Bay Area Regional Desalination Project
Site Specific Analyses
Final Report
Delta Modeling Tasks

Potential Water Quality Impacts,

Potential Impacts to Sensitive Fish Populations,

Conjunctive Operation of Los Vaqueros Reservoir

Prepared by the Contra Costa Water District

January 2014

CONTRA COSTA
WATER DISTRICT

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Executive Summary

In 2011, the Bay Area Regional Desalination Project partner agencies signed a memorandum of understanding (MOU) to fund several site specific analyses of a desalination facility that would draw its source water from the Contra Costa Water District's (CCWD) Mallard Slough Pump Station (MSPS) with a maximum pumping capacity of 25 million gallons per day (MGD) or 39 cubic feet per second (cfs). The analyses funded by the 2011 MOU included: 1) potential water quality impacts of the desalination facility and brine disposal, 2) potential impacts to sensitive fish populations, 3) conjunctive operation of the desalination facility with the Los Vaqueros Reservoir, 4) estimation of greenhouse gas emissions associated with operation of the desalination facility and conveyance of the water to partners, 5) distribution modeling of desalination water through East Bay Municipal Utility District's conveyance system. Contained within this report are the analyses of the potential water quality impacts, potential entrainment impacts to sensitive fish populations, and the conjunctive operation of Los Vaqueros.

Summary of Potential Water Quality Impacts

Chapter 1 of this report discusses the potential water quality impacts of the BARDP facility and brine disposal. A one dimensional hydrodynamic model was used to determine how the increased diversions at MSPS and brine disposal at local waste water treatment plants could change Delta salinity. On average, the proposed BARDP would increase ambient salinity by a small amount, less than 0.23%, for the operational scenarios modeled. Modeled changes in ambient salinity are smaller than what can be accurately measured in the field. During most conditions, BARDP operations would not have a significant impact on water quality or beneficial uses (municipal water supply, wildlife, agriculture). During critically dry water years, BARDP operations would need to be coordinated with CVP/SWP and the City of Antioch to avoid potential impacts.

Summary of Potential Entrainment Impacts to Sensitive Fish Populations

Chapter 2 of this report discusses the potential impact the BARDP facility could have on sensitive fish populations. Two methods were used to estimate entrainment risk of listed larval species. One method utilized historical biological monitoring data near MSPS and the second method utilized a one dimensional hydrodynamic/particle tracking model to estimate entrainment at the BARDP intake. Both methods found that entrainment risk at BARDP intake was relatively small due to the positive barrier fish screen and seasonally variable. The risk of entrainment is greatest when the fish population near MSPS consists of mostly of small young larvae. Longfin smelt are typically found as larvae near MSPS from January through March with the population typically peaking in February. Delta smelt larvae have been found near MSPS from March through July with the population typically peaking in May. A variety of methods to avoid or minimize potential fisheries impacts were discussed at a BARDP partners workshop held in January 2013. Changes to operations, additional physical barriers, and intake design could reduce or avoid impacts to fisheries.

Summary of Conjunctive Operation of Los Vaqueros Reservoir

Chapter 3 of this report discusses the improvement in dry year supplies available to BARDP partners by operating the BARDP conjunctively with the Los Vaqueros Reservoir. BARDP plant production exceeds partner demands in non-drought years but falls short of the higher combined partner demands in drought years. Interannual storage of BARDP water increases the amount of water available to meet dry year partner demands. The excess BARDP production can be stored in Los Vaqueros Reservoir in non-drought years through an exchange with CCWD, and the stored BARDP water can be released from Los Vaqueros Reservoir in drought years. Only 54% of drought year partner demands can be met without storage. Under current EBMUD system limitations on timing and flow rates, 71% of drought year demands can be met with the use of interannual storage in the 160 TAF Los Vaqueros Reservoir. Pre-treatment of releases from storage, to make that water compatible with EBMUD's in-line water treatment plants, could increase the amount of drought year demands met to 84%.

Cost estimates were also provided by CCWD for BARDP's use of Mallard Slough Pump Station and Los Vaqueros Reservoir. The cost estimation approach was composed of a capital recovery component and a reimbursement of fixed and variable operation and maintenance (O&M) costs, taking into consideration both CCWD's additional costs and avoided costs. The preliminary cost estimate for BARDP use of the Mallard Slough Pump Station and associated water rights is approximately $86-121/AF. The preliminary cost estimate for BARDP use of storage in Los Vaqueros Reservoir, based on this annual cost model is approximately $70-105/AF per year. Delivery of water from Los Vaqueros storage into the EBMUD system through the existing raw water intertie is approximately $16/AF; this does not include EBMUD's costs for wheeling water through their system for final delivery to the other BARDP partners.

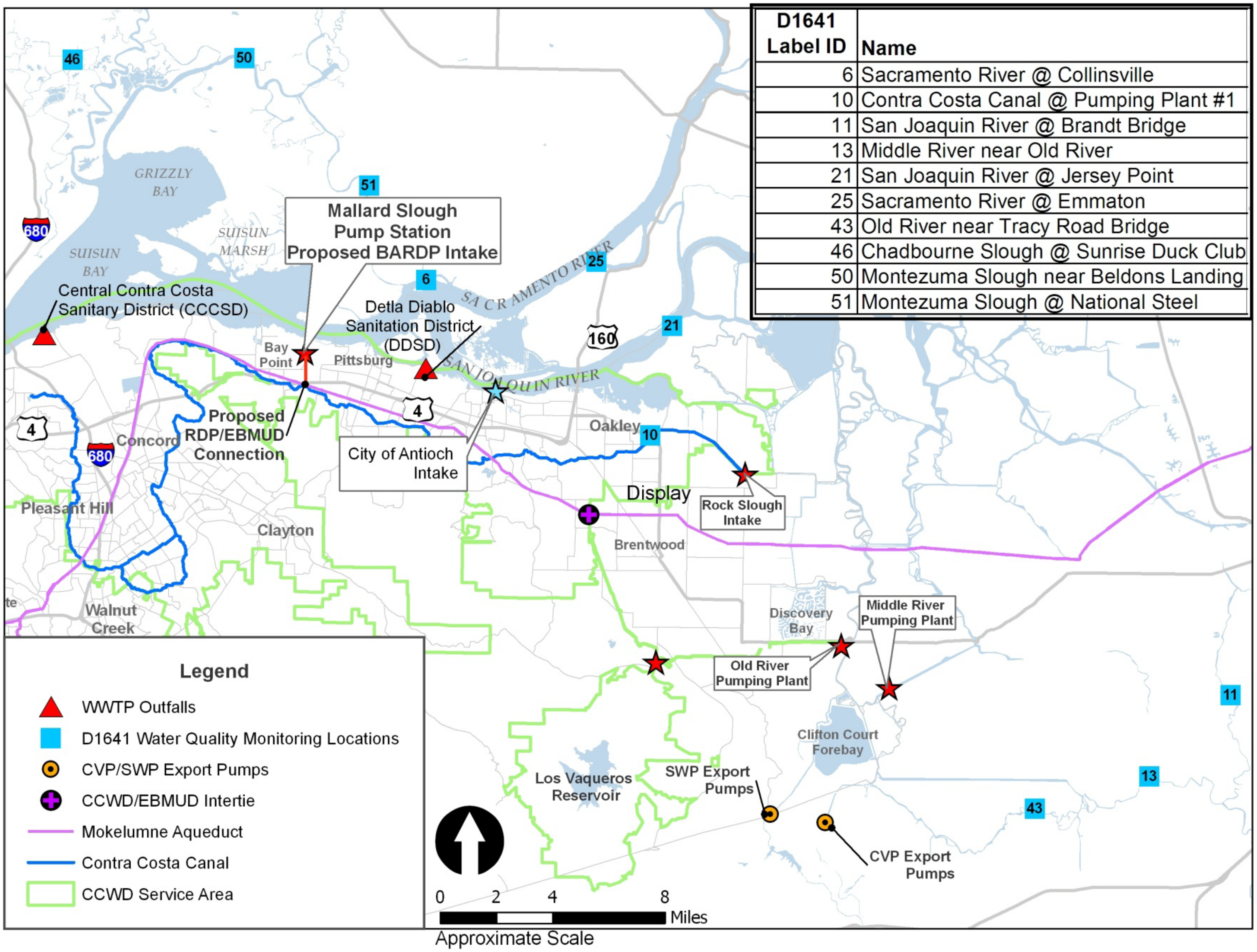
1 Potential Water Quality Impacts of Proposed BARDP Operations

1.1 Executive Summary

Changes in ambient Delta salinity associated with the proposed Bay Area Regional Desalination Project (BARDP) operations were modeled using a one-dimensional hydrodynamic model of the Sacramento-San Joaquin Delta (Delta). Three scenarios were modeled for the existing and future conditions: 1) no brine disposal, 2) brine disposal at Delta Diablo Sanitation District (DDSD), and 3) brine disposal at Central Contra Costa Sanitary District (CCCSD). Results were analyzed to determine if the changes in salinity would affect compliance with existing water quality regulations. On average, proposed BARDP operations would increase salinity by a small amount, less than 0.23%, for the three operational scenarios modeled. Changes in salinity were similar for both the future and existing conditions. Modeling indicates when water quality approaches a water quality standard during dry or critically dry years small changes in salinity appear to result in an exceedence of the standard when in fact it is an indication of model uncertainty. All of the predicted water quality standard exceedences associated with BARDP operations occurred during times when there was a discrepancy between CalSim and DSM2 in the 'no project' scenario such that CalSim estimated a certain amount of flow was needed to meet water quality standards but DSM2 predicts that the level of flow would not be sufficient. In other words, there was an exceedence of the water quality standard in the "no project" scenario. The maximum change in salinity associated with BARDP operations during times when water quality standards were exceeded was small, less than 4 µS/cm or 0.17%. This degree of change is below the accuracy of what can be measured in the field, suggesting that the modeled exceedence would not be found in actual operations. During other water year types, model results predict the proposed BARDP operations would not have a significant impact on water quality, other beneficial uses, or CVP/SWP operations.

1.2 Background

The proposed Bay Area Regional Desalination Project (BARDP) operations have the potential to increase salinity in the Delta through two distinct mechanisms; 1) increased diversions at the Mallard Slough Pump Station (MSPS) intake could decrease river outflow causing an increase in seawater intrusion, 2) disposal of the brine waste in a local waste water treatment plants' effluent could also increase Delta salinity. The increase in salinity has the potential to impact beneficial uses: aquatic wildlife have specific salinity tolerances and could be affected if ambient salinity increases, local municipal and industrial users could be affected by poorer water quality, and upstream reservoir operations could be affected if changes in salinity jeopardized compliance with water quality regulations. The potential changes in Delta salinity due to proposed BARDP operations were evaluated using the Delta Simulation Model II (DSM2), a one-dimensional numerical mixing model of the Delta. The results of the modeling were analyzed to assess potential impacts to beneficial uses. Figure 1-1 shows the location of the proposed BARDP facilities, potential brine disposal locations, and existing water quality compliance points.



D1641 Label ID	Name
6	Sacramento River @ Collinsville
10	Contra Costa Canal @ Pumping Plant #1
11	San Joaquin River @ Brandt Bridge
13	Middle River near Old River
21	San Joaquin River @ Jersey Point
25	Sacramento River @ Emmaton
43	Old River near Tracy Road Bridge
46	Chadbourne Slough @ Sunrise Duck Club
50	Montezuma Slough near Beldons Landing
51	Montezuma Slough @ National Steel

Figure 1-1 Map showing proposed desalination plant at Mallard Slough Intake and two possible brine disposal sites, Central Contra Costa Sanitary District (CCCSD) and Delta Diablo Sanitation District (DDSD).

1.3 Objectives

The objectives of the numerical modeling study were to answer the following questions:

1) Given the existing conditions, how will the increased pumping (assumed to be a constant withdrawal of 39 cfs) to the desalination plant affect Delta salinity, standards compliance and water supply?
2) Given the existing conditions, how will brine disposal affect Delta salinity, standard compliance and water supply?
   - Will brine discharge to the Delta be acceptable in terms of impacts to salinity and water supply or will another disposal method be needed to minimize impacts?
   - How does the difference in location of brine disposal affect salinity, water quality standards and water supply?
3) Given future conditions, how will the answers to questions 1 and 2 above change? Future conditions will include climate change (sea level rise and changes to hydrology).

1.4 Proposed BARDP Operations at MSPS

As noted above, the BARDP could increase Delta salinity by two distinct mechanisms: 1) increasing diversions in the Western Delta, thereby decreasing river outflow and increasing seawater intrusion; 2) the waste byproduct of desalination is concentrated brine; if the brine is sent to a local wastewater treatment plant for disposal, the increased salinity of the wastewater plant effluent could increase local salinity.

1.4.1 Diversions

The BARDP intake facility considered in the modeling study would draw its source water from the Contra Costa Water District's (CCWD) Mallard Slough Pump Station (MSPS). In the recent past, CCWD has not used this intake when the ambient water quality is saltier at MSPS than at other CCWD intakes. To model the maximum potential changes in Delta salinity, the BARDP was assumed to pump continuously at a maximum pumping capacity of 25 million gallons per day (MGD) or 39 cubic feet per second (cfs), except for 30 days each April when CCWD operating permits require no Delta pumping. 20% of water diverted, or 8 cfs, was assumed to return to the Delta via brine disposal discussed below. Actual operations could be constrained further by future permit terms, conveyance constraints, or other factors.

1.4.2 Membrane Waste & Brine Disposal

The recovery rate of the BARDP facility was assumed to be 80% of the diverted source water, leaving 20% of the source water going to the brine waste stream. These assumptions are based on results from the two stage brackish-seawater reverse osmosis treatment train evaluated during a 2009 pilot plant study at MSPS[1]. The regional desalination workgroup has identified two possible wastewater treatment plants to dispose of the brine originating from the desalination treatment process: Central Contra Costa Sanitary District (CCCSD) and Delta Diablo Sanitation District (DDSD) (see Figure 1-1). Changes in ambient water quality associated with brine disposal at each of these wastewater treatment plants were evaluated.

[1] MWH, 2010, Pilot Testing at Mallard Slough Pilot Plant Engineering Report

1.5 Regulatory Setting

For this analysis BARDP operations were not considered in a comprehensive regulatory setting. BARDP operations were evaluated within the context of several key water quality regulations: California State Water Resources Control Board Decision 1641 and California Department of Public Health Secondary Maximum Contaminant Level of Chlorides in drinking water. Changes in compliance with these two regulations were evaluated based on the location of the proposed BARDP facilities and the nature of the operations. Evaluation of BARDP operations in a comprehensive regulatory setting would be required in an environmental impact report.

1.5.1 State Water Resources Control Board D-1641 Objectives

Water quality objectives have been promulgated by the State Water Resources Control Board's Decision 1641 (D1641) to protect environmental, agriculture, and municipal and industrial water supplies, uses in the Delta. Water quality standards can vary with water year type and time of year to protect beneficial uses. Salinity, measured as either electrical conductivity (EC) or chlorides (Cl), is the dominant indicator used to evaluate water quality standards. The Central Valley Project (CVP) and the State Water Project (SWP) adjust operations to ensure these water quality standards are met; changes to diversions and salinity in the Delta can affect water quality and in turn affect releases made from upstream reservoirs. Increases in salinity due to the BARDP operations have the potential to affect compliance with existing water quality standards and statewide water operations to meet those standards. The State Water Resources Control Board sets and updates water quality objectives and standards in the Delta to protect municipal and industrial water supplies, environmental, and agriculture uses in the Delta. Figure 1-1 shows the BARDP and the various compliance points for existing water quality standards. The compliance stations in closest proximity to the proposed BARDP facilities are environmental standards to protect wildlife. Standards to protect drinking water and agricultural uses are farther east towards the interior of the Delta. Appendix 1-A contains a complete description of the compliance metrics for each station. Changes in water quality at each of the compliance points were evaluated.

1.5.2 Local Municipal Intakes

There are several municipal intakes in the Delta but the intake serving the City of Antioch (City) is the only one in close proximity to the proposed BARDP facilities. The City of Antioch has been diverting fresh water from its intake in the western Delta since the 1860s. The City has a pre-1914 appropriative water right on the San Joaquin River. When salinity at the City's intake is above 250 mg/L chlorides, the maximum concentration limit recommended by the California Department of Public Health, the City stops using the intake and instead purchases water from CCWD. The City has an agreement with the Department of Water Resources to reimburse a portion of the expense the City incurs by purchasing water from CCWD. Changes in water quality near Antioch's intake were evaluated, specifically changes in the number of days water quality exceeds the 250 mg/L chloride threshold.

1.6 Methods & Modeling

Two models in series were used to evaluate the changes to water quality associated with the BARDP. The output from the California Department of Water Resources (DWR)/United States Bureau of Reclamation's (Reclamation) hydrology and water operations model, CalSim II, was input to the DWR one-dimensional water quality model DSM 2. CalSim II provided the flow boundary conditions needed in DSM 2 to determine Delta water quality. The water quality output from DSM2 was then analyzed to assess changes in water quality and compliance with existing water quality standards. Figure 1-2 provides a schematic of the modeling train.

The CalSim II and DSM2 models are the industry standard analytical tools for analyzing changes in Delta conditions and statewide water project operations. The following provides a discussion of background information and key elements, assumptions, and limitations of the CalSim II and DSM2 models.

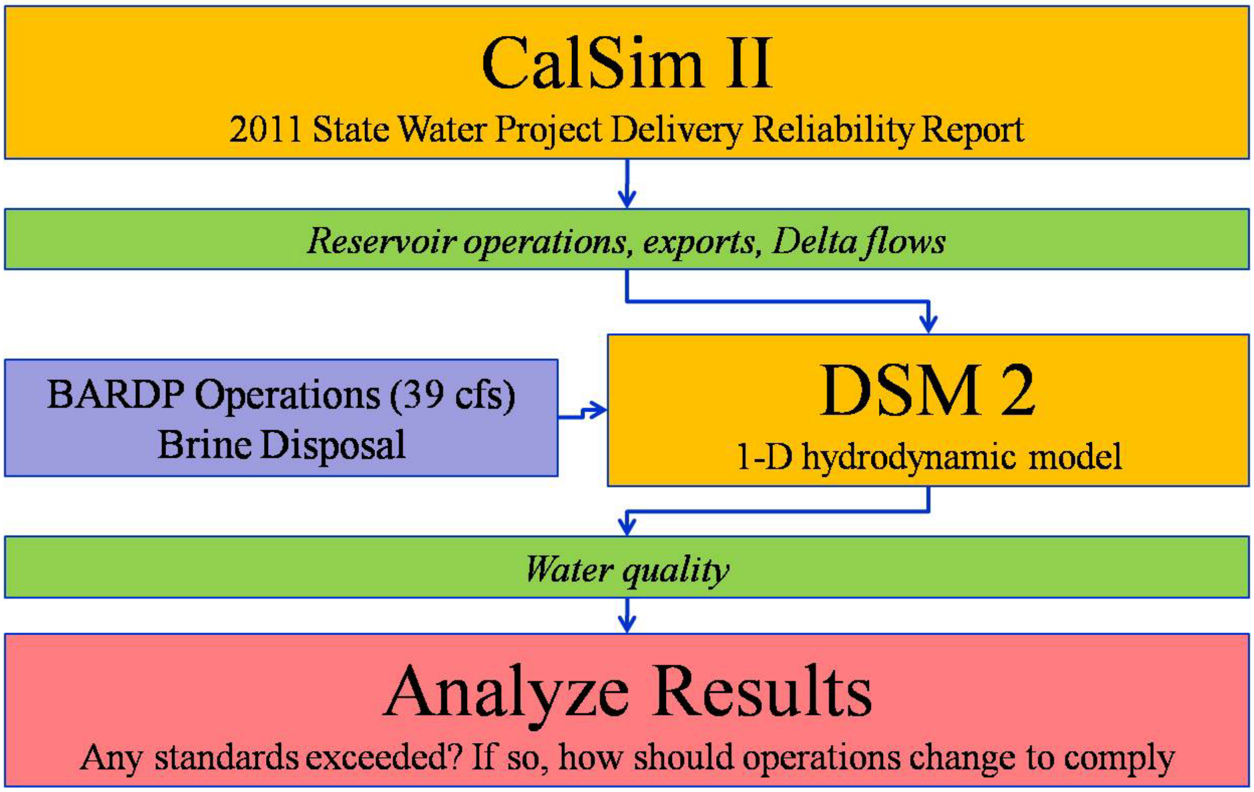


Figure 1-2 Schematic of modeling train used in study.

Eight model scenarios were run to quantify potential changes to water quality and water supply caused by the proposed desalination plant and associated brine disposal, during existing and future hydrologic conditions. Table 1-1 lists the modeling scenarios that were analyzed to meet the study objectives.

