3	-0.2
Wet	-1.2	0.0

Table C-19. X2 change in the position (in km) from No Action Alternative for Alternative 2 and Alternative 3

Change in X2 Alternative 2

WY	FEB	MAR	APR	MAY	JUN
Average	-0.02	-0.02	-0.07	-0.13	-0.09
Critical	-0.06	-0.04	-0.22	-0.31	-0.10
Dry	-0.04	-0.05	-0.11	-0.20	-0.19
BN	-0.01	-0.05	-0.09	-0.20	-0.15
AN	0.00	0.02	0.00	-0.03	-0.04
Wet	0.00	0.00	0.00	-0.01	-0.01

Change in X2 Alternative 3

WY	FEB	MAR	APR	MAY	JUN
Average	0.01	0.01	0.04	0.08	0.06
Critical	0.06	-0.01	0.06	0.17	0.18
Dry	0.01	0.05	0.07	0.15	0.15
BN	0.00	0.01	0.05	0.10	-0.04
AN	0.00	0.02	0.00	0.00	0.01
Wet	0.00	0.00	0.02	0.02	0.03

Table C-20. X2 percent change from No Action Alternative for Alternative 2 and Alternative 3

% Dfference in X2 Alternative 2

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	-0.04	0.05	0.06	0.01	-0.02	-0.03	-0.10	-0.17	-0.12	-0.09	-0.07	-0.04
Critical	-0.11	-0.01	0.00	-0.08	-0.06	-0.06	-0.28	-0.38	-0.11	-0.25	0.02	0.01
Dry	0.01	0.09	0.06	-0.05	-0.06	-0.07	-0.16	-0.26	-0.24	-0.09	-0.35	-0.23
BN	0.02	0.07	0.34	0.24	-0.01	-0.07	-0.14	-0.29	-0.20	-0.16	0.04	0.03
AN	-0.01	-0.05	-0.08	-0.03	0.00	0.04	0.01	-0.05	-0.05	-0.05	-0.02	0.00
Wet	-0.07	0.07	-0.01	0.00	0.00	0.00	0.00	-0.01	-0.02	0.00	0.01	0.02

% Dfference in X2 Alternative 3

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average	0.00	0.02	-0.04	-0.05	0.02	0.02	0.05	0.11	0.08	-0.03	0.01	0.04
Critical	0.00	-0.01	-0.02	-0.02	0.09	-0.01	0.08	0.20	0.21	0.02	0.06	0.05
Dry	-0.02	0.00	-0.19	-0.18	0.02	0.07	0.10	0.20	0.18	-0.15	0.05	0.21
BN	0.02	0.04	0.05	-0.03	0.00	0.01	0.07	0.14	-0.05	-0.03	-0.07	-0.04
AN	-0.03	-0.07	-0.05	0.00	0.00	0.04	0.01	0.00	0.02	0.02	-0.01	-0.03
Wet	0.00	0.05	0.00	0.00	0.00	-0.01	0.02	0.03	0.04	0.01	0.00	0.00