Table 1-1 Description of Modeling Runs to Assess Potential Water Quality and Supply Impacts

Hydrologic Condition	Model Run	Description
Existing Conditions	E1	Current hydrology, CalSim II operation assumptions (see Table 2), no withdrawals for the desalination plant, no brine disposal
	E2	E1 conditions plus 39 cfs constant withdrawal from the Mallard Slough Pump Station
	E3	E2 conditions plus brine disposal at DDSD
	E4	E2 conditions brine disposal at CCCSD
Future Conditions	F1	Climate Change (shift in streamflow, precipitation, temperature and sea level rise), CalSim II operation assumptions (see Table 2), no withdrawals for the desalination plant, no brine disposal
	F2	F1 conditions plus 39 cfs constant withdrawal from the Mallard Slough Pump Station
	F3	F2 conditions plus brine disposal at DDSD
	F4	F2 conditions plus brine disposal at CCCSD

1.6.1 CalSim II Description

CalSim II is considered the best available tool for analyzing operations of the CVP and SWP and is the state-wide hydrologic and operations model used by Reclamation and DWR to conduct planning and impact analyses for the Sacramento River, San Joaquin River, and Delta. CalSim II is also the only peer-reviewed model available to analyze the impacts of the project on the water resources of the Delta and the upstream watershed[2]. CalSim II was developed to determine the reliability of water deliveries to CVP and SWP contractors. The model is now regularly used for water resource studies in the Delta, including water rights studies prepared for the SWRCB and CEQA/ NEPA documents to estimate potential changes to surface water resources.

Land use, water infrastructure, water supply contracts, and regulatory requirements are held constant over the period of simulation, representing a fixed level of water demands and operational parameters in CalSim II. The model also includes DWR and Reclamation land-use-based estimates of water demands associated with current and anticipated future land uses in the Central Valley.

The historical flow record from October 1921 to September 2003, adjusted for the influence of land use changes and upstream flow regulation, is used in CalSim II to represent the possible range of water supply conditions at a given level of development. This 82-year historical period provides a sufficient variety of hydrological conditions (e.g., droughts and wet-year periods of

[2] Close, A., W.M. Hanemann, J.W. Labadie, D.P. Loucks (Chair), J.R. Lund, D.C. McKinney, and J.R. Stedinger. 2003.A Strategic Review of CalSimII and its Use for Water Planning, Management, and Operations in Central California, Submitted to the California Bay Delta Authority Science Program, Sacramento, Association of Bay Governments, Oakland, CA, December 4, 2003. Available at: http://www.sacramentoriverportal.org/modeling/CALSIM-Review.pdf

varying magnitude and length) to evaluate the potential consequences of a project that would change water operations in the Delta.

1.6.1.1 CalSim II Limitations

The main limitations of CalSim II relevant to its application for evaluating the BARDP at Mallard Slough Pump Station are the monthly time step and threshold sensitivity.

1.6.1.1.1 Monthly Time Step

Since CalSim II uses a monthly time step, it does not represent daily variations that may occur in the rivers under actual flow and weather conditions. The hydrodynamic and water quality modeling (conducted using DSM2) uses a 15-minute time step, but uses the CalSim II average monthly inflows to the Delta as boundary conditions. Changes in salinity on a monthly time step can be substantial and may not accurately capture operational decisions that change over the time scale of days or weeks. This is a recognized limitation of the model, and is addressed through careful interpretation of model results that can include large changes between subsequent months.

1.6.1.1.2 Threshold Sensitivity in CalSim II

CalSim II simulates operational rules to guide reservoir and pumping operations and decisions. Some of these rules specify threshold values that, when exceeded, trigger a different operation. This can result in simulated operations with changes greater than might be expected in practice, because in practice operator judgment plays a role in interpreting and implementing operational rules.

Similarly, some regulatory requirements specify thresholds that trigger different standards, which cannot be simulated with accuracy in a monthly time-step model. For example, the X2 requirement at Port Chicago applies only in months when the average electrical conductivity (EC) at Port Chicago during the 14 days just before the first day of the month is less than or equal to 2.64 millimhos per centimeter (mmhos/cm). In this example, CalSim II cannot estimate the 14-day average EC to determine if an X2 requirement exists. Use of these threshold values in CalSim II, coupled with a monthly time step, can result in responses to small changes that might be larger than expected in practice for any given month, but generally average out over several months.

CalSim II is recognized as a valuable comparative analysis tool. Results from a single simulation may not correspond to actual system operations for a specific month or year, but are representative of general water supply conditions. Model results are best interpreted using various statistical measures such as long-term and water-year-type averages, and exceedence probabilities. In this form, the model results adequately estimate the potential impacts of the project alternatives (e.g. with versus without project and existing versus future conditions), notwithstanding the limitations of CalSim II previously discussed.

1.6.1.2 Specific CalSim II Assumptions for BARDP

The most up-to-date publicly available version of CalSim II was released by DWR as part of the *State Water Project Delivery Reliability Report*[3]. This version includes implementation of the revised NMFS Biological Opinions and a climate change scenario that was developed in *Using Future Climate Projections to Support Water Resources Decision Making in California*[4]. Table 1-2 provides a summary of the key model assumptions.

Table 1-2 CalSim II Assumptions Used to Assess Potential Water Quality and Supply Impacts of Project

Assumption	Existing	Future with Climate Change
Regulations and Operating Rules	2011 Article 21, Article 56 Carryover for Existing Conditions, New Melones Interim Plan of Operations, Revised Operations Plan, NMFS BO Action III.1.2-3, D-1641, San Joaquin Restoration Flows	Same as Existing
Infrastructure	2011, No Freeport Regional Water Project	Same as Existing
Land Use	2011	2030
Reservoir Inflows	Historical	Adjusted for future air temperature and precipitation changes due to climate change
Water Year Type	Historical	Adjusted for changes in conditions such as land use and climate change
Ag & Urban Outdoor Demands	2009	Sacramento Valley demands adjusted for precipitation changes due to climate change
Sea Level Rise	None	1ft

1.6.2 DSM2: Key Elements and Background Information

DSM2 is a one-dimensional numerical model developed by DWR for simulation of tidal hydraulics, water quality, and particle tracking in the Delta. This model is the standard tool used by DWR and Reclamation for analyzing potential project impacts to Delta water resources. The DSM2 model was used in conjunction with CalSim II to evaluate the potential impacts of BARDP on water quality. The DSM2 model uses monthly simulated boundary flows from the CalSim II analysis described above. Changes in simulated Delta water quality were determined for the 16-

[3] DWR, 2012. State Water Project Final Delivery Reliability Report ,2011.

[4] DWR, 2009, Using Future Climate Projections to Support Water Resources Decision Making in California. Report from California Climate Change Center. CEC-500-2009-052-D

year period from 1976 to 1991. This period includes the 2-year drought from 1976 to 1977, as well as the 6-year drought, from 1987 to 1992. This shorter period of simulation, rather than the 82-year CalSim II analysis period, is standard practice for DSM2 modeling studies.[5] The proposed BARDP location corresponds to node RSAC077, CCCSD corresponds to node 360 and DDSD corresponds to node 463 in DSM2. Table 1-3 describes the model runs and assumptions proposed for the DSM2 runs.

Table 1-3 DSM2 Modeling Run Assumptions to Assess Potential Water Quality and Supply Impacts

Assumption	E1	E2	E3	E4	F1	F2	F3	F4
Infrastructure	No Change	Desal	Desal	Desal	No Change	Desal	Desal	Desal
Waste Water Treatment Plant (WWTP) Effluent	With 'normal' effluent at both plants	With 'normal' effluent at both plants	With 'normal' effluent @ CCCSD plus brine disposal @ DDSD	With 'normal' effluent @ DDSD plus brine disposal @ CCCSD	With 'normal' effluent at both plants	With 'normal' effluent at both plants	With 'normal' effluent @ CCCSD plus brine disposal @ DDSD	With 'normal' effluent @ DDSD plus brine disposal @ CCCSD

1.6.3 CalSim II – DSM 2 Discrepancies

A recognized issue in using CalSim II inputs to DSM2 is that the estimation of Delta water quality is approached differently by the two models. This sometimes leads to a condition in which the CalSim II model estimates the amount of outflow required to avoid causing a Delta water quality exceedence, but the subsequent DSM2 estimate of Delta salinity shows that the standard might be exceeded. Due to this known mismatch, interpretation of DSM2 results that are based on CalSim II inputs is best done in a comparative fashion between two model studies, i.e. comparing the 'no project' condition (E1 & F1) to the 'with project' condition (E2-4, F2-4). The mismatch between CalSim II and DSM2 is evident when water quality exceedences are predicted by DSM2 in the 'no project' case. This discrepancy in water quality prediction between the models is generally small, but still occurs.

1.7 Brine Disposal

The desalination treatment process generates a brine waste stream, and blending the brine with effluent from either DDSD or CCCSD was evaluated as a possible brine disposal option. A time-series of the brine and waste water treatment plant effluent volume and concentration was developed to evaluate blending the brine with the effluent. Data characterizing the blended effluent was input to DSM2 (Table 1-4) to model any changes in Delta water quality and compliance with water quality standards. Appendix 1-B contains complete information regarding the development of wastewater treatment timeseries.

[5] CCWD used this DSM2 modeling approach in the Los Vaqueros Reservoir Expansion Environmental Impact Report, 2010.

1.7.1 Brine Volume

From October 2008 to April 2009 the project partners operated a desalination pilot plant at CCWD's Mallard Slough intake[6]. Based on the pilot project results, the brine stream is assumed to be a constant 20% of the 39 cfs diverted (5.04 mgd or 7.8 cfs). Though cleaning the membranes every 30 to 40 days will contribute to the waste stream, it was assumed that the volume and concentration would be insignificant compared to the brine and therefore was not included in this analysis.

1.7.2 Brine Concentration

To model the expected brine concentration from the desalination process, a relationship was developed between source and brine water quality using pilot plant data. Table 1-4 compares salinity, reported as EC, at the Mallard Slough Pump Station during the pilot study period with historical values measured by DWR at Mallard Slough. The pilot project period had a higher average salinity than the historical record due to drought conditions. However, during the time that the pilot plant operated data from the pilot plant study spanned a wide range of salinity conditions and reasonably represents the range of operating conditions at Mallard Slough.

Table 1-4 Range of Salinity at Mallard Slough since 1995 Compared to Pilot Plant Conditions

Period	**Average EC** (µS/cm)	**Min EC** (µS/cm)	**Max EC** (µS/cm)
All Months 1995-2011[(1)]	4,747	0	23,820
Nov-Apr 1995-2011[(1)]	3,821	10	23,820
Pilot Plant Study (Nov 2008-Apr 2009)	7,403	257	18,075

(1) http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=MAL

A correlation was developed between source water and brine electrical conductivity using analytical samples collected during the pilot project. The resulting equation was linear: $y = 2.46x + 2.68$ ($R^2 = 0.96$), where y is the brine EC and x is the source water EC. Figure 1-3 shows the data and regression.

[6] MWH, 2010, Pilot Testing at Mallard Slough Pilot Plant Engineering Report

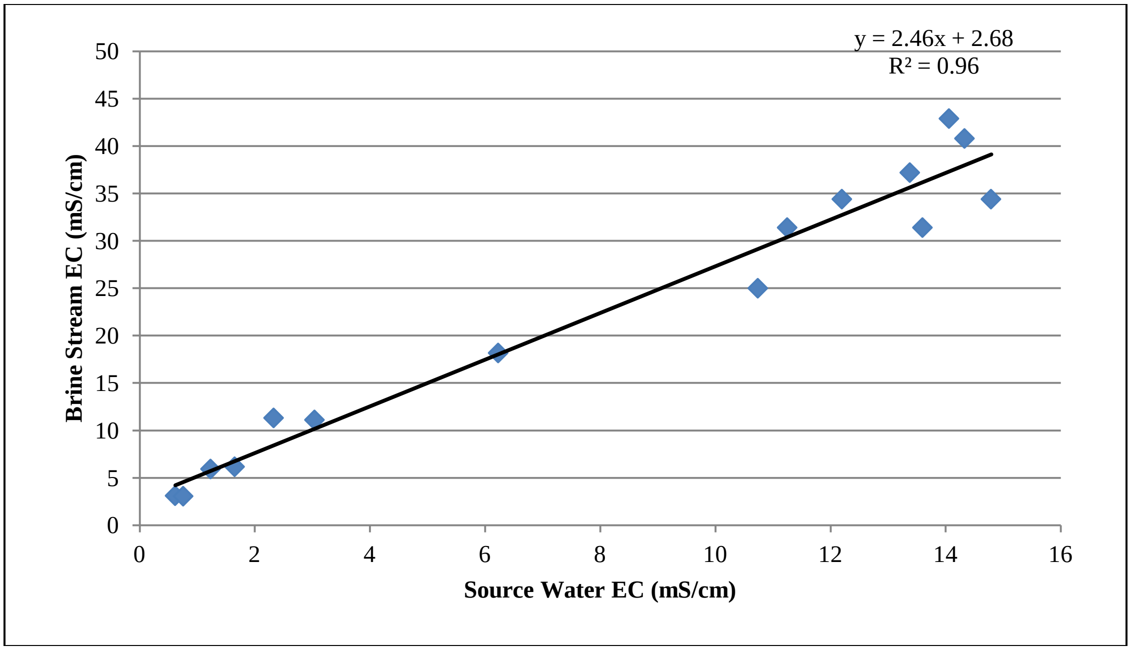


Figure 1-3 Pilot Project Discreet Measured Salinity

This regression was applied to the source water quality timeseries from modeling runs E1 and F1 to calculate the brine concentration potentially delivered to the treatment plants. A spreadsheet model was used to simulate mixing the brine effluent with the 'normal' treatment plant effluent for input into DSM2 to assess water quality changes in modeling scenarios E3, E4, F3 and F4 (Table 3). The 'normal' treatment plant effluent time-series is discussed in the next section.

1.7.3 Treatment Plant Effluent Concentration

Both CCCSD[7] and DDSD[8] operate as sewage treatment plants with individual National Pollutant Discharge Elimination System (NPDES) permits which control the quality and quantity of the effluent released from the plants. The NPDES permits for both plants do not list a maximum level for TDS or salinity; however, they do contain a non-toxicity condition that the effluent must meet certain standards with respect to its effect on living organisms. MWH (2010)[9] found the brine stream of the pilot project to be non-toxic at all levels of exposure for the standard test organisms under consideration.

The desalination plant is expected to draw a constant 39 cfs of water, 20% of which is assumed to become part of the brine stream. This would yield 5.04 mgd or 7.8 cfs of brine. DDSD's current maximum dry weather discharge capacity is 16.5 mgd, which will potentially be increased to 22.6 mgd[10]. CCCSD's current dry weather discharge capacity is 53.8 mgd. Table 1-5 summarizes the projected dry weather outflows from each WWTP through 2030. Based on those numbers and the projected discharges in Table 1-5, CCCSD would have the capacity to

[7] RWQCB, 2004, Delta Diablo Sanitation District NPDES Permit
[8] RWQCB, 2001, Central Contra Costa Sanitation District NPDES Permit
[9] MWH, 2010, Pilot Testing at Mallard Slough Pilot Plant Engineering Report
[10] RMC, 2009, East County Industrial Recycled Water Facilities Plan.

accept the brine through the projection horizon, 2030, while DDSD would only be able to accommodate the extra inflows until 2015 under their current NPDES permit. At DDSD, the brine stream could comprise 22% to 31% of the treatment plant effluent.

Table 1-5 Projected Treatment Plant Dry Weather Outflows (mgd)[10]

	NPDES Max	2010	2015	2020	2025	2030
DDSD	16.5 – 22.6	14.9	16.4	18.1	20.0	22.1
CCCSD	53.8	41.3	42.7	44	45.4	46.8

Discharge volume and effluent salinity data were obtained for each of the treatment plants. The data were used to calculate an input time-series of discharge concentration from each of the treatment plants. Measured discharge volumes were averaged by water year type and a time-series was calculated for the model input based on water year type. Limited effluent salinity data is available, therefore it was assumed that the 'normal' effluent salinity was constant and equal to the average of the data provided. The time-series of discharge concentration and the time-series of brine generated by MSPS were used for input into the 'with disposal' model runs. Appendix 1-B contains the complete input.

Figure 1-4 shows the ambient water quality near DDSD and DDSD's discharge concentration that was used in model runs E3 & F3. The ambient salinity surrounding DDSD is relatively fresh. DDSD's existing effluent stream is typically saltier than the ambient salinity. Once the brine is added to DDSD's existing effluent, the blended brine effluent is always saltier than the ambient Delta water. The need for a near-field analysis and changes in local stratification is discussed further in Section 1.8.

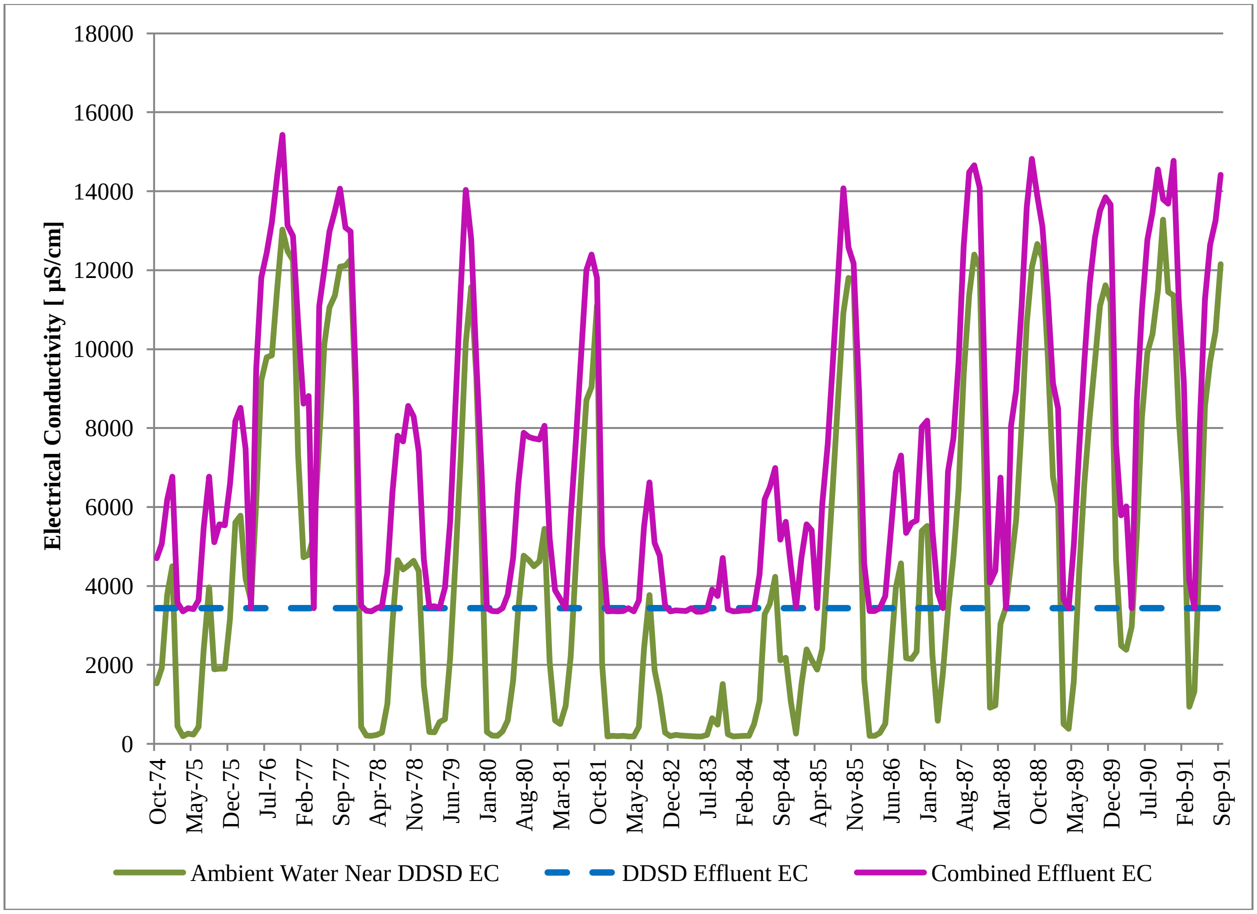


Figure 1-4 Timeseries of DDSD effluent with and without brine from BARDP

Figure 1-5 shows the ambient water quality near CCCSD and CCCSD's discharge concentration that was used for model runs E4 & F4. The ambient salinity is relatively high surrounding CCCSD and the concentration of CCCSD's existing effluent is nearly always fresher than the ambient salinity. Once the brine is added to CCCSD's existing effluent, the concentration of the blended brine discharge typically remains less salty than the ambient salinity. There were 18 months when the predicted blended brine was saltier than ambient conditions. The majority of these events occurred between water years 1982 and 1983 when the Sacramento River Index [11](used to determine water year type) was 15.29, the largest on record since 1902. During times when there is high freshwater flow, the water at MSPS is fresh and would not need to be desalinated if a pre-treatment process were in place that allowed water to bypass the membranes and to be delivered directly to partners. If the membranes could be bypassed during these fresh times, there would be no need for brine disposal, thereby eliminating the potential for a heavy discharge plume to form. Additional considerations for near field analysis are presented in Section 1.8.

[11] http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST

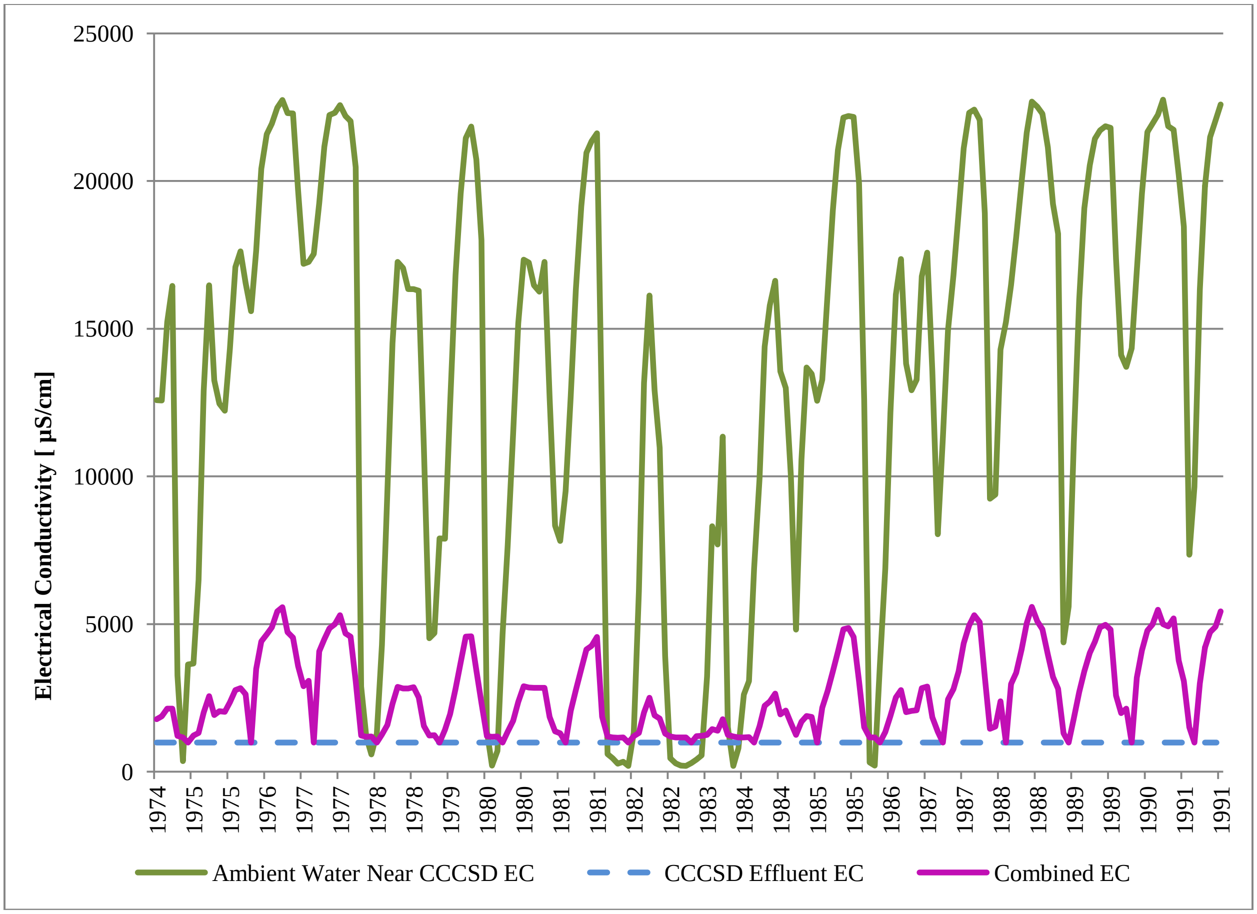


Figure 1-5 Timeseries of brine from CCCSD with and without brine.

1.8 Near Field Analysis

Although the changes in salinity of the blended brine are often small compared to the ambient salinity, changes in local plume dynamics may still be a concern. To address these potential concerns, CCWD could submit an addendum to this report if requested by partners or outside agencies. The addendum may include a near field effluent mixing analysis and preliminary estimates of changes in local stratification that could result from blended brine disposal. Potential new analyses and the data required for those analyses would also be discussed in the addendum.

1.9 Modeling Results

The modeling shows that increasing diversions and brine disposal will generally increase salinity in the Delta by a small amount. For the 'no disposal' and CCCSD runs, changes in daily salinity were always less than 0.25%, below the accuracy of what can be measured in the field (< 0.5%[12]). Changes in daily salinity were greatest for those runs when the brine was disposed at DDSD (runs E3 & F3) but typically less than 0.5%. Each scenario had less than two potential

[12]Probes designed by YSI are used by DWR & USGS to monitor salinity in the region. http://www.ysi.com/accessoriesdetail.php?6560-Conductivity-Temperature-Probe-95

water quality exceedences during dry or critically dry years. The changes in salinity and potential exceedences were nearly identical under the existing conditions and future conditions. All of the modeled water quality exceedences occurred during times when there was a discrepancy between CalSim and DSM2 as described in Section 1.6.3; therefore, the predicted water quality exceedences associated with BARDP operations are likely modeling artifacts and would not occur in practice.

1.9.1 Existing Conditions

As expected, brine disposal at DDSD (E3) has the greatest impact near DDSD and the change in salinity decreases as distance from DDSD increases. At DDSD, salinity increased 7µS/cm or 0.09% on average for the scenario where BARDP diverts 39 cfs from MSPS (E2), 15 µS/cm or 0.21% for the scenario where BARDP diverts 39 cfs from MSPS and blends brine with DDSD effluent (E3) and 6 µS/cm or 0.08% for the scenario where BARDP diverts 39 cfs from MSPS and blends brine with CCCSD effluent (E4). At MSPS, salinity increased 7 µS/cm or 0.09% on average for the E2 run, 12 µS/cm or 0.16% on average for the E3 run and 6 µS/cm or 0.08% on average for the E4 run. The change at the desalination facility was less than near DDSD and greater than near CCCSD. The change near CCCSD is small compared to ambient salinity and is less than the accuracy of the model. At CCCSD, salinity increased 1 µS/cm or 0.01% on average for the E2 & E4 runs and 1.3 µS/cm or 0.02% on average for the E3 run. Figure 1-6 shows the average change for the existing model runs (E2-E4) at MSPS, DDSD and CCCSD. Appendix 1-C contains additional modeling results and figures.

The modeling shows that brine disposal at CCCSD (E4) increases salinity the least, and at times may even decrease ambient salinity; however, this is likely a modeling artifact reflecting CCCSD's proximity to the tidal boundary condition of the model rather than a genuine decrease in salinity. CCCSD is adjacent to the model boundary where salinity and stage are inputs and therefore the blended brine effluent is not mixed throughout the tidal cycle beyond the boundary and likely results in an underestimation of salinity increase for a portion of the tidal cycle. This will be examined more in the near-field mixing analysis, but the conclusion that the salinity increase associated with brine disposal at CCCSD is small and would not have a significant impact will likely not change because most of the effect is captured.

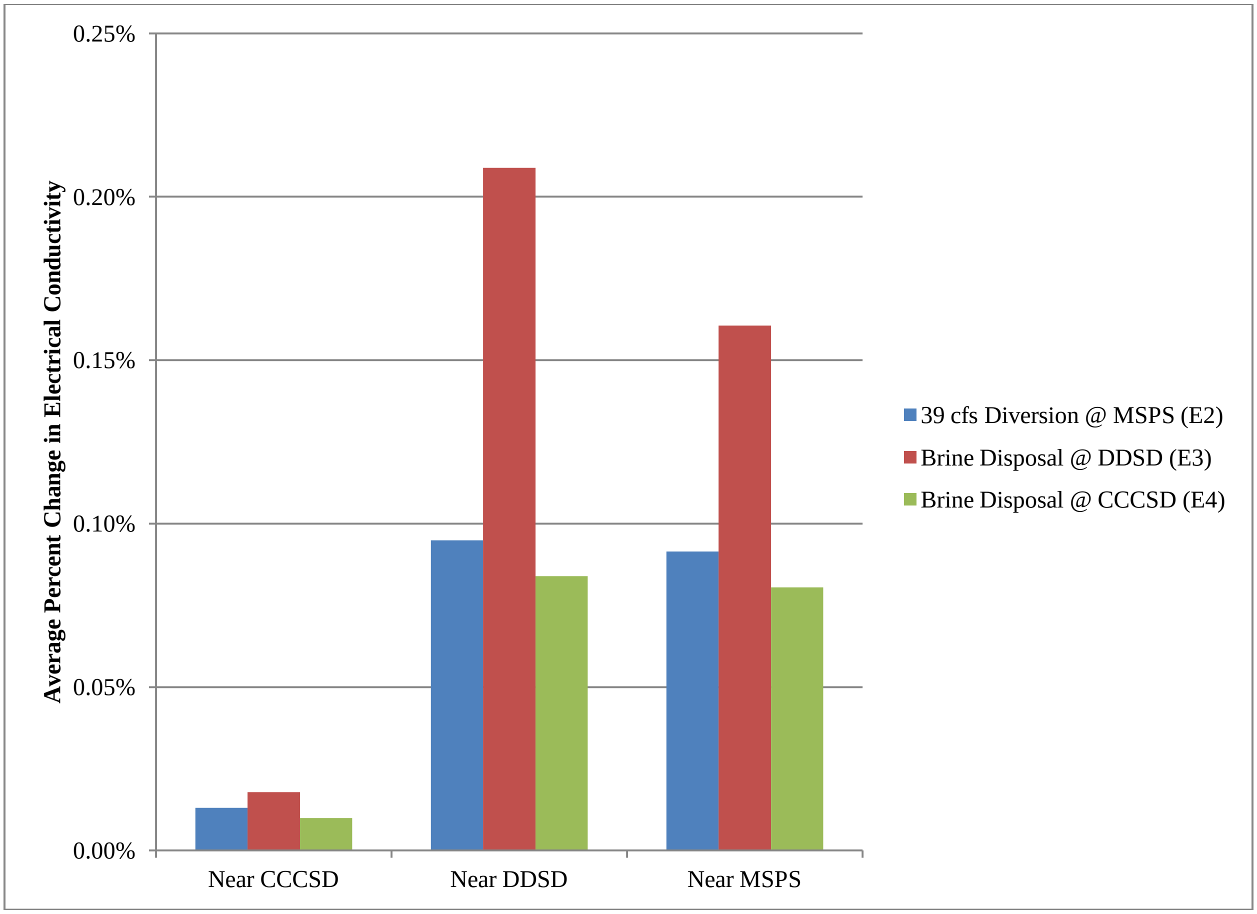


Figure 1-6 Average percent change in salinity at the intake and wastewater treatment plant outfalls for the existing conditions.

1.9.2 Existing Condition Water Quality Standard Exceedences

As noted above, the most water quality standard exceedences occur when brine is disposed at DDSD (E3). Three potential new water quality standard exceedences were modeled under E3 (out of 5,844 model days), the majority of these instances occurred at stations (Rock Slough, Jersey Point, Emmaton) located near DDSD. The increases in salinity were short in duration and small in magnitude during these additional exceedences; the maximum change observed was less than 0.18%. All of the exceedences occurred during critically dry years (1977, 1988, & 1991). Changes in salinity and standards exceedences were nearly identical for the E2 and E3 scenarios. A total of one additional exceedence was observed at Emmaton for these two runs. Both of the exceedences occurred during 1987, a dry year. Changes in salinity during the exceedences were small, less than 0.6 µS/cm or 0.08%. Table 1-6 summarizes key results of water quality standards exceedences. See Appendix 1-C for additional modeling results and figures.

All of the predicted water quality exceedences occurred during times when there was a discrepancy between CalSim and DSM2 as described in Section 1.6.3. This means that there were standard exceedences in the 'no project' run (E1) because CalSim estimated a certain amount of flow was needed to meet water quality standards but DSM2 predicts that the level of flow would not be sufficient. For example, the 'no project' run had a CalSim II/DSM2 discrepancy at Emmaton for a brief period during the late spring of 1987. BARDP operations proposed in E2 and E4 shifted the beginning of the exceedence period found in the 'no project' case one day earlier. The shift resulted in an additional predicted exceedence at Emmaton for runs E2 & E4. However, it is important to recognize that the CalSim/DSM2 mismatch in predicted water quality is the root cause of the additional violation rather than the proposed BARDP operations. In the absence of the CalSim/DSM 2 mismatch, there would be no water quality violations in the 'no project' case and the miniscule increase in salinity at Emmaton during the spring of 1987 associated with BARDP operations, less than 0.6 µS/cm or 0.08%, would likely not be detectable and would not actually result in exceeding the standard.

Although BARDP operations are not expected to cause 'genuine' water quality standard exceedences, the modeling does highlight the difficulty upstream water operators face when required to meet water quality standards during critically dry years. During critically dry times, BARDP diversions and brine disposal should be coordinated with upstream operations to ensure all water quality standards are met.

Table 1-6 Water quality standards exceedences for existing runs

	Number of Days Potential New Standard Exceedences Occurred [out of 5,844 days]	**Location of Exceedences**	**Notes & Conditions**
No Disposal (E2)	1	Emmaton	Exceedence at Emmaton occurred during a dry year when there were CalSim/DSM2 discrepancies. Increase in salinity was less than 0.6 µS/cm
Disposal @ DDSD (E3)	3	Rock Slough, Jersey Point, Emmaton	Greatest salinity increase found at Rock Slough during fall of critically dry year. All exceedences occurred during critically dry years when there were CalSim/DSM2 discrepancies.
Disposal @ CCCSD (E4)	1	Emmaton	Exceedence at Emmaton occurred during a dry year when there were CalSim/DSM2 discrepancies. Increase in salinity was less than 0.6 µS/cm

1.9.3 Existing Condition Local M& I Intake Effects

Changes in salinity at Antioch's intake were small, less than 5.3 µS/cm or 0.20% increase on average (Table 1-7). Antioch's intake is in close proximity to DDSD's outfall and changes in salinity patterns track changes in salinity at DDSD. Consequently, changes in salinity at

Antioch's intake were greatest when brine was disposed at DDSD (E3). Changes in salinity were nearly identical for the other two runs (E2 & E4).

Salinity at Antioch's intake exceeds 250 mg/L chloride every year without BARDP; the timing and duration of the high salinity condition depends on water year type. During wet years this threshold is not exceeded until mid-summer whereas during critically dry years it can be exceeded by the end of winter. Under most conditions BARDP operations did not change the onset or duration of the high salinity conditions at Antioch's intake. In two instances when brine was disposed at DDSD (E3), BARDP operations resulted in exceeding the 250 mg/L chloride threshold one day earlier than would be expected without the BARDP (Table 1-7). Both of these events occurred during the winter of critically dry years.

Table 1-7 Change in salinity at the City of Antioch's Intake for the existing condition.

	Increased Number of Days Chloride Concentration Exceeds 250 mg/L [out of 5,844 days]	Average Increase in Salinity µS/cm	Average Percent Increase in Salinity
No Disposal (E2)	0	2.3	0.08%
Disposal @ DDSD (E3)	2	5.3	0.20%
Disposal @ CCCSD (E4)	0	2.0	0.07%

1.9.4 Future Conditions

Future conditions modeling showed slightly higher changes in salinity to those modeled under the existing conditions. At CCCSD, salinity increased 1 µS/cm or 0.01% on average for the F2 & F4 runs and 1.3 µS/cm or 0.02% on average for the F3 run. At MSPS, salinity increased 7 µS/cm or 0.10% on average for the F2 run, 12 µS/cm or 0.18% on average for the F3 run and 6 µS/cm or 0.09% on average for the F4 run. At DDSD, salinity increased 7 µS/cm or 0.10% on average for the F2 run, 16 µS/cm or 0.23% for the F3 run and 6 µS/cm or 0.09% for the F4 run. Figure 1-7 shows the average change for the existing model runs (F2-F4) at MSPS, DDSD and CCCSD. Again, these changes are less than can be measured accurately in the field. See Appendix 1-C for additional modeling results and figures.

The modeling shows that brine disposal at CCCSD (F4) increases salinity the least, and at times may even decrease ambient salinity; however, this is likely a modeling artifact reflecting CCCSD's proximity to the tidal boundary condition of the model rather than a genuine decrease in salinity. This could be examined more in the near-field mixing analysis, but the conclusion that the salinity increase associated with brine disposal at CCCSD is small and would not have a significant impact will likely not change because most of the effect is captured.

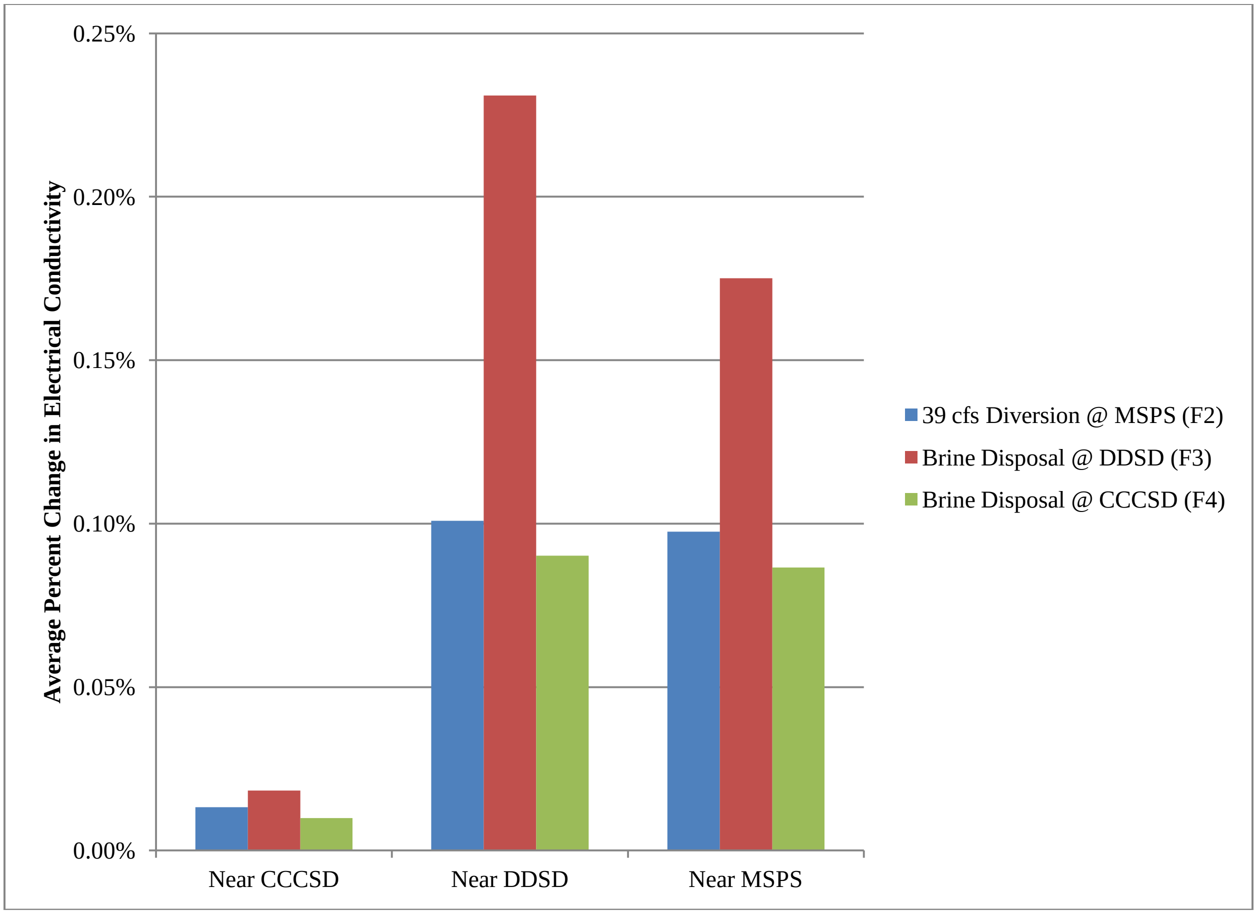


Figure 1-7 Average percent change in salinity at the intake and wastewater treatment plant outfalls for the future conditions.

1.9.5 Future Condition Water Quality Standard Exceedences

Three potential new water quality standard exceedences (out of 5,844 model days) were modeled under F3, the new exceedences occurred at stations (Rock Slough, Collinsville, Emmaton) located near DDSD. The increases in salinity were small during these additional exceedences; the maximum change observed was less than 5.3 µS/cm or 0.15%. All of the exceedences occurred during critically dry years (1976, 1988, & 1990). Changes in salinity and standards exceedences were nearly identical for the F2 and F3 scenarios. A total of three additional exceedences were observed for these two runs. All of the exceedences occurred during dry or critically dry years (1987, 1988, & 1990). Changes in salinity during the exceedences were small, less than 3 µS/cm or 0.10% and less than can be accurately measured in the field. Table 1-8 summarizes key results of water quality standards exceedences. See Appendix 1-C for additional modeling results and figures.

All of the predicted water quality exceedences occurred during times when there was a discrepancy between CalSim and DSM2 as described in Section 1.6.3. This means that there were standard exceedences in the 'no project' run (F1) because CalSim estimated a certain amount of flow was needed to meet water quality standards but DSM2 predicts that the level of flow would not be sufficient. Although BARDP operations are not expected to cause 'genuine' water quality standard exceedences, the modeling does highlight the difficulty upstream water operators face when required to meet water quality standards during critically dry years. During critically dry times, BARDP diversions and brine disposal should be coordinated with upstream operations to ensure all water quality standards are met.

Table 1-8 Water quality exceedences for future conditions.

	Number of Days Potential New Standard Exceedences Occurred [out of 5,844 days]	**Location of Exceedences**	**Notes & Conditions**
No Disposal (F2)	3	Rock Slough, Emmaton, Collinsville	Greatest salinity increase found at Collinsville during spring of critically dry year. All exceedences occurred during critically dry years when there were CalSim/DSM2 discrepancies.
Disposal @ DDSD (F3)	3	Rock Slough, Jersey Point, Emmaton	Greatest salinity increase found in Western Delta (Rock Slough & Emmaton) during summer of critically dry years. All exceedences occurred during critically dry years when there were CalSim/DSM2 discrepancies.
Disposal @ CCCSD (F4)	3	Rock Slough, Emmaton, Collinsville	Greatest salinity increase found at Collinsville during spring of critically dry year. All exceedences occurred during dry or critically dry years when there were CalSim/DSM2 discrepancies.

1.9.6 Future Condition Local M&I Intake Effects

For the future condition modeling scenario the changes in salinity at Antioch's intake were small, less than a 0.23% increase on average (Table 1-9). Antioch's intake is in close proximity to DDSD's outfall and changes in salinity patterns track changes in salinity at DDSD. As expected, changes in salinity at Antioch's intake were greatest when brine was disposed at DDSD (F3). Changes in salinity were identical for the other two runs (F2 & F4).

Salinity at Antioch's intake exceeds 250 mg/L chloride every year without BARDP; the timing and duration of the high salinity condition depends on water year type. During wet years this threshold is not exceeded until mid-summer whereas during critically dry years it can be exceeded by the end of winter. Under most conditions BARDP operations did not change the onset or duration of the high salinity conditions at Antioch's intake. In a few instances, BARDP operations resulted in exceeding the 250 mg/L chloride threshold one day earlier than would be expected without the BARDP. During two wet years, the threshold was exceeded one day earlier in the summer than otherwise would have been expected. Similarly during critically dry years, the threshold was exceeded one day earlier in the late winter or early spring than would have been otherwise expected.

Table 1-9 Change in Salinity at the City of Antioch's Intake for the future condition.

	Increased Number of Days Chloride Concentration Exceeds 250 mg/L [out of 5,844 days]	Average Increase in Salinity µS/cm	Average Increase in Salinity
No Disposal (F2)	3	2.1	0.08%
Disposal @ DDSD (F3)	7	4.9	0.23%
Disposal @ CCCSD (F4)	3	1.8	0.07%

1.10 Conclusions & Recommendations

Based on the water quality modeling the following conclusions and recommendations are provided:

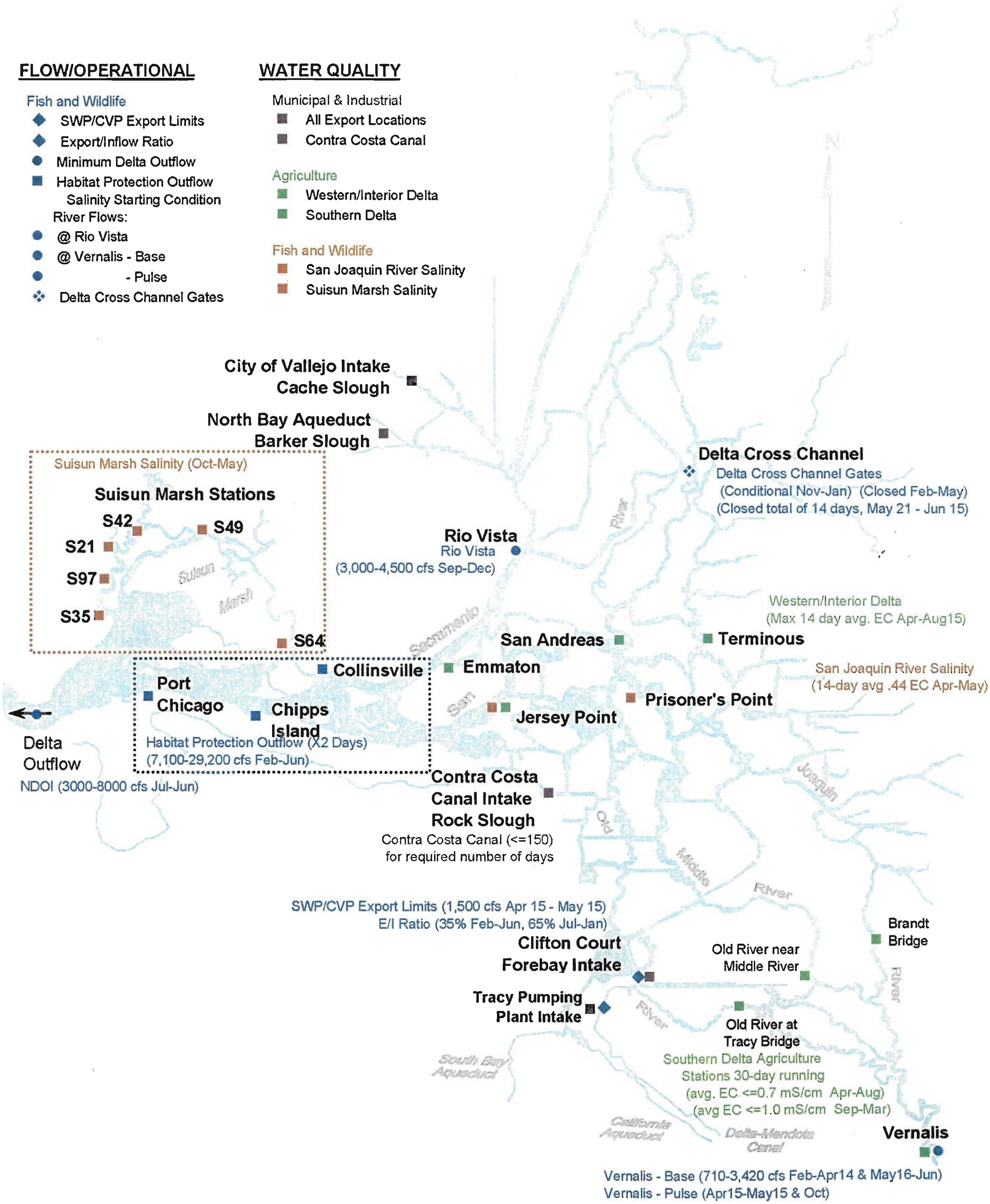
- Changes in ambient water quality associated with BARDP operations and brine disposal are too small to be accurately measured in the field;
- During most conditions, BARDP operations do not have a significant impact on water quality or beneficial uses (municipal water supply, wildlife, agriculture); and
- During critically dry water years, BARDP operations should be coordinated with CVP/SWP and the City of Antioch to avoid impacts.

As noted above, an addendum to this report may be submitted to partners addressing near field concerns related to brine disposal. Bulk estimates of existing stratification and potential changes to stratification given the data currently available will be provided. Additional analyses may be appropriate and will be discussed further in the addendum.

Although the most recent version of the modeling tools available were used for this study, new versions are released often. The potential water quality impacts of BARDP operations should be re-analyzed as new versions of modeling tools are released and as new Delta water projects are planned. Two major changes to water projects and Delta operations are currently being evaluated; the Bay-Delta Conservation Plan (BDCP) and the State Resources Control Board’s update to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta. The BDCP will release a draft environmental impact report in the spring of 2013 and new modeling may be available at that time. The State Water Resources Control Board has begun a process to set new flow criteria for the Delta but it is unknown at this time when or if any new modeling tools will be available.

1.11 Appendix 1-A: D-1641 Water Quality Standards

D-1641 BAY-DELTA STANDARDS STATIONS



Operations Compliance
and Studies Section

Revised 5/7/2002

Preliminary: Subject to Revision

D1641 WATER QUALITY OBJECTIVES - SUMMARY

Consult D1641 for details & exceptions

<table>
<tr><th></th><th colspan="2">Oct</th><th colspan="2">Nov</th><th colspan="2">Dec</th><th colspan="2">Jan</th><th colspan="2">Feb</th><th colspan="2">Mar</th><th colspan="2">Apr</th><th colspan="2">May</th><th colspan="2">Jun</th><th colspan="2">Jul</th><th colspan="2">Aug</th><th colspan="2">Sep</th></tr>
<tr><td>Rock Slough
max mean daily cl <=150 mg/l</td><td colspan="24">155 - 240 days per year</td></tr>
<tr><td>Rock Slough
max mean daily cl</td><td colspan="24">250</td></tr>
<tr><td>Emmaton
max 14 average EC</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="9">0.45 - 2.78</td><td></td><td></td><td></td></tr>
<tr><td>Jersey Point
max 14 day average EC</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="9">0.44 - 2.20</td><td></td><td></td><td></td></tr>
<tr><td>Vernalis, Brandt Bridge, OR near MR, OR at Tracy
max 30 day average EC</td><td colspan="12">1.0</td><td colspan="10">0.7
effective 4/1/05</td><td colspan="2">1.0</td></tr>
<tr><td>NDOI
min monthly average</td><td colspan="8">3000 - 4500</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="6">3000-8000</td></tr>
<tr><td>NDOI or Collinsville EC:3 day NDO or daily or 14 day EC</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="10">7100, 2.64</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>NDOI
min 7 day average</td><td colspan="8">2000 - 3500</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="6">2000 - 6400</td></tr>
<tr><td>Exports
max 3 day (VAMP) - may be varied</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">1500</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>E/I Ratio</td><td colspan="8">65%</td><td colspan="10">35%</td><td colspan="6">65%</td></tr>
<tr><td>Delta Cross Channel
max days closed</td><td></td><td></td><td colspan="6">45</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">14</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

D1641 WATER QUALITY OBJECTIVES

Key: critical year; dry year; below normal year; above normal year; wet year

Municipal & Industrial Beneficial Uses	Year type	Oct–Sep
Cl <=150 mg/l # days per year of max mean daily Cl <= 150 at CCC PP#1 OR Antioch Water Works intake in intervals >= 2 weeks	critical year	155
	dry year	165
	below normal year	175
	above normal year	190
	wet year	240
Cl max mean daily Cl at CCC PP#1 and CCF and DMC and NBA and Cache Slough	critical year	250
	dry year	250
	below normal year	250
	above normal year	250
	wet year	250

Agricultural Beneficial Uses	Year type	Oct–Mar	Apr–Aug	Sep
Emmaton EC max 14 average EC	critical year		2.78	
	dry year		0.45 / 1.67	
	below normal year		0.45 (to 6/20) / 1.14	
	above normal year		0..45 / 0.63	
	wet year		0.45	
Jersey Point EC max 14 day average EC	critical year		2.20	
	dry year		0.45 / 1.35	
	below normal year		0.45 (to 6/20) / 0.74	
	above normal year		0.45	
	wet year		0.45	
Terminous EC max 14 day average EC at Terminous on the Mokulemne	critical year		0.54	
	dry year		0.45	
	below normal year		0.45	
	above normal year		0.45	
	wet year		0.45	
San Andreas EC max 14 day average EC at San Andreas Landing on the San Joaquin	critical year		0.87	
	dry year		0.45 (to 6/25) / 0.58	
	below normal year		0.45	
	above normal year		0.45	
	wet year		0.45	
Vernalis EC max 30 day average EC at Vernalis on the San Joaquin (applies to Brandt Bridge on the San Joaquin, Old River near Middle River, & Old River at Tracy Rd. Bridge after 4/1/05. Standard is 1.0 all year at these sites until then.)	critical year	1.0	0.7	1.0
	dry year	1.0	0.7	1.0
	below normal year	1.0	0.7	1.0
	above normal year	1.0	0.7	1.0
	wet year	1.0	0.7	1.0
Clifton Court and DMC EC max monthly average of mean daily EC (Oct–Sep)	critical year	1.0		
	dry year	1.0		
	below normal year	1.0		
	above normal year	1.0		
	wet year	1.0		

D1641 WATER QUALITY OBJECTIVES

Fish & Wildlife Beneficial Uses	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
San Joaquin Salinity												
max 14 day average EC							0.44					
at Jersey Point & Prisoners Point							0.44					
(In May, only applies if Sac. River Index >8.1 MAF at							0.44					
90% exceedence level.)							0.44					
Eastern Suisun Marsh Salinity	19.0	15.5		12.5	8.0		11.0					
max monthly average of both daily high tide ECs	19.0	15.5		12.5	8.0		11.0					
or demonstrate that equivalent protection is provided	19.0	15.5		12.5	8.0		11.0					
at Collinsville, Montezuma Slough at National Steel	19.0	15.5		12.5	8.0		11.0					
and Montezuma Slough near Beldon Landing	19.0	15.5		12.5	8.0		11.0					
Western Suisun Marsh Salinity - Normal Period	19.0	16.5	15.5	12.5	8.0		11.0					
max monthly average of both daily high tide ECs	19.0	16.5	15.5	12.5	8.0		11.0					
or demonstrate that equivalent protection is provided	19.0	16.5	15.5	12.5	8.0		11.0					
at Chadbourne Slough at Sunrise Duck Club and Suisun	19.0	16.5	15.5	12.5	8.0		11.0					
Slough 300 ft south of Valenti Slough	19.0	16.5	15.5	12.5	8.0		11.0					
Western Suisun Marsh Salinity - Deficiency Period	19.0	16.5	15.6				14.0	12.5				
EC and locations as in normal period, above	19.0	16.5	15.6				14.0	12.5				
Deficiency period = 2nd consecutive dry year after critica	19.0	16.5	15.6				14.0	12.5				
year or dry year after year w. Sac River Index<11.35	19.0	16.5	15.6				14.0	12.5				
MAF or critical year after dry or critical year	19.0	16.5	15.6				14.0	12.5				
NDOI	3000	3500		4500						4000	3000	3000
min monthly average	4000	4500		4500						5000	3500	3000
Jan. min monthly average=6000 if Dec. 8RI>800 TAF	4000	4500		4500						6500	4000	3000
	4000	4500		4500						8000	4000	3000
	4000	4500		4500						8000	4000	3000
NDOI or Collinsville EC					7100, 2.64							
3 day average NDO or daily or 14 day average EC					7100, 2.64							
(See Footnote 10, p. 185 for relaxation of standard in Feb					7100, 2.64							
if Jan 8RI<900; in Mar if Feb 8RI<500; in May & June if					7100, 2.64							
May Sac. RI <8.1 MAF at 90% exceedence)					7100, 2.64							
NDOI	2000	2500		3500						3000	2000	2000
min 7 day average	3000	3500		3500						4000	2500	2000
Jan. min 7 day average=5000 if Dec. 8RI>800 TAF	3000	3500		3500						5200	3000	2000
Standard can be met with daily or 14 day average	3000	3500		3500						6400	3000	2000
Collinsville EC >2.64 in Feb-Jun.	3000	3500		3500						6400	3000	2000
Sacramento Monthly Flow	3000	3500										3000
min monthly average at Rio Vista	4000	4500										3000
	4000	4500										3000
	4000	4500										3000
	4000	4500										3000
Sacramento 7 Day Flow	2000	2500										2000
min 7 day average at Rio Vista	3000	3500										2000
	3000	3500										2000
	3000	3500										2000
	3000	3500										2000
San Joaquin Monthly Flow, no X2	1000				710 (to 4/14)		3110*	710**				
minimum monthly average at Vernalis	1000				1420 (to 4/14)		4020*	1420**				
when X2 at or west of Chipps not required per Table 4	1000				1420 (to 4/14)		4620*	1420**				
* may be varied based on real time monitoring	1000				2130 (to 4/14)		5730*	2130**				
** from 5/16	1000				2130 (to 4/14)		7330*	2130**				
San Joaquin 7 Day Flow, no X2	800				568 (to 4/14)			568**				
minimum 7 day average at Vernalis	800				1136 (to 4/14)			1136**				
when X2 at or west of Chipps not required per Table 4	800				1136 (to 4/14)			1136**				
* may be varied based on real time monitoring	800				1704 (to 4/14)			1704**				
** from 5/16	800				1704 (to 4/14)			1704**				
San Joaquin Monthly Flow, with X2	1000				1140 (to 4/14)		3540*	1140**				
minimum monthly average at Vernalis	1000				2280 (to 4/14)		4880*	2280**				
when X2 at or west of Chipps not required per Table 4	1000				2280 (to 4/14)		5480*	2280**				
* may be varied based on real time monitoring	1000				3420 (to 4/14)		7020*	3420**				
** from 5/16	1000				3420 (to 4/14)		8620*	3420**				
San Joaquin 7 DayFlow, with X2	800				912 (to 4/14)			912**				
minimum 7 day average at Vernalis	800				1824 (to 4/14)			1824**				
when X2 at or west of Chipps not required per Table 4	800				1824 (to 4/14)			1824**				
	800				2736(to 4/14)			2736**				
	800				2736(to 4/14)			2736**				
Exports							1500*					
max 3 day running average from Clifton Court							1500*					
and Tracy less Byron-Bethany diversions							1500*					
*period may be varied based on monitoring; limit may be							1500*					
varied; limit is max of 1500, 3 day average Vernalis flow							1500*					
E/I Ratio	65%				35%					65%		
for variations see footnote 20, p. 187; footnote 21, p.187	65%				35%					65%		
	65%				35%					65%		
	65%				35%					65%		
	65%				35%					65%		
Delta Cross Channel Gate Closure		45						14*				
max total number of days closed		45						14*				
* from 5/21		45						14*				
		45						14*				
		45						14*				

Key

- critical year
- dry year
- below normal year
- above normal year
- wet year

X2 REQUIREMENTS

<table>
<tr><th></th><th>Oct</th><th>Nov</th><th>Dec</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th></th></tr>
<tr><td>D1641</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Collinsville
possible to relax in Feb, March if low 8 River Index
possible to relax in May, June if low Sac River Index</td><td></td><td></td><td></td><td></td><td colspan="5">7,100 cfs 3 day NDO
OR
2.64 µS/cm daily average EC
OR
2.64 µS/cm 14 day EC</td><td></td><td></td><td></td><td>D1641, p. 185, footnote 10</td></tr>
<tr><td>Chipps
# of days in each month depends on previous month's 8RI</td><td></td><td></td><td></td><td></td><td colspan="5">11,400 cfs 3 day NDO
OR
2.64 µS/cm daily average EC
OR
2.64 µS/cm 14 day EC</td><td></td><td></td><td></td><td>D1641, p. 191, Table 4</td></tr>
<tr><td>Port Chicago
triggers when average EC for last 14 days of previous month <2.64
# of days in each month depends on previous month's 8RI</td><td></td><td></td><td></td><td></td><td colspan="5">29,200 cfs 3 day NDO
OR
2.64 µS/cm daily average EC
OR
2.64 µS/cm 14 day EC</td><td></td><td></td><td></td><td>D1641, p. 191, Table 4</td></tr>
<tr><td>CCWD Delta Smelt BO & MOU with DFG</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Collinsville
3 ways to comply allowed from 5/02 through 3/31/2010
do not need to meet in July & August from 5/02 through 3/31/2010</td><td></td><td></td><td>2.64 µS/cm 14 day EC if adult smelt at intake</td><td>2.64 µS/cm 14 day EC</td><td></td><td></td><td></td><td></td><td colspan="3">2.64 µS/cm 14 day EC</td><td></td><td>Smelt BO, p. 18 Management Authorization, DFG MOU, p.29</td></tr>
<tr><td>Chipps
3 ways to comply allowed from 5/02 through 3/31/2010</td><td></td><td></td><td></td><td></td><td colspan="4">2.64 µS/cm 14 day EC</td><td></td><td></td><td></td><td></td><td>Smelt BO, p. 18 Management Authorization, DFG MOU, p.29</td></tr>
</table>

1.12 Appendix 1-B: Waster Water Assumptions and Timeseries Input

Water Year Type	Month	Discharge Lookup I.D.	Date	MSPS Salinity EC mS/cm (DSM2)	Brine Salinity EC mS/cm	Average CCCSD Salinity EC mS/cm	Average Historical CCCSD Flow Volume MG	Desal Plant Waste Stream Volume MG	Combined Flow Volume MG	Avg Combined Concentration mS/cm	Avg Combined Concentration µS/cm
5.00	10.00	5.10	10/31/1974	1.97	7.54	0.99	1134.86	156.27	1291.13	1.78	1780.87
5.00	11.00	5.11	11/30/1974	2.51	8.85	0.99	1177.73	151.23	1328.96	1.88	1882.41
5.00	12.00	5.12	12/31/1974	4.10	12.77	0.99	1439.86	156.27	1596.13	2.14	2141.99
5.00	1.00	5.01	1/31/1975	5.08	15.18	0.99	1778.32	156.27	1934.59	2.13	2134.53
5.00	2.00	5.02	2/28/1975	0.50	3.91	0.99	1665.05	141.15	1806.20	1.22	1216.58
5.00	3.00	5.03	3/31/1975	0.19	3.15	0.99	1756.52	156.27	1912.79	1.16	1164.41
5.00	4.00	5.04	4/30/1975	0.29	3.41	0.99	1511.78	0.00	1511.78	0.99	988.08
5.00	5.00	5.05	5/31/1975	0.27	3.35	0.99	1375.45	156.27	1531.72	1.23	1229.23
5.00	6.00	5.06	6/30/1975	0.58	4.12	0.99	1270.75	151.23	1421.98	1.32	1320.85
5.00	7.00	5.07	7/31/1975	3.02	10.11	0.99	1240.48	156.27	1396.75	2.01	2008.82
5.00	8.00	5.08	8/31/1975	4.92	14.78	0.99	1213.33	156.27	1369.60	2.56	2562.26
5.00	9.00	5.09	9/30/1975	2.62	9.12	0.99	1165.53	151.23	1316.76	1.92	1921.69
1.00	10.00	1.10	10/31/1975	2.78	9.52	0.99	1099.01	156.27	1255.28	2.05	2049.96
1.00	11.00	1.11	11/30/1975	2.78	9.51	0.99	1085.32	151.23	1236.55	2.03	2030.89
1.00	12.00	1.12	12/31/1975	4.01	12.55	0.99	1159.21	156.27	1315.47	2.36	2361.29
1.00	1.00	1.01	1/31/1976	6.22	17.99	0.99	1332.91	156.27	1489.18	2.77	2772.14
1.00	2.00	1.02	2/29/1976	6.67	19.09	0.99	1292.08	146.19	1438.27	2.83	2827.81
1.00	3.00	1.03	3/31/1976	5.17	15.40	0.99	1214.22	156.27	1370.48	2.63	2631.20
1.00	4.00	1.04	4/30/1976	4.78	14.43	0.99	1101.84	0.00	1101.84	0.99	988.08
1.00	5.00	1.05	5/31/1976	7.77	21.80	0.99	1145.59	156.27	1301.85	3.49	3486.39
1.00	6.00	1.06	6/30/1976	10.46	28.41	0.99	1057.35	151.23	1208.57	4.42	4418.77
1.00	7.00	1.07	7/31/1976	10.78	29.19	0.99	1045.03	156.27	1201.30	4.66	4656.61
1.00	8.00	1.08	8/31/1976	11.49	30.94	0.99	1042.72	156.27	1198.98	4.89	4892.44
1.00	9.00	1.09	9/30/1976	13.03	34.73	0.99	996.77	151.23	1147.99	5.43	5433.60
1.00	10.00	1.10	10/31/1976	14.30	37.86	0.99	1099.01	156.27	1255.28	5.58	5578.22
1.00	11.00	1.11	11/30/1976	11.75	31.58	0.99	1085.32	151.23	1236.55	4.73	4729.15
1.00	12.00	1.12	12/31/1976	11.47	30.89	0.99	1159.21	156.27	1315.47	4.54	4540.16
1.00	1.00	1.01	1/31/1977	9.35	25.67	0.99	1332.91	156.27	1489.18	3.58	3578.08
1.00	2.00	1.02	2/28/1977	6.95	19.79	0.99	1247.53	141.15	1388.67	2.90	2898.97
1.00	3.00	1.03	3/31/1977	6.79	19.39	0.99	1214.22	156.27	1370.48	3.09	3086.73
1.00	4.00	1.04	4/30/1977	7.29	20.60	0.99	1101.84	0.00	1101.84	0.99	988.08
1.00	5.00	1.05	5/31/1977	9.77	26.72	0.99	1145.59	156.27	1301.85	4.08	4076.58
1.00	6.00	1.06	6/30/1977	10.70	29.00	0.99	1057.35	151.23	1208.57	4.49	4492.88
1.00	7.00	1.07	7/31/1977	11.40	30.72	0.99	1045.03	156.27	1201.30	4.86	4855.83
1.00	8.00	1.08	8/31/1977	11.82	31.77	0.99	1042.72	156.27	1198.98	5.00	4999.65
1.00	9.00	1.09	9/30/1977	12.63	33.74	0.99	996.77	151.23	1147.99	5.30	5302.49
4.00	10.00	4.10	10/31/1977	12.61	33.71	0.99	1225.65	156.27	1381.92	4.69	4687.98
4.00	11.00	4.11	11/30/1977	12.66	33.82	0.99	1232.25	151.23	1383.48	4.58	4577.29
4.00	12.00	4.12	12/31/1977	8.22	22.89	0.99	1483.85	156.27	1640.12	3.08	3075.09
4.00	1.00	4.01	1/31/1978	0.39	3.65	0.99	1555.00	156.27	1711.27	1.23	1230.88

Water Year Type	Month	Discharge Lookup I.D.	Date	MSPS Salinity EC mS/cm (DSM2)	Brine Salinity EC mS/cm	Average CCCSD Salinity EC mS/cm	Average Historical CCCSD Flow Volume MG	Desal Plant Waste Stream Volume MG	Combined Flow Volume MG	Avg Combined Concentration mS/cm	Avg Combined Concentration µS/cm
4.00	2.00	4.02	2/28/1978	0.21	3.20	0.99	1443.13	141.15	1584.28	1.19	1185.05
4.00	3.00	4.03	3/31/1978	0.20	3.18	0.99	1506.67	156.27	1662.94	1.19	1193.88
4.00	4.00	4.04	4/30/1978	0.22	3.23	0.99	1328.37	0.00	1328.37	0.99	988.08
4.00	5.00	4.05	5/31/1978	0.37	3.58	0.99	1324.07	156.27	1480.34	1.26	1261.95
4.00	6.00	4.06	6/30/1978	1.48	6.31	0.99	1196.17	151.23	1347.39	1.59	1585.64
4.00	7.00	4.07	7/31/1978	3.96	12.42	0.99	1200.07	156.27	1356.34	2.31	2305.58
4.00	8.00	4.08	8/31/1978	5.80	16.95	0.99	1165.53	156.27	1321.80	2.87	2874.96
4.00	9.00	4.09	9/30/1978	5.61	16.49	0.99	1129.93	151.23	1281.16	2.82	2817.39
3.00	10.00	3.10	10/31/1978	5.77	16.88	0.99	1194.47	156.27	1350.74	2.83	2826.39
3.00	11.00	3.11	11/30/1978	5.94	17.29	0.99	1159.83	151.23	1311.06	2.87	2867.95
3.00	12.00	3.12	12/31/1978	5.15	15.36	0.99	1307.80	156.27	1464.07	2.52	2522.03
3.00	1.00	3.01	1/31/1979	1.86	7.26	0.99	1564.80	156.27	1721.07	1.56	1557.24
3.00	2.00	3.02	2/28/1979	0.36	3.55	0.99	1380.77	141.15	1521.92	1.23	1226.05
3.00	3.00	3.03	3/31/1979	0.36	3.57	0.99	1471.67	156.27	1627.94	1.24	1236.33
3.00	4.00	3.04	4/30/1979	0.76	4.55	0.99	1295.37	0.00	1295.37	0.99	988.08
3.00	5.00	3.05	5/31/1979	0.96	5.05	0.99	1303.70	156.27	1459.97	1.42	1422.76
3.00	6.00	3.06	6/30/1979	2.81	9.59	0.99	1194.33	151.23	1345.56	1.96	1955.26
3.00	7.00	3.07	7/31/1979	5.67	16.63	0.99	1185.07	156.27	1341.34	2.81	2810.85
3.00	8.00	3.08	8/31/1979	8.62	23.88	0.99	1165.30	156.27	1321.57	3.69	3694.71
3.00	9.00	3.09	9/30/1979	11.59	31.20	0.99	1120.10	151.23	1271.33	4.58	4581.87
4.00	10.00	4.10	10/31/1979	12.24	32.78	0.99	1225.65	156.27	1381.92	4.58	4583.60
4.00	11.00	4.11	11/30/1979	8.41	23.38	0.99	1232.25	151.23	1383.48	3.44	3435.52
4.00	12.00	4.12	12/31/1979	5.07	15.15	0.99	1483.85	156.27	1640.12	2.34	2336.97
4.00	1.00	4.01	1/31/1980	0.30	3.43	0.99	1555.00	156.27	1711.27	1.21	1210.98
4.00	2.00	4.02	2/29/1980	0.21	3.19	0.99	1494.67	146.19	1640.86	1.18	1184.13
4.00	3.00	4.03	3/31/1980	0.20	3.18	0.99	1506.67	156.27	1662.94	1.19	1194.02
4.00	4.00	4.04	4/30/1980	0.39	3.64	0.99	1328.37	0.00	1328.37	0.99	988.08
4.00	5.00	4.05	5/31/1980	0.76	4.55	0.99	1324.07	156.27	1480.34	1.36	1363.94
4.00	6.00	4.06	6/30/1980	1.97	7.53	0.99	1196.17	151.23	1347.39	1.72	1722.25
4.00	7.00	4.07	7/31/1980	4.19	12.98	0.99	1200.07	156.27	1356.34	2.37	2370.16
4.00	8.00	4.08	8/31/1980	5.89	17.17	0.99	1165.53	156.27	1321.80	2.90	2901.45
4.00	9.00	4.09	9/30/1980	5.76	16.84	0.99	1129.93	151.23	1281.16	2.86	2859.14
2.00	10.00	2.10	10/31/1980	5.78	16.89	0.99	1181.66	156.27	1337.93	2.85	2845.63
2.00	11.00	2.11	11/30/1980	5.94	17.28	0.99	1177.35	151.23	1328.58	2.84	2842.83
2.00	12.00	2.12	12/31/1980	6.51	18.70	0.99	1334.40	156.27	1490.67	2.85	2845.06
2.00	1.00	2.01	1/31/1981	2.65	9.21	0.99	1312.64	156.27	1468.91	1.86	1862.73
2.00	2.00	2.02	2/28/1981	0.92	4.93	0.99	1337.13	141.15	1478.27	1.36	1364.86
2.00	3.00	2.03	3/31/1981	0.62	4.21	0.99	1438.19	156.27	1594.46	1.30	1303.83
2.00	4.00	2.04	4/30/1981	1.16	5.54	0.99	1231.34	0.00	1231.34	0.99	988.08
2.00	5.00	2.05	5/31/1981	3.22	10.61	0.99	1241.23	156.27	1397.49	2.06	2064.04

Water Year Type	Month	Discharge Lookup I.D.	Date	MSPS Salinity EC mS/cm (DSM2)	Brine Salinity EC mS/cm	Average CCCSD Salinity EC mS/cm	Average Historical CCCSD Flow Volume MG	Desal Plant Waste Stream Volume MG	Combined Flow Volume MG	Avg Combined Concentration mS/cm	Avg Combined Concentration µS/cm
2.00	6.00	2.06	6/30/1981	5.58	16.40	0.99	1155.57	151.23	1306.80	2.77	2771.62
2.00	7.00	2.07	7/31/1981	7.82	21.91	0.99	1152.02	156.27	1308.29	3.49	3487.26
2.00	8.00	2.08	8/31/1981	9.88	26.99	0.99	1131.98	156.27	1288.24	4.14	4142.52
2.00	9.00	2.09	9/30/1981	10.25	27.89	0.99	1089.27	151.23	1240.49	4.27	4267.68
5.00	10.00	5.10	10/31/1981	11.32	30.53	0.99	1134.86	156.27	1291.13	4.56	4563.95
5.00	11.00	5.11	11/30/1981	2.48	8.77	0.99	1177.73	151.23	1328.96	1.87	1873.66
5.00	12.00	5.12	12/31/1981	0.19	3.15	0.99	1439.86	156.27	1596.13	1.20	1199.39
5.00	1.00	5.01	1/31/1982	0.20	3.17	0.99	1778.32	156.27	1934.59	1.16	1164.63
5.00	2.00	5.02	2/28/1982	0.19	3.15	0.99	1665.05	141.15	1806.20	1.16	1156.89
5.00	3.00	5.03	3/31/1982	0.20	3.18	0.99	1756.52	156.27	1912.79	1.17	1166.75
5.00	4.00	5.04	4/30/1982	0.19	3.14	0.99	1511.78	0.00	1511.78	0.99	988.08
5.00	5.00	5.05	5/31/1982	0.19	3.14	0.99	1375.45	156.27	1531.72	1.21	1207.67
5.00	6.00	5.06	6/30/1982	0.57	4.09	0.99	1270.75	151.23	1421.98	1.32	1318.18
5.00	7.00	5.07	7/31/1982	3.04	10.16	0.99	1240.48	156.27	1396.75	2.01	2014.25
5.00	8.00	5.08	8/31/1982	4.72	14.29	0.99	1213.33	156.27	1369.60	2.51	2505.25
5.00	9.00	5.09	9/30/1982	2.59	9.06	0.99	1165.53	151.23	1316.76	1.92	1915.30
5.00	10.00	5.10	10/31/1982	2.05	7.73	0.99	1134.86	156.27	1291.13	1.80	1804.13
5.00	11.00	5.11	11/30/1982	0.39	3.64	0.99	1177.73	151.23	1328.96	1.29	1289.53
5.00	12.00	5.12	12/31/1982	0.19	3.16	0.99	1439.86	156.27	1596.13	1.20	1200.46
5.00	1.00	5.01	1/31/1983	0.22	3.22	0.99	1778.32	156.27	1934.59	1.17	1168.07
5.00	2.00	5.02	2/28/1983	0.21	3.20	0.99	1665.05	141.15	1806.20	1.16	1160.97
5.00	3.00	5.03	3/31/1983	0.20	3.17	0.99	1756.52	156.27	1912.79	1.17	1166.54
5.00	4.00	5.04	4/30/1983	0.19	3.15	0.99	1511.78	0.00	1511.78	0.99	988.08
5.00	5.00	5.05	5/31/1983	0.18	3.13	0.99	1375.45	156.27	1531.72	1.21	1206.31
5.00	6.00	5.06	6/30/1983	0.19	3.14	0.99	1270.75	151.23	1421.98	1.22	1216.49
5.00	7.00	5.07	7/31/1983	0.25	3.30	0.99	1240.48	156.27	1396.75	1.25	1246.99
5.00	8.00	5.08	8/31/1983	0.96	5.04	0.99	1213.33	156.27	1369.60	1.45	1449.87
5.00	9.00	5.09	9/30/1983	0.73	4.48	0.99	1165.53	151.23	1316.76	1.39	1389.39
5.00	10.00	5.10	10/31/1983	1.98	7.55	0.99	1134.86	156.27	1291.13	1.78	1782.50
5.00	11.00	5.11	11/30/1983	0.26	3.33	0.99	1177.73	151.23	1328.96	1.25	1254.30
5.00	12.00	5.12	12/31/1983	0.19	3.14	0.99	1439.86	156.27	1596.13	1.20	1198.84
5.00	1.00	5.01	1/31/1984	0.20	3.16	0.99	1778.32	156.27	1934.59	1.16	1163.52
5.00	2.00	5.02	2/29/1984	0.22	3.22	0.99	1724.52	146.19	1870.70	1.16	1162.14
5.00	3.00	5.03	3/31/1984	0.22	3.22	0.99	1756.52	156.27	1912.79	1.17	1170.18
5.00	4.00	5.04	4/30/1984	0.65	4.28	0.99	1511.78	0.00	1511.78	0.99	988.08
5.00	5.00	5.05	5/31/1984	1.51	6.38	0.99	1375.45	156.27	1531.72	1.54	1538.44
5.00	6.00	5.06	6/30/1984	4.07	12.68	0.99	1270.75	151.23	1421.98	2.23	2231.68
5.00	7.00	5.07	7/31/1984	4.38	13.45	0.99	1240.48	156.27	1396.75	2.38	2381.80
5.00	8.00	5.08	8/31/1984	5.22	15.53	0.99	1213.33	156.27	1369.60	2.65	2646.74
5.00	9.00	5.09	9/30/1984	2.71	9.34	0.99	1165.53	151.23	1316.76	1.95	1947.70

Water Year Type	Month	Discharge Lookup I.D.	Date	MSPS Salinity EC mS/cm (DSM2)	Brine Salinity EC mS/cm	Average CCCSD Salinity EC mS/cm	Average Historical CCCSD Flow Volume MG	Desal Plant Waste Stream Volume MG	Combined Flow Volume MG	Avg Combined Concentration mS/cm	Avg Combined Concentration µS/cm
2.00	10.00	2.10	10/31/1984	3.10	10.30	0.99	1181.66	156.27	1337.93	2.08	2076.18
2.00	11.00	2.11	11/30/1984	1.69	6.85	0.99	1177.35	151.23	1328.58	1.65	1654.96
2.00	12.00	2.12	12/31/1984	0.33	3.49	0.99	1334.40	156.27	1490.67	1.25	1250.14
2.00	1.00	2.01	1/31/1985	2.00	7.59	0.99	1312.64	156.27	1468.91	1.69	1690.27
2.00	2.00	2.02	2/28/1985	3.14	10.41	0.99	1337.13	141.15	1478.27	1.89	1887.61
2.00	3.00	2.03	3/31/1985	2.93	9.90	0.99	1438.19	156.27	1594.46	1.86	1861.27
2.00	4.00	2.04	4/30/1985	2.56	8.97	0.99	1231.34	0.00	1231.34	0.99	988.08
2.00	5.00	2.05	5/31/1985	3.61	11.57	0.99	1241.23	156.27	1397.49	2.17	2171.17
2.00	6.00	2.06	6/30/1985	5.47	16.14	0.99	1155.57	151.23	1306.80	2.74	2741.08
2.00	7.00	2.07	7/31/1985	7.51	21.16	0.99	1152.02	156.27	1308.29	3.40	3396.94
2.00	8.00	2.08	8/31/1985	9.64	26.39	0.99	1131.98	156.27	1288.24	4.07	4069.33
2.00	9.00	2.09	9/30/1985	12.11	32.48	0.99	1089.27	151.23	1240.49	4.83	4826.92
5.00	10.00	5.10	10/31/1985	12.34	33.03	0.99	1134.86	156.27	1291.13	4.87	4865.85
5.00	11.00	5.11	11/30/1985	12.08	32.41	0.99	1177.73	151.23	1328.96	4.56	4563.23
5.00	12.00	5.12	12/31/1985	7.90	22.11	0.99	1439.86	156.27	1596.13	3.06	3056.48
5.00	1.00	5.01	1/31/1986	1.93	7.43	0.99	1778.32	156.27	1934.59	1.51	1508.51
5.00	2.00	5.02	2/28/1986	0.20	3.18	0.99	1665.05	141.15	1806.20	1.16	1159.35
5.00	3.00	5.03	3/31/1986	0.20	3.18	0.99	1756.52	156.27	1912.79	1.17	1166.90
5.00	4.00	5.04	4/30/1986	0.30	3.42	0.99	1511.78	0.00	1511.78	0.99	988.08
5.00	5.00	5.05	5/31/1986	0.74	4.51	0.99	1375.45	156.27	1531.72	1.35	1347.00
5.00	6.00	5.06	6/30/1986	2.78	9.51	0.99	1270.75	151.23	1421.98	1.89	1894.52
5.00	7.00	5.07	7/31/1986	4.87	14.66	0.99	1240.48	156.27	1396.75	2.52	2518.05
5.00	8.00	5.08	8/31/1986	5.66	16.61	0.99	1213.33	156.27	1369.60	2.77	2770.71
5.00	9.00	5.09	9/30/1986	2.95	9.93	0.99	1165.53	151.23	1316.76	2.02	2015.36
2.00	10.00	2.10	10/31/1986	3.06	10.20	0.99	1181.66	156.27	1337.93	2.06	2063.55
2.00	11.00	2.11	11/30/1986	3.23	10.63	0.99	1177.35	151.23	1328.58	2.09	2085.54
2.00	12.00	2.12	12/31/1986	6.47	18.59	0.99	1334.40	156.27	1490.67	2.83	2833.49
2.00	1.00	2.01	1/31/1987	6.57	18.83	0.99	1312.64	156.27	1468.91	2.89	2886.60
2.00	2.00	2.02	2/28/1987	2.96	9.96	0.99	1337.13	141.15	1478.27	1.84	1844.72
2.00	3.00	2.03	3/31/1987	0.84	4.75	0.99	1438.19	156.27	1594.46	1.36	1356.66
2.00	4.00	2.04	4/30/1987	2.61	9.09	0.99	1231.34	0.00	1231.34	0.99	988.08
2.00	5.00	2.05	5/31/1987	4.65	14.12	0.99	1241.23	156.27	1397.49	2.46	2456.82
2.00	6.00	2.06	6/30/1987	5.67	16.63	0.99	1155.57	151.23	1306.80	2.80	2798.74
2.00	7.00	2.07	7/31/1987	7.52	21.19	0.99	1152.02	156.27	1308.29	3.40	3400.92
2.00	8.00	2.08	8/31/1987	10.56	28.66	0.99	1131.98	156.27	1288.24	4.34	4344.38
2.00	9.00	2.09	9/30/1987	12.56	33.57	0.99	1089.27	151.23	1240.49	4.96	4960.38
1.00	10.00	1.10	10/31/1987	13.40	35.65	0.99	1099.01	156.27	1255.28	5.30	5303.14
1.00	11.00	1.11	11/30/1987	12.87	34.34	0.99	1085.32	151.23	1236.55	5.07	5067.07
1.00	12.00	1.12	12/31/1987	6.93	19.73	0.99	1159.21	156.27	1315.47	3.21	3214.41
1.00	1.00	1.01	1/31/1988	1.12	5.43	0.99	1332.91	156.27	1489.18	1.45	1453.70

Water Year Type	Month	Discharge Lookup I.D.	Date	MSPS Salinity EC mS/cm (DSM2)	Brine Salinity EC mS/cm	Average CCCSD Salinity EC mS/cm	Average Historical CCCSD Flow Volume MG	Desal Plant Waste Stream Volume MG	Combined Flow Volume MG	Avg Combined Concentration mS/cm	Avg Combined Concentration µS/cm
1.00	2.00	1.02	2/29/1988	1.49	6.35	0.99	1292.08	146.19	1438.27	1.53	1533.26
1.00	3.00	1.03	3/31/1988	4.30	13.26	0.99	1214.22	156.27	1370.48	2.39	2387.74
1.00	4.00	1.04	4/30/1988	4.58	13.94	0.99	1101.84	0.00	1101.84	0.99	988.08
1.00	5.00	1.05	5/31/1988	6.02	17.50	0.99	1145.59	156.27	1301.85	2.97	2969.62
1.00	6.00	1.06	6/30/1988	6.99	19.88	0.99	1057.35	151.23	1208.57	3.35	3352.54
1.00	7.00	1.07	7/31/1988	9.19	25.28	0.99	1045.03	156.27	1201.30	4.15	4147.98
1.00	8.00	1.08	8/31/1988	11.94	32.05	0.99	1042.72	156.27	1198.98	5.04	5035.97
1.00	9.00	1.09	9/30/1988	13.50	35.90	0.99	996.77	151.23	1147.99	5.59	5587.02
2.00	10.00	2.10	10/31/1988	13.62	36.18	0.99	1181.66	156.27	1337.93	5.10	5098.33
2.00	11.00	2.11	11/30/1988	13.04	34.75	0.99	1177.35	151.23	1328.58	4.83	4830.81
2.00	12.00	2.12	12/31/1988	10.89	29.47	0.99	1334.40	156.27	1490.67	3.97	3973.38
2.00	1.00	2.01	1/31/1989	7.82	21.91	0.99	1312.64	156.27	1468.91	3.21	3213.66
2.00	2.00	2.02	2/28/1989	7.07	20.08	0.99	1337.13	141.15	1478.27	2.81	2810.77
2.00	3.00	2.03	3/31/1989	0.61	4.18	0.99	1438.19	156.27	1594.46	1.30	1301.21
2.00	4.00	2.04	4/30/1989	0.49	3.89	0.99	1231.34	0.00	1231.34	0.99	988.08
2.00	5.00	2.05	5/31/1989	2.29	8.31	0.99	1241.23	156.27	1397.49	1.81	1806.51
2.00	6.00	2.06	6/30/1989	5.34	15.83	0.99	1155.57	151.23	1306.80	2.71	2705.42
2.00	7.00	2.07	7/31/1989	7.55	21.25	0.99	1152.02	156.27	1308.29	3.41	3407.72
2.00	8.00	2.08	8/31/1989	9.50	26.06	0.99	1131.98	156.27	1288.24	4.03	4028.88
2.00	9.00	2.09	9/30/1989	10.72	29.04	0.99	1089.27	151.23	1240.49	4.41	4408.07
1.00	10.00	1.10	10/31/1989	12.05	32.33	0.99	1099.01	156.27	1255.28	4.89	4889.56
1.00	11.00	1.11	11/30/1989	12.59	33.64	0.99	1085.32	151.23	1236.55	4.98	4981.34
1.00	12.00	1.12	12/31/1989	12.41	33.21	0.99	1159.21	156.27	1315.47	4.82	4815.66
1.00	1.00	1.01	1/31/1990	5.49	16.19	0.99	1332.91	156.27	1489.18	2.58	2583.04
1.00	2.00	1.02	2/28/1990	3.32	10.85	0.99	1247.53	141.15	1388.67	1.99	1990.56
1.00	3.00	1.03	3/31/1990	3.42	11.09	0.99	1214.22	156.27	1370.48	2.14	2140.08
1.00	4.00	1.04	4/30/1990	4.14	12.88	0.99	1101.84	0.00	1101.84	0.99	988.08
1.00	5.00	1.05	5/31/1990	6.77	19.35	0.99	1145.59	156.27	1301.85	3.19	3191.72
1.00	6.00	1.06	6/30/1990	9.47	25.98	0.99	1057.35	151.23	1208.57	4.11	4114.91
1.00	7.00	1.07	7/31/1990	11.15	30.12	0.99	1045.03	156.27	1201.30	4.78	4777.39
1.00	8.00	1.08	8/31/1990	11.79	31.69	0.99	1042.72	156.27	1198.98	4.99	4989.26
1.00	9.00	1.09	9/30/1990	13.19	35.13	0.99	996.77	151.23	1147.99	5.49	5485.19
1.00	10.00	1.10	10/31/1990	12.39	33.17	0.99	1099.01	156.27	1255.28	4.99	4994.03
1.00	11.00	1.11	11/30/1990	12.40	33.18	0.99	1085.32	151.23	1236.55	4.92	4924.75
1.00	12.00	1.12	12/31/1990	13.72	36.43	0.99	1159.21	156.27	1315.47	5.20	5197.96
1.00	1.00	1.01	1/31/1991	10.07	27.46	0.99	1332.91	156.27	1489.18	3.77	3766.31
1.00	2.00	1.02	2/28/1991	7.64	21.48	0.99	1247.53	141.15	1388.67	3.07	3071.09
1.00	3.00	1.03	3/31/1991	1.16	5.53	0.99	1214.22	156.27	1370.48	1.51	1506.48
1.00	4.00	1.04	4/30/1991	1.64	6.70	0.99	1101.84	0.00	1101.84	0.99	988.08
1.00	5.00	1.05	5/31/1991	6.09	17.66	0.99	1145.59	156.27	1301.85	2.99	2989.70

Water Year Type	Month	Discharge Lookup I.D.	Date	MSPS Salinity EC mS/cm (DSM2)	Brine Salinity EC mS/cm	Average CCCSD Salinity EC mS/cm	Average Historical CCCSD Flow Volume MG	Desal Plant Waste Stream Volume MG	Combined Flow Volume MG	Avg Combined Concentration mS/cm	Avg Combined Concentration µS/cm
1.00	6.00	1.06	6/30/1991	9.79	26.76	0.99	1057.35	151.23	1208.57	4.21	4212.30
1.00	7.00	1.07	7/31/1991	11.00	29.75	0.99	1045.03	156.27	1201.30	4.73	4729.67
1.00	8.00	1.08	8/31/1991	11.55	31.08	0.99	1042.72	156.27	1198.98	4.91	4910.53
1.00	9.00	1.09	9/30/1991	13.03	34.73	0.99	996.77	151.23	1147.99	5.43	5433.39
									1403.28		2627.63
									46.78		

Water Year Type	Month	Historical Discharge Lookup I.D.	Date	MSPS Salinity EC mS/cm (DSM2)	Brine Salinity EC mS/cm	Average DDSD Salinity EC mS/cm	Historical DDSD Effluent Volume MG	Desal Plant Waste Stream Volume MG	Combined Effluent Volume MG	Avg Combined Concentration mS/cm	Avg Combined Concentration µS/cm
5	10	5.1	10/31/1974	1.97	7.54	3.44	349.97	156.27	506.23	4.71	4706.00
5	11	5.11	11/30/1974	2.51	8.85	3.44	350.74	151.23	501.97	5.07	5069.96
5	12	5.12	12/31/1974	4.10	12.77	3.44	374.87	156.27	531.14	6.19	6187.15
5	1	5.01	1/31/1975	5.08	15.18	3.44	394.85	156.27	551.12	6.77	6770.07
5	2	5.02	2/28/1975	0.50	3.91	3.44	367.05	141.15	508.20	3.57	3572.07
5	3	5.03	3/31/1975	0.19	3.15	3.44	400.41	156.27	556.68	3.36	3358.54
5	4	5.04	4/30/1975	0.29	3.41	3.44	379.30	0.00	379.30	3.44	3441.33
5	5	5.05	5/31/1975	0.27	3.35	3.44	385.62	156.27	541.89	3.42	3415.50
5	6	5.06	6/30/1975	0.58	4.12	3.44	356.40	151.23	507.63	3.64	3642.63
5	7	5.07	7/31/1975	3.02	10.11	3.44	354.12	156.27	510.39	5.48	5483.61
5	8	5.08	8/31/1975	4.92	14.78	3.44	376.56	156.27	532.83	6.77	6768.15
5	9	5.09	9/30/1975	2.62	9.12	3.44	364.30	151.23	515.53	5.11	5106.30
1	10	1.1	10/31/1975	2.78	9.52	3.44	292.34	156.27	448.61	5.56	5558.04
1	11	1.11	11/30/1975	2.78	9.51	3.44	287.76	151.23	438.98	5.53	5533.63
1	12	1.12	12/31/1975	4.01	12.55	3.44	298.78	156.27	455.05	6.57	6568.56
1	1	1.01	1/31/1976	6.22	17.99	3.44	323.79	156.27	480.05	8.18	8177.09
1	2	1.02	2/29/1976	6.67	19.09	3.44	304.56	146.19	450.75	8.52	8515.99
1	3	1.03	3/31/1976	5.17	15.40	3.44	307.84	156.27	464.10	7.47	7467.36
1	4	1.04	4/30/1976	4.78	14.43	3.44	286.02	0.00	286.02	3.44	3441.33
1	5	1.05	5/31/1976	7.77	21.80	3.44	319.11	156.27	475.38	9.48	9476.67
1	6	1.06	6/30/1976	10.46	28.41	3.44	299.75	151.23	450.97	11.81	11812.65
1	7	1.07	7/31/1976	10.78	29.19	3.44	290.70	156.27	446.96	12.44	12443.48
1	8	1.08	8/31/1976	11.49	30.94	3.44	283.95	156.27	440.22	13.20	13204.43
1	9	1.09	9/30/1976	13.03	34.73	3.44	280.15	151.23	431.38	14.41	14411.89
1	10	1.1	10/31/1976	14.30	37.86	3.44	292.34	156.27	448.61	15.43	15430.62
1	11	1.11	11/30/1976	11.75	31.58	3.44	287.76	151.23	438.98	13.13	13134.17
1	12	1.12	12/31/1976	11.47	30.89	3.44	298.78	156.27	455.05	12.87	12867.28
1	1	1.01	1/31/1977	9.35	25.67	3.44	323.79	156.27	480.05	10.68	10677.20
1	2	1.02	2/28/1977	6.95	19.79	3.44	304.56	141.15	445.71	8.62	8618.12
1	3	1.03	3/31/1977	6.79	19.39	3.44	307.84	156.27	464.10	8.81	8812.55
1	4	1.04	4/30/1977	7.29	20.60	3.44	286.02	0.00	286.02	3.44	3441.33
1	5	1.05	5/31/1977	9.77	26.72	3.44	319.11	156.27	475.38	11.09	11092.94
1	6	1.06	6/30/1977	10.70	29.00	3.44	299.75	151.23	450.97	12.01	12011.25

Water Year Type	Month	Historical Discharge Lookup I.D.	Date	MSPS Salinity EC mS/cm (DSM2)	Brine Salinity EC mS/cm	Average DDSD Salinity EC mS/cm	Historical DDSD Effluent Volume MG	Desal Plant Waste Stream Volume MG	Combined Effluent Volume MG	Avg Combined Concentration mS/cm	Avg Combined Concentration µS/cm
1	7	1.07	7/31/1977	11.40	30.72	3.44	290.70	156.27	446.96	12.98	12978.91
1	8	1.08	8/31/1977	11.82	31.77	3.44	283.95	156.27	440.22	13.50	13496.42
1	9	1.09	9/30/1977	12.63	33.74	3.44	280.15	151.23	431.38	14.06	14062.97
4	10	4.1	10/31/1977	12.61	33.71	3.44	334.64	156.27	490.91	13.08	13075.63
4	11	4.11	11/30/1977	12.66	33.82	3.44	330.51	151.23	481.73	12.98	12978.93
4	12	4.12	12/31/1977	8.22	22.89	3.44	363.61	156.27	519.88	9.29	9288.02
4	1	4.01	1/31/1978	0.39	3.65	3.44	370.10	156.27	526.37	3.50	3502.36
4	2	4.02	2/28/1978	0.21	3.20	3.44	338.67	141.15	479.82	3.37	3370.02
4	3	4.03	3/31/1978	0.20	3.18	3.44	345.70	156.27	501.97	3.36	3359.37
4	4	4.04	4/30/1978	0.22	3.23	3.44	339.31	0.00	339.31	3.44	3441.33
4	5	4.05	5/31/1978	0.37	3.58	3.44	352.29	156.27	508.56	3.48	3484.70
4	6	4.06	6/30/1978	1.48	6.31	3.44	332.03	151.23	483.26	4.34	4339.70
4	7	4.07	7/31/1978	3.96	12.42	3.44	321.32	156.27	477.59	6.38	6380.29
4	8	4.08	8/31/1978	5.80	16.95	3.44	327.08	156.27	483.35	7.81	7808.19
4	9	4.09	9/30/1978	5.61	16.49	3.44	316.56	151.23	467.78	7.66	7658.32
3	10	3.1	10/31/1978	5.77	16.88	3.44	254.03	156.27	410.30	8.56	8558.78
3	11	3.11	11/30/1978	5.94	17.29	3.44	280.07	151.23	431.29	8.30	8295.60
3	12	3.12	12/31/1978	5.15	15.36	3.44	313.97	156.27	470.24	7.40	7402.00
3	1	3.01	1/31/1979	1.86	7.26	3.44	328.13	156.27	484.40	4.67	4672.12
3	2	3.02	2/28/1979	0.36	3.55	3.44	273.77	141.15	414.92	3.48	3479.65
3	3	3.03	3/31/1979	0.36	3.57	3.44	286.50	156.27	442.77	3.49	3488.21
3	4	3.04	4/30/1979	0.76	4.55	3.44	278.00	0.00	278.00	3.44	3441.33
3	5	3.05	5/31/1979	0.96	5.05	3.44	328.57	156.27	484.84	3.96	3959.56
3	6	3.06	6/30/1979	2.81	9.59	3.44	278.17	151.23	429.39	5.61	5608.10
3	7	3.07	7/31/1979	5.67	16.63	3.44	240.70	156.27	396.97	8.63	8634.62
3	8	3.08	8/31/1979	8.62	23.88	3.44	241.50	156.27	397.77	11.47	11470.20
3	9	3.09	9/30/1979	11.59	31.20	3.44	245.20	151.23	396.43	14.03	14030.61
4	10	4.1	10/31/1979	12.24	32.78	3.44	334.64	156.27	490.91	12.78	12781.79
4	11	4.11	11/30/1979	8.41	23.38	3.44	330.51	151.23	481.73	9.70	9699.93
4	12	4.12	12/31/1979	5.07	15.15	3.44	363.61	156.27	519.88	6.96	6959.41
4	1	4.01	1/31/1980	0.30	3.43	3.44	370.10	156.27	526.37	3.44	3437.66
4	2	4.02	2/29/1980	0.21	3.19	3.44	338.67	146.19	484.86	3.37	3365.12
4	3	4.03	3/31/1980	0.20	3.18	3.44	345.70	156.27	501.97	3.36	3359.83

Water Year Type	Month	Historical Discharge Lookup I.D.	Date	MSPS Salinity EC mS/cm (DSM2)	Brine Salinity EC mS/cm	Average DDSD Salinity EC mS/cm	Historical DDSD Effluent Volume MG	Desal Plant Waste Stream Volume MG	Combined Effluent Volume MG	Avg Combined Concentration mS/cm	Avg Combined Concentration µS/cm
4	4	4.04	4/30/1980	0.39	3.64	3.44	339.31	0.00	339.31	3.44	3441.33
4	5	4.05	5/31/1980	0.76	4.55	3.44	352.29	156.27	508.56	3.78	3781.57
4	6	4.06	6/30/1980	1.97	7.53	3.44	332.03	151.23	483.26	4.72	4720.58
4	7	4.07	7/31/1980	4.19	12.98	3.44	321.32	156.27	477.59	6.56	6563.69
4	8	4.08	8/31/1980	5.89	17.17	3.44	327.08	156.27	483.35	7.88	7880.61
4	9	4.09	9/30/1980	5.76	16.84	3.44	316.56	151.23	467.78	7.77	7772.67
2	10	2.1	10/31/1980	5.78	16.89	3.44	333.77	156.27	490.04	7.73	7730.62
2	11	2.11	11/30/1980	5.94	17.28	3.44	338.98	151.23	490.20	7.71	7711.35
2	12	2.12	12/31/1980	6.51	18.70	3.44	360.47	156.27	516.74	8.06	8056.32
2	1	2.01	1/31/1981	2.65	9.21	3.44	350.45	156.27	506.72	5.22	5220.24
2	2	2.02	2/28/1981	0.92	4.93	3.44	323.08	141.15	464.23	3.90	3895.23
2	3	2.03	3/31/1981	0.62	4.21	3.44	357.22	156.27	513.49	3.68	3675.17
2	4	2.04	4/30/1981	1.16	5.54	3.44	336.68	0.00	336.68	3.44	3441.33
2	5	2.05	5/31/1981	3.22	10.61	3.44	326.25	156.27	482.52	5.76	5763.07
2	6	2.06	6/30/1981	5.58	16.40	3.44	312.18	151.23	463.40	7.67	7670.31
2	7	2.07	7/31/1981	7.82	21.91	3.44	289.38	156.27	445.64	9.92	9918.00
2	8	2.08	8/31/1981	9.88	26.99	3.44	273.30	156.27	429.57	12.01	12008.79
2	9	2.09	9/30/1981	10.25	27.89	3.44	261.70	151.23	412.93	12.40	12395.24
5	10	5.1	10/31/1981	11.32	30.53	3.44	349.97	156.27	506.23	11.80	11804.12
5	11	5.11	11/30/1981	2.48	8.77	3.44	350.74	151.23	501.97	5.05	5046.81
5	12	5.12	12/31/1981	0.19	3.15	3.44	374.87	156.27	531.14	3.35	3354.56
5	1	5.01	1/31/1982	0.20	3.17	3.44	394.85	156.27	551.12	3.37	3365.43
5	2	5.02	2/28/1982	0.19	3.15	3.44	367.05	141.15	508.20	3.36	3359.95
5	3	5.03	3/31/1982	0.20	3.18	3.44	400.41	156.27	556.68	3.37	3366.58
5	4	5.04	4/30/1982	0.19	3.14	3.44	379.30	0.00	379.30	3.44	3441.33
5	5	5.05	5/31/1982	0.19	3.14	3.44	385.62	156.27	541.89	3.35	3354.57
5	6	5.06	6/30/1982	0.57	4.09	3.44	356.40	151.23	507.63	3.64	3635.16
5	7	5.07	7/31/1982	3.04	10.16	3.44	354.12	156.27	510.39	5.50	5498.47
5	8	5.08	8/31/1982	4.72	14.29	3.44	376.56	156.27	532.83	6.62	6621.61
5	9	5.09	9/30/1982	2.59	9.06	3.44	364.30	151.23	515.53	5.09	5089.99
5	10	5.1	10/31/1982	2.05	7.73	3.44	349.97	156.27	506.23	4.77	4765.34
5	11	5.11	11/30/1982	0.39	3.64	3.44	350.74	151.23	501.97	3.50	3500.33
5	12	5.12	12/31/1982	0.19	3.16	3.44	374.87	156.27	531.14	3.36	3357.75

Water Year Type	Month	Historical Discharge Lookup I.D.	Date	MSPS Salinity EC mS/cm (DSM2)	Brine Salinity EC mS/cm	Average DDSD Salinity EC mS/cm	Historical DDSD Effluent Volume MG	Desal Plant Waste Stream Volume MG	Combined Effluent Volume MG	Avg Combined Concentration mS/cm	Avg Combined Concentration µS/cm
5	1	5.01	1/31/1983	0.22	3.22	3.44	394.85	156.27	551.12	3.38	3377.51
5	2	5.02	2/28/1983	0.21	3.20	3.44	367.05	141.15	508.20	3.37	3374.42
5	3	5.03	3/31/1983	0.20	3.17	3.44	400.41	156.27	556.68	3.37	3365.86
5	4	5.04	4/30/1983	0.19	3.15	3.44	379.30	0.00	379.30	3.44	3441.33
5	5	5.05	5/31/1983	0.18	3.13	3.44	385.62	156.27	541.89	3.35	3350.71
5	6	5.06	6/30/1983	0.19	3.14	3.44	356.40	151.23	507.63	3.35	3350.31
5	7	5.07	7/31/1983	0.25	3.30	3.44	354.12	156.27	510.39	3.40	3398.76
5	8	5.08	8/31/1983	0.96	5.04	3.44	376.56	156.27	532.83	3.91	3908.82
5	9	5.09	9/30/1983	0.73	4.48	3.44	364.30	151.23	515.53	3.75	3746.70
5	10	5.1	10/31/1983	1.98	7.55	3.44	349.97	156.27	506.23	4.71	4710.17
5	11	5.11	11/30/1983	0.26	3.33	3.44	350.74	151.23	501.97	3.41	3407.05
5	12	5.12	12/31/1983	0.19	3.14	3.44	374.87	156.27	531.14	3.35	3352.89
5	1	5.01	1/31/1984	0.20	3.16	3.44	394.85	156.27	551.12	3.36	3361.57
5	2	5.02	2/29/1984	0.22	3.22	3.44	367.05	146.19	513.24	3.38	3376.99
5	3	5.03	3/31/1984	0.22	3.22	3.44	400.41	156.27	556.68	3.38	3378.38
5	4	5.04	4/30/1984	0.65	4.28	3.44	379.30	0.00	379.30	3.44	3441.33
5	5	5.05	5/31/1984	1.51	6.38	3.44	385.62	156.27	541.89	4.29	4289.51
5	6	5.06	6/30/1984	4.07	12.68	3.44	356.40	151.23	507.63	6.19	6194.09
5	7	5.07	7/31/1984	4.38	13.45	3.44	354.12	156.27	510.39	6.50	6504.34
5	8	5.08	8/31/1984	5.22	15.53	3.44	376.56	156.27	532.83	6.99	6985.28
5	9	5.09	9/30/1984	2.71	9.34	3.44	364.30	151.23	515.53	5.17	5172.75
2	10	2.1	10/31/1984	3.10	10.30	3.44	333.77	156.27	490.04	5.63	5629.81
2	11	2.11	11/30/1984	1.69	6.85	3.44	338.98	151.23	490.20	4.49	4491.90
2	12	2.12	12/31/1984	0.33	3.49	3.44	360.47	156.27	516.74	3.46	3455.40
2	1	2.01	1/31/1985	2.00	7.59	3.44	350.45	156.27	506.72	4.72	4720.32
2	2	2.02	2/28/1985	3.14	10.41	3.44	323.08	141.15	464.23	5.56	5559.84
2	3	2.03	3/31/1985	2.93	9.90	3.44	357.22	156.27	513.49	5.41	5406.10
2	4	2.04	4/30/1985	2.56	8.97	3.44	336.68	0.00	336.68	3.44	3441.33
2	5	2.05	5/31/1985	3.61	11.57	3.44	326.25	156.27	482.52	6.07	6073.33
2	6	2.06	6/30/1985	5.47	16.14	3.44	312.18	151.23	463.40	7.58	7584.18
2	7	2.07	7/31/1985	7.51	21.16	3.44	289.38	156.27	445.64	9.65	9652.85
2	8	2.08	8/31/1985	9.64	26.39	3.44	273.30	156.27	429.57	11.79	11789.32
2	9	2.09	9/30/1985	12.11	32.48	3.44	261.70	151.23	412.93	14.08	14075.27

Water Year Type	Month	Historical Discharge Lookup I.D.	Date	MSPS Salinity EC mS/cm (DSM2)	Brine Salinity EC mS/cm	Average DDSD Salinity EC mS/cm	Historical DDSD Effluent Volume MG	Desal Plant Waste Stream Volume MG	Combined Effluent Volume MG	Avg Combined Concentration mS/cm	Avg Combined Concentration µS/cm
5	10	5.1	10/31/1985	12.34	33.03	3.44	349.97	156.27	506.23	12.57	12574.10
5	11	5.11	11/30/1985	12.08	32.41	3.44	350.74	151.23	501.97	12.17	12167.37
5	12	5.12	12/31/1985	7.90	22.11	3.44	374.87	156.27	531.14	8.94	8935.27
5	1	5.01	1/31/1986	1.93	7.43	3.44	394.85	156.27	551.12	4.57	4572.57
5	2	5.02	2/28/1986	0.20	3.18	3.44	367.05	141.15	508.20	3.37	3368.67
5	3	5.03	3/31/1986	0.20	3.18	3.44	400.41	156.27	556.68	3.37	3367.08
5	4	5.04	4/30/1986	0.30	3.42	3.44	379.30	0.00	379.30	3.44	3441.33
5	5	5.05	5/31/1986	0.74	4.51	3.44	385.62	156.27	541.89	3.75	3748.40
5	6	5.06	6/30/1986	2.78	9.51	3.44	356.40	151.23	507.63	5.25	5249.62
5	7	5.07	7/31/1986	4.87	14.66	3.44	354.12	156.27	510.39	6.88	6877.20
5	8	5.08	8/31/1986	5.66	16.61	3.44	376.56	156.27	532.83	7.30	7303.95
5	9	5.09	9/30/1986	2.95	9.93	3.44	364.30	151.23	515.53	5.35	5345.56
2	10	2.1	10/31/1986	3.06	10.20	3.44	333.77	156.27	490.04	5.60	5595.33
2	11	2.11	11/30/1986	3.23	10.63	3.44	338.98	151.23	490.20	5.66	5658.89
2	12	2.12	12/31/1986	6.47	18.59	3.44	360.47	156.27	516.74	8.02	8022.94
2	1	2.01	1/31/1987	6.57	18.83	3.44	350.45	156.27	506.72	8.19	8188.31
2	2	2.02	2/28/1987	2.96	9.96	3.44	323.08	141.15	464.23	5.42	5423.27
2	3	2.03	3/31/1987	0.84	4.75	3.44	357.22	156.27	513.49	3.84	3839.23
2	4	2.04	4/30/1987	2.61	9.09	3.44	336.68	0.00	336.68	3.44	3441.33
2	5	2.05	5/31/1987	4.65	14.12	3.44	326.25	156.27	482.52	6.90	6900.65
2	6	2.06	6/30/1987	5.67	16.63	3.44	312.18	151.23	463.40	7.75	7746.78
2	7	2.07	7/31/1987	7.52	21.19	3.44	289.38	156.27	445.64	9.66	9664.53
2	8	2.08	8/31/1987	10.56	28.66	3.44	273.30	156.27	429.57	12.61	12614.16
2	9	2.09	9/30/1987	12.56	33.57	3.44	261.70	151.23	412.93	14.48	14476.21
1	10	1.1	10/31/1987	13.40	35.65	3.44	292.34	156.27	448.61	14.66	14660.92
1	11	1.11	11/30/1987	12.87	34.34	3.44	287.76	151.23	438.98	14.09	14086.05
1	12	1.12	12/31/1987	6.93	19.73	3.44	298.78	156.27	455.05	9.03	9034.78
1	1	1.01	1/31/1988	1.12	5.43	3.44	323.79	156.27	480.05	4.09	4087.15
1	2	1.02	2/29/1988	1.49	6.35	3.44	304.56	146.19	450.75	4.39	4385.27
1	3	1.03	3/31/1988	4.30	13.26	3.44	307.84	156.27	464.10	6.75	6748.45
1	4	1.04	4/30/1988	4.58	13.94	3.44	286.02	0.00	286.02	3.44	3441.33
1	5	1.05	5/31/1988	6.02	17.50	3.44	319.11	156.27	475.38	8.06	8061.46
1	6	1.06	6/30/1988	6.99	19.88	3.44	299.75	151.23	450.97	8.96	8955.22

Water Year Type	Month	Historical Discharge Lookup I.D.	Date	MSPS Salinity EC mS/cm (DSM2)	Brine Salinity EC mS/cm	Average DDSD Salinity EC mS/cm	Historical DDSD Effluent Volume MG	Desal Plant Waste Stream Volume MG	Combined Effluent Volume MG	Avg Combined Concentration mS/cm	Avg Combined Concentration µS/cm
1	7	1.07	7/31/1988	9.19	25.28	3.44	290.70	156.27	446.96	11.08	11076.45
1	8	1.08	8/31/1988	11.94	32.05	3.44	283.95	156.27	440.22	13.60	13595.35
1	9	1.09	9/30/1988	13.50	35.90	3.44	280.15	151.23	431.38	14.82	14820.18
2	10	2.1	10/31/1988	13.62	36.18	3.44	333.77	156.27	490.04	13.88	13881.11
2	11	2.11	11/30/1988	13.04	34.75	3.44	338.98	151.23	490.20	13.10	13099.30
2	12	2.12	12/31/1988	10.89	29.47	3.44	360.47	156.27	516.74	11.31	11311.24
2	1	2.01	1/31/1989	7.82	21.91	3.44	350.45	156.27	506.72	9.14	9136.42
2	2	2.02	2/28/1989	7.07	20.08	3.44	323.08	141.15	464.23	8.50	8499.53
2	3	2.03	3/31/1989	0.61	4.18	3.44	357.22	156.27	513.49	3.67	3667.04
2	4	2.04	4/30/1989	0.49	3.89	3.44	336.68	0.00	336.68	3.44	3441.33
2	5	2.05	5/31/1989	2.29	8.31	3.44	326.25	156.27	482.52	5.02	5017.19
2	6	2.06	6/30/1989	5.34	15.83	3.44	312.18	151.23	463.40	7.48	7483.63
2	7	2.07	7/31/1989	7.55	21.25	3.44	289.38	156.27	445.64	9.68	9684.50
2	8	2.08	8/31/1989	9.50	26.06	3.44	273.30	156.27	429.57	11.67	11668.01
2	9	2.09	9/30/1989	10.72	29.04	3.44	261.70	151.23	412.93	12.82	12817.01
1	10	1.1	10/31/1989	12.05	32.33	3.44	292.34	156.27	448.61	13.50	13503.64
1	11	1.11	11/30/1989	12.59	33.64	3.44	287.76	151.23	438.98	13.84	13844.56
1	12	1.12	12/31/1989	12.41	33.21	3.44	298.78	156.27	455.05	13.66	13663.70
1	1	1.01	1/31/1990	5.49	16.19	3.44	323.79	156.27	480.05	7.59	7590.48
1	2	1.02	2/28/1990	3.32	10.85	3.44	304.56	141.15	445.71	5.79	5787.82
1	3	1.03	3/31/1990	3.42	11.09	3.44	307.84	156.27	464.10	6.02	6017.10
1	4	1.04	4/30/1990	4.14	12.88	3.44	286.02	0.00	286.02	3.44	3441.33
1	5	1.05	5/31/1990	6.77	19.35	3.44	319.11	156.27	475.38	8.67	8669.70
1	6	1.06	6/30/1990	9.47	25.98	3.44	299.75	151.23	450.97	11.00	10998.33
1	7	1.07	7/31/1990	11.15	30.12	3.44	290.70	156.27	446.96	12.77	12768.09
1	8	1.08	8/31/1990	11.79	31.69	3.44	283.95	156.27	440.22	13.47	13468.13
1	9	1.09	9/30/1990	13.19	35.13	3.44	280.15	151.23	431.38	14.55	14549.18
1	10	1.1	10/31/1990	12.39	33.17	3.44	292.34	156.27	448.61	13.80	13795.97
1	11	1.11	11/30/1990	12.40	33.18	3.44	287.76	151.23	438.98	13.69	13685.16
1	12	1.12	12/31/1990	13.72	36.43	3.44	298.78	156.27	455.05	14.77	14768.87
1	1	1.01	1/31/1991	10.07	27.46	3.44	323.79	156.27	480.05	11.26	11261.11
1	2	1.02	2/28/1991	7.64	21.48	3.44	304.56	141.15	445.71	9.15	9154.38
1	3	1.03	3/31/1991	1.16	5.53	3.44	307.84	156.27	464.10	4.15	4146.12

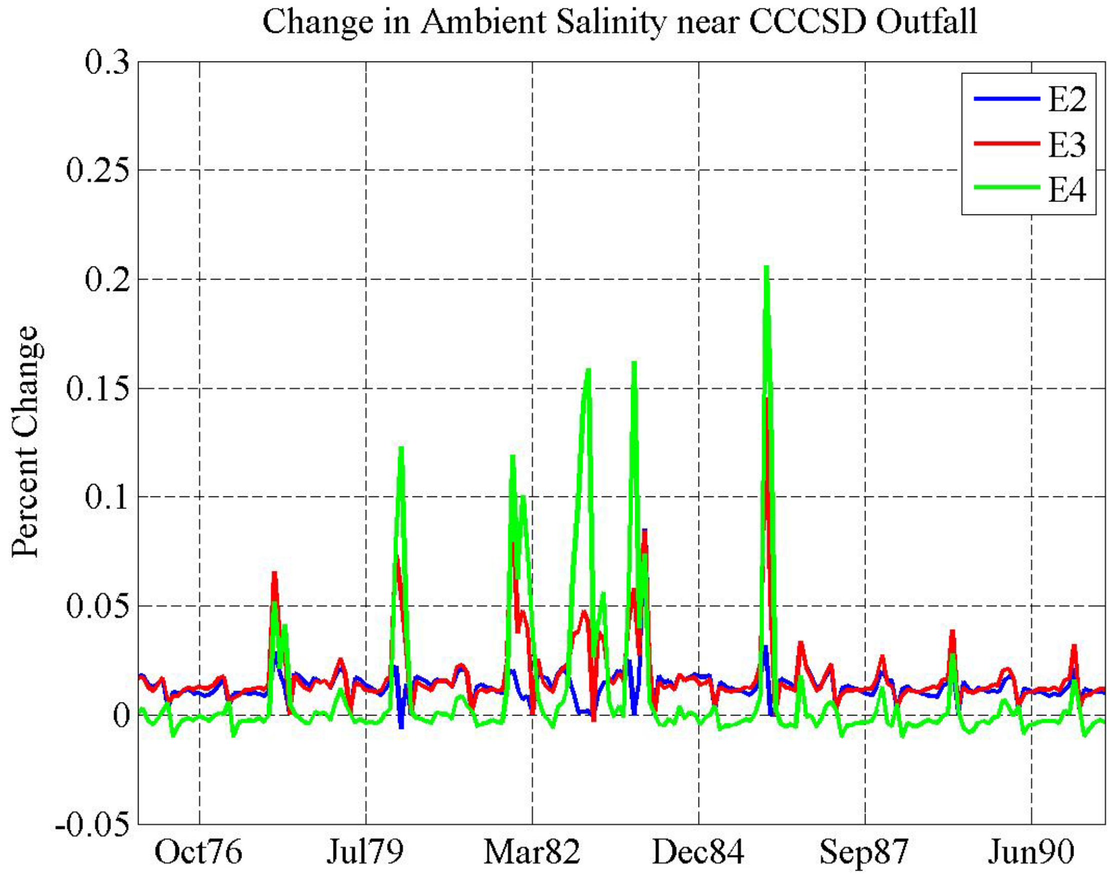
Water Year Type	Month	Historical Discharge Lookup I.D.	Date	MSPS Salinity EC mS/cm (DSM2)	Brine Salinity EC mS/cm	Average DDSD Salinity EC mS/cm	Historical DDSD Effluent Volume MG	Desal Plant Waste Stream Volume MG	Combined Effluent Volume MG	Avg Combined Concentration mS/cm	Avg Combined Concentration µS/cm
1	4	1.04	4/30/1991	1.64	6.70	3.44	286.02	0.00	286.02	3.44	3441.33
1	5	1.05	5/31/1991	6.09	17.66	3.44	319.11	156.27	475.38	8.12	8116.44
1	6	1.06	6/30/1991	9.79	26.76	3.44	299.75	151.23	450.97	11.26	11259.33
1	7	1.07	7/31/1991	11.00	29.75	3.44	290.70	156.27	446.96	12.64	12639.83
1	8	1.08	8/31/1991	11.55	31.08	3.44	283.95	156.27	440.22	13.25	13253.69
1	9	1.09	9/30/1991	13.03	34.73	3.44	280.15	151.23	431.38	14.41	14411.32

1.13 Appendix 1-C: Modeling Results Tables & Figures

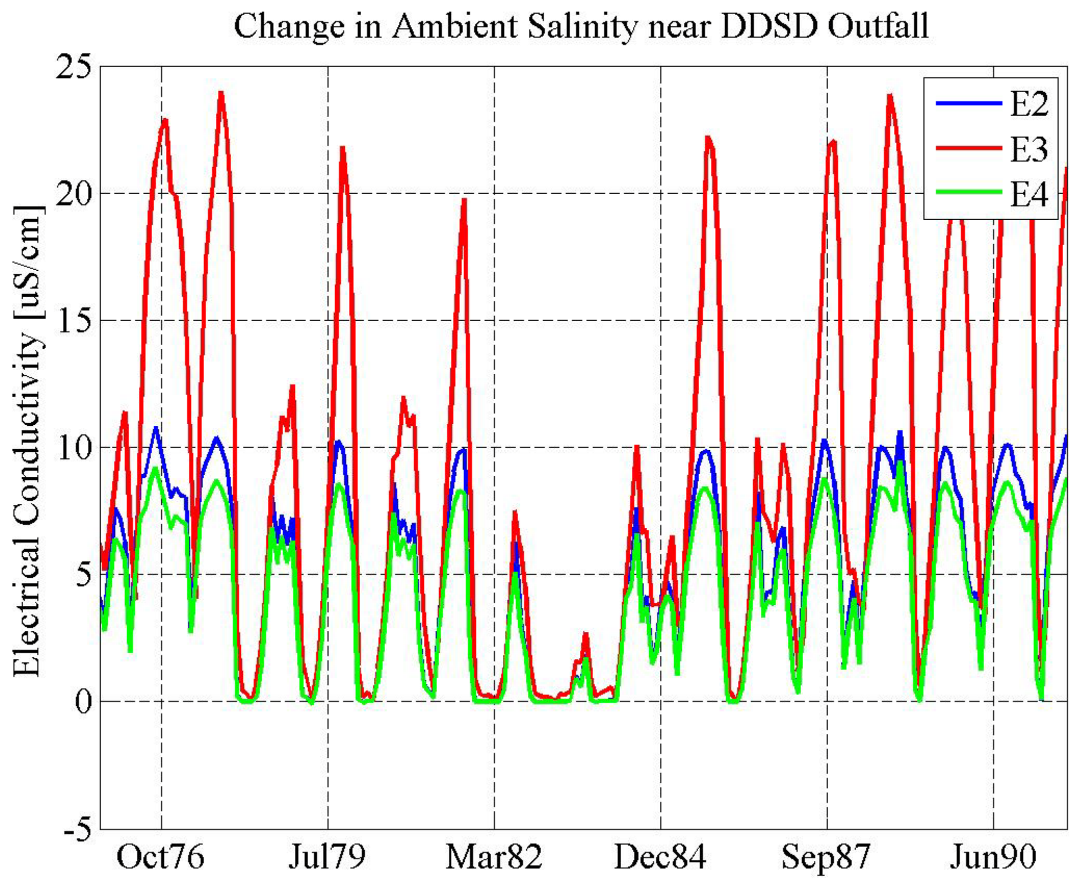
Western Delta												
	Rock Slough			Sacramento River at Emmaton			San Joaquin River at Jersey Pt			Sacramento River at Collinsville		
	Date of Violation	Increase in Salinity [µS/cm]	% Increase in Salinity	Date of Violation	Increase in Salinity [µS/cm]	% Increase in Salinity	Date of Violation	Increase in Salinity [µS/cm]	% Increase in Salinity	Date of Violation	Increase in Salinity [µS/cm]	% Increase in Salinity
No Disposal (E2)	NA	0.00	0.00%	5/16/87	0.59	0.08%	NA	0.00	0.00%	NA	0.00	0.00%
Disposal @ DDSD (E3)	10/4/77	1.86	0.18%	7/24/88	0.46	0.06%	7/14/91	3.99	0.17%	NA	0.00	0.00%
Disposal @ CCCSD (E4)	NA	0.00	0.00%	5/16/87	0.53	0.07%	NA	0.00	0.00%	NA	0.00	0.00%
No Disposal (F2)	8/19/90	0.72	0.07%	7/24/88	2.94	0.09%	NA	0.00	0.00%	5/14/88	3.48	0.10%
Disposal @ DDSD (F3)	8/19/90	1.59	0.15%	7/24/88	5.26	0.15%	NA	0.00	0.00%	5/7/76 & 5/14/88	3.4 & 2.69	0.1% & 0.08%
Disposal @ CCCSD (F4)	8/19/90	0.60	0.06%	5/16/87	2.47	0.07%	NA	0.00	0.00%	5/14/88	2.97	0.09%

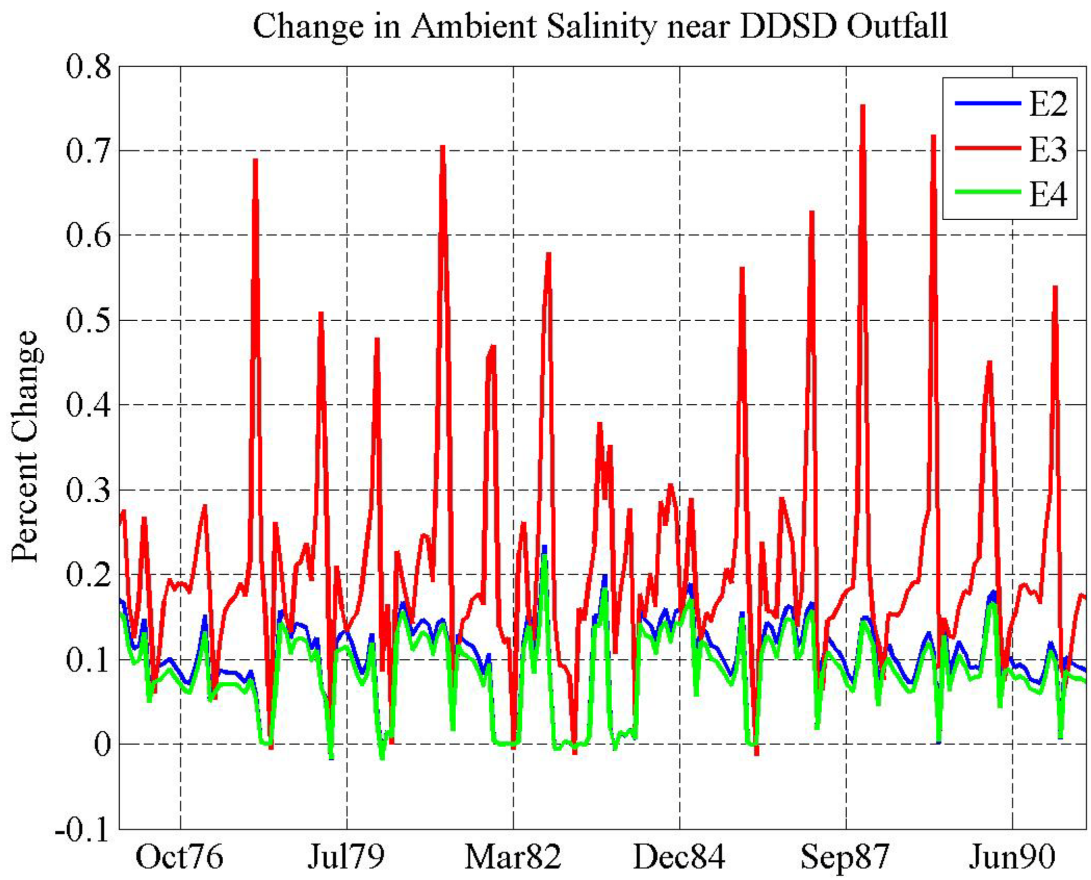
Suisun Marsh									
	Montezuma Slough at Beldon Landing			**Montezuma Slough at National Steel**			**Chadbourne Slough**		
	Date of Violation	**Increase in Salinity [µS/cm]**	**% Increase in Salinity**	**Date of Violation**	**Increase in Salinity [µS/cm]**	**% Increase in Salinity**	**Date of Violation**	**Increase in Salinity [µS/cm]**	**% Increase in Salinity**
No Disposal (E2)	NA	0.00	0.00%	NA	0.00	0.00%	NA	0.00	0.00%
Disposal @ DDSD (E3)	NA	0.00	0.00%	NA	0.00	0.00%	NA	0.00	0.00%
Disposal @ CCCSD (E4)	NA	0.00	0.00%	NA	0.00	0.00%	NA	0.00	0.00%
No Disposal (F2)	NA	0.00	0.00%	NA	0.00	0.00%	NA	0.00	0.00%
Disposal @ DDSD (F3)	NA	0.00	0.00%	NA	0.00	0.00%	NA	0.00	0.00%
Disposal @ CCCSD (F4)	NA	0.00	0.00%	NA	0.00	0.00%	NA	0.00	0.00%

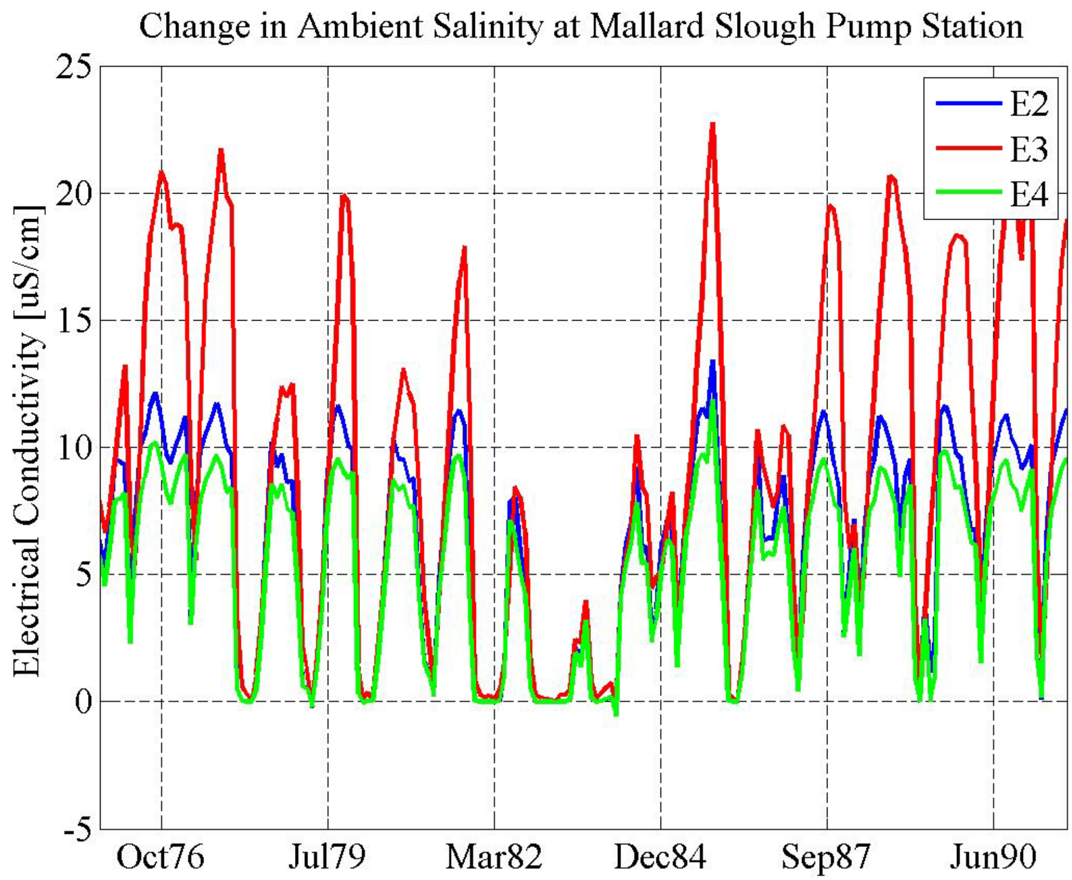
Southern Delta									
	San Joaquin at Brandt Bridge			Old River near Middle River			Old River at Tracy		
	Date of Violation	Increase in Salinity [µS/cm]	% Increase in Salinity	Date of Violation	Increase in Salinity [µS/cm]	% Increase in Salinity	Date of Violation	Increase in Salinity [µS/cm]	% Increase in Salinity
No Disposal (E2)	NA	0.00	0.00%	NA	0.00	0.00%	NA	0.00	0.05%
Disposal @ DDSD (E3)	NA	0.00	0.00%	NA	0.00	0.00%	NA	0.00	0.09%
Disposal @ CCCSD (E4)	NA	0.00	0.00%	NA	0.00	0.00%	NA	0.00	0.04%
No Disposal (F2)	NA	0.00	0.00%	NA	0.00	0.00%	NA	0.00	0.00%
Disposal @ DDSD (F3)	NA	0.00	0.00%	NA	0.00	0.00%	NA	0.00	0.00%
Disposal @ CCCSD (F4)	NA	0.00	0.00%	NA	0.00	0.00%	NA	0.00	0.00%

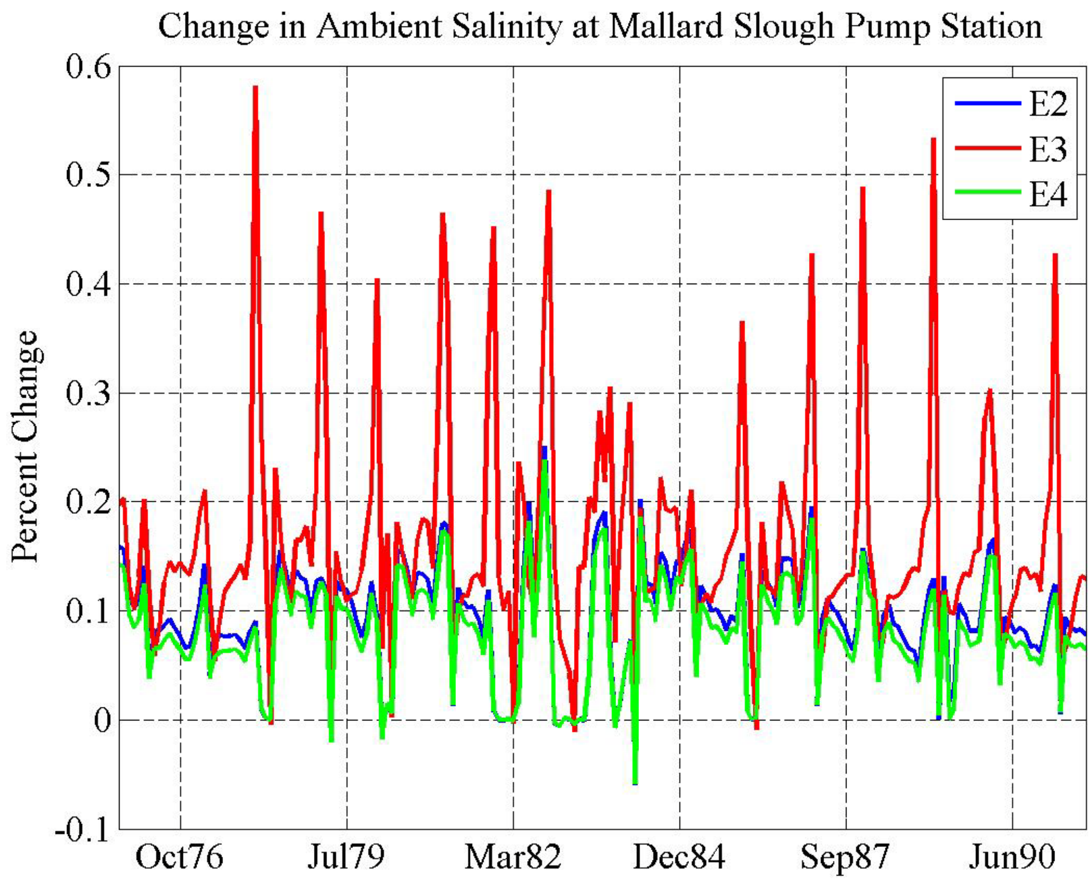


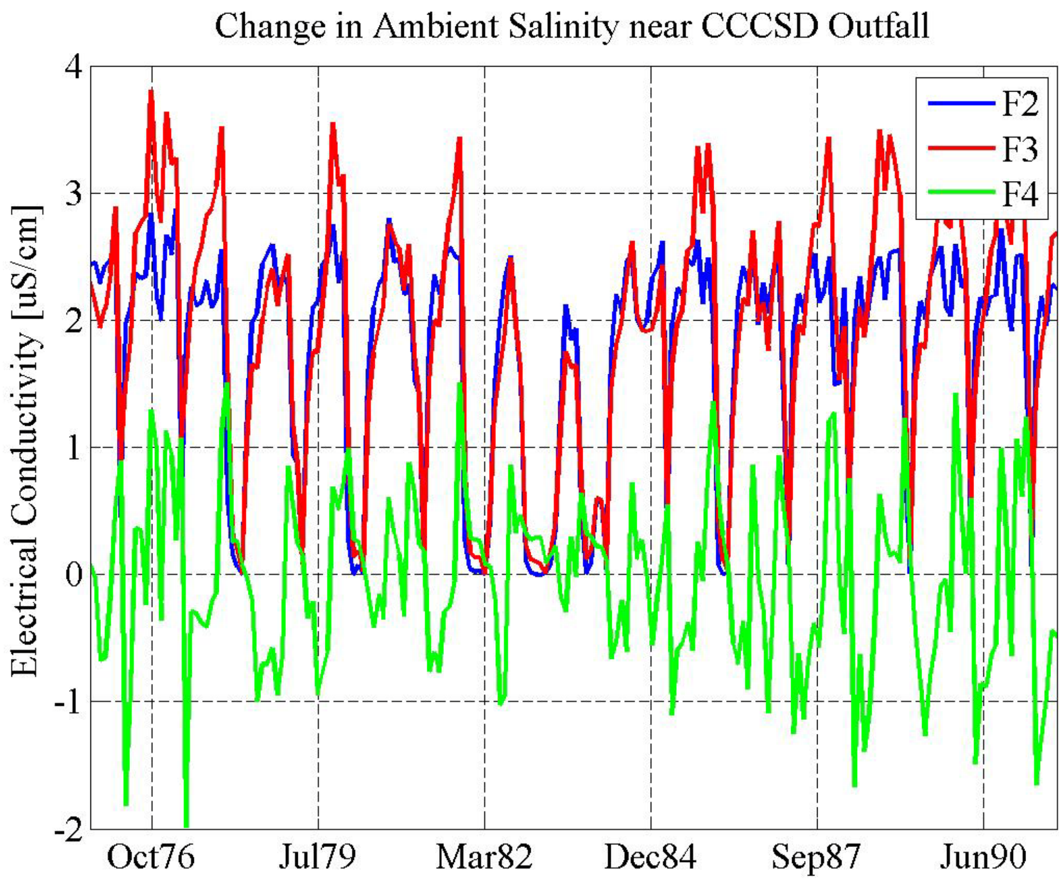
Change in Ambient Salinity near CCCSD Outfall
Percent Change
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
Oct76
Jul79
Mar82
Dec84
Sep87
Jun90
E2
E3
E4

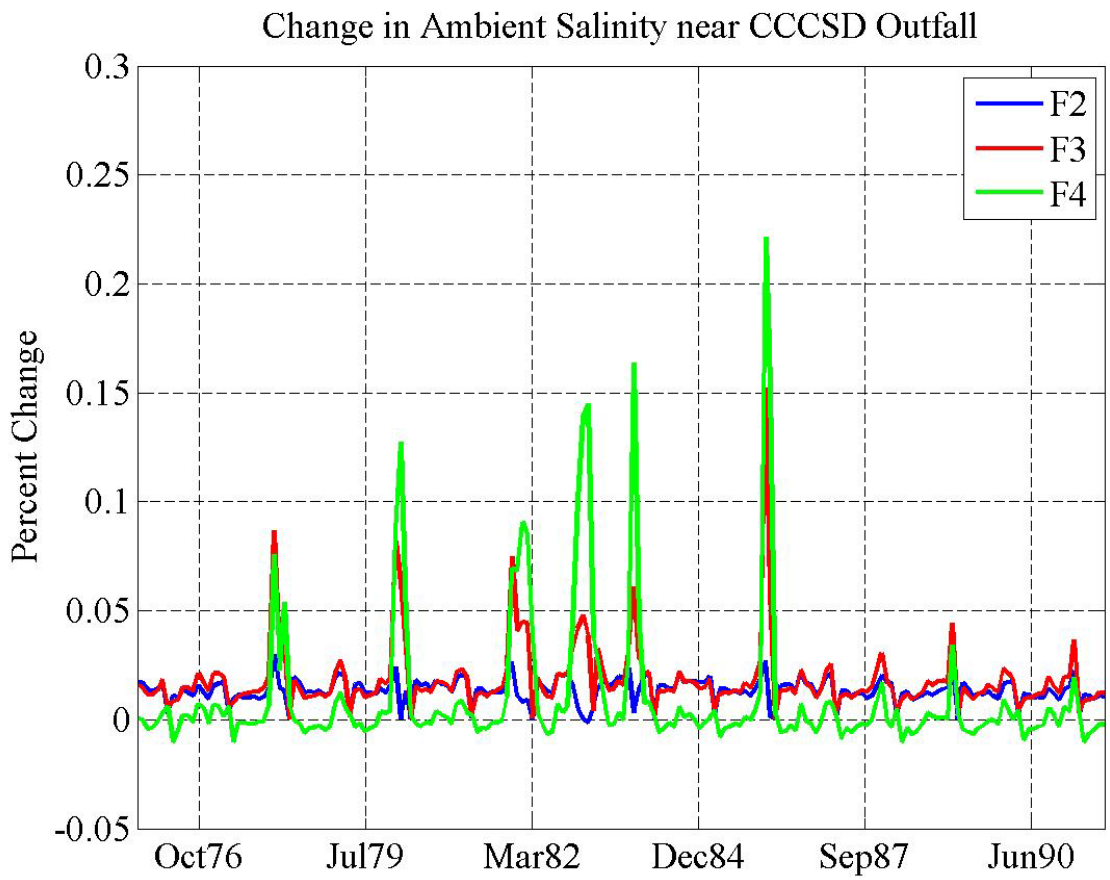

Change in Ambient Salinity near DDSD Outfall
Electrical Conductivity [uS/cm]
25
20
15
10
5
0
-5
Oct76
Jul79
Mar82
Dec84
Sep87
Jun90
E2
E3
E4


Change in Ambient Salinity near DDSD Outfall
Percent Change
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
Oct76
Jul79
Mar82
Dec84
Sep87
Jun90
E2
E3
E4

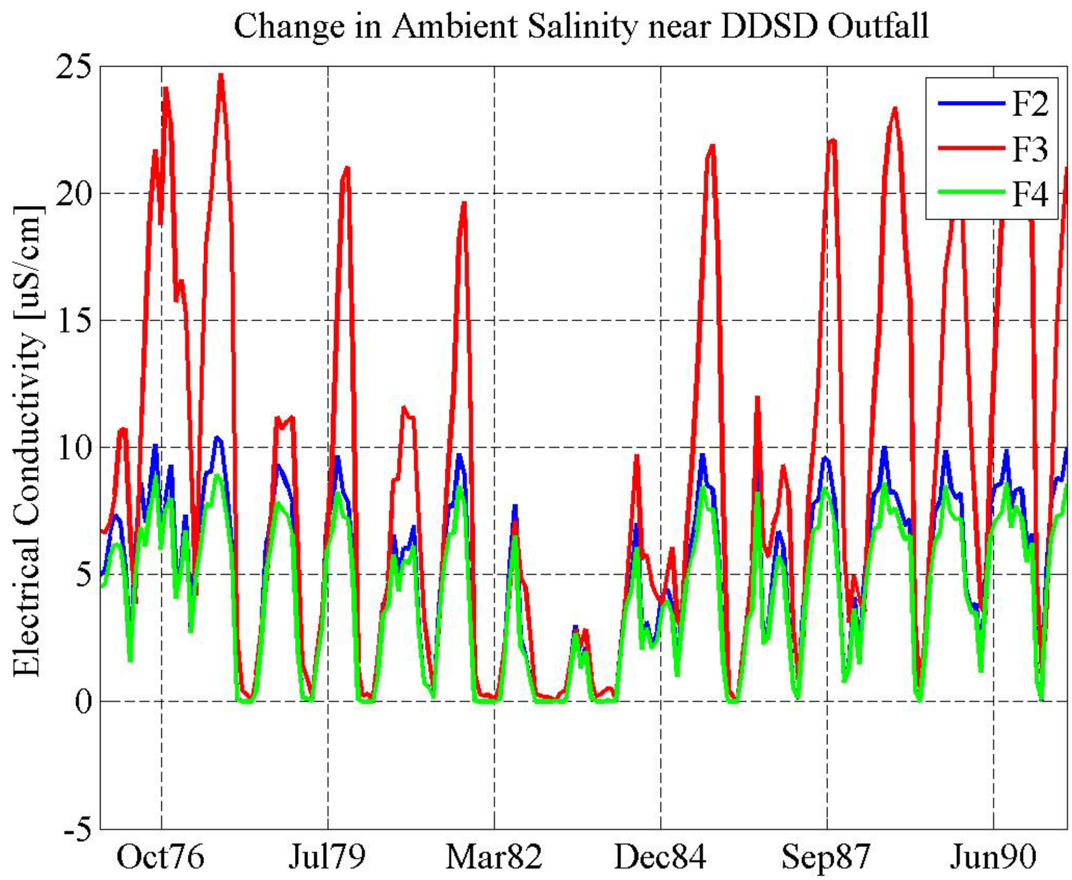

Change in Ambient Salinity at Mallard Slough Pump Station
Electrical Conductivity [uS/cm]
25
20
15
10
5
0
-5
Oct76
Jul79
Mar82
Dec84
Sep87
Jun90
E2
E3
E4

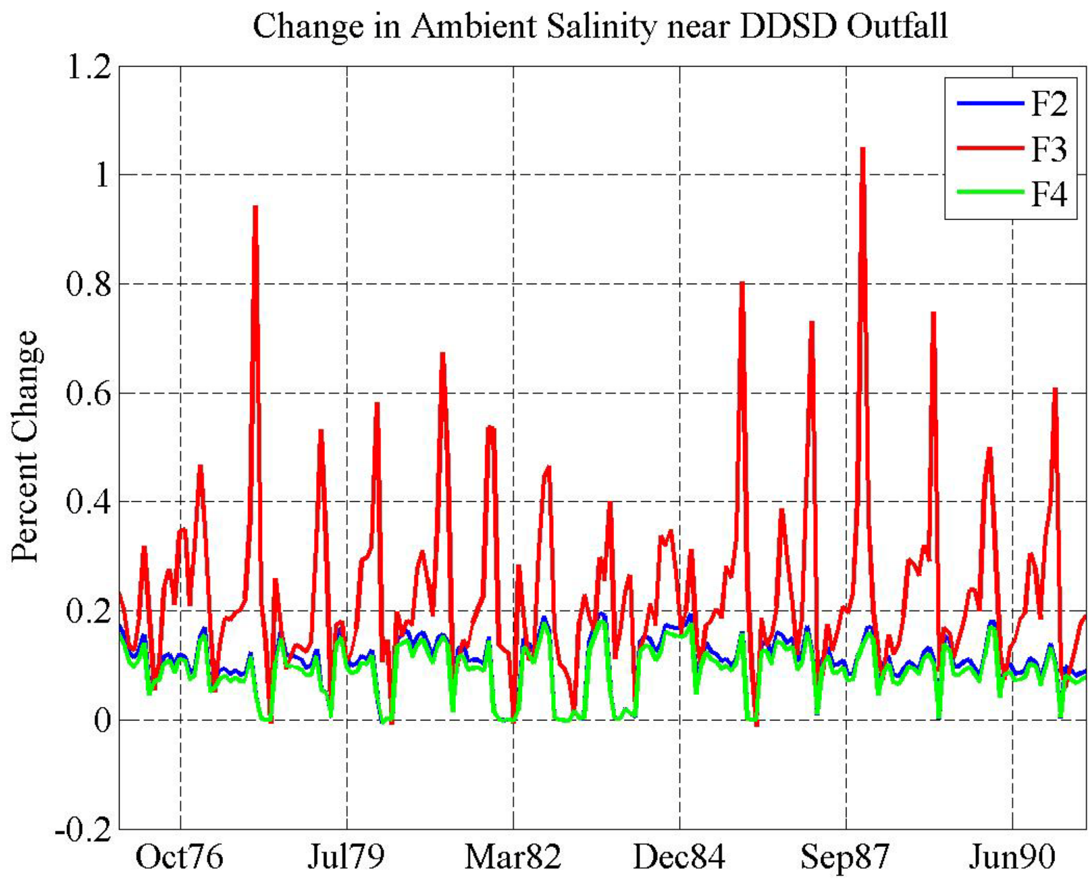

Change in Ambient Salinity at Mallard Slough Pump Station
Percent Change
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
Oct76
Jul79
Mar82
Dec84
Sep87
Jun90
E2
E3
E4


Change in Ambient Salinity near CCCSD Outfall
Electrical Conductivity [uS/cm]
4
3
2
1
0
-1
-2
Oct76
Jul79
Mar82
Dec84
Sep87
Jun90
F2
F3
F4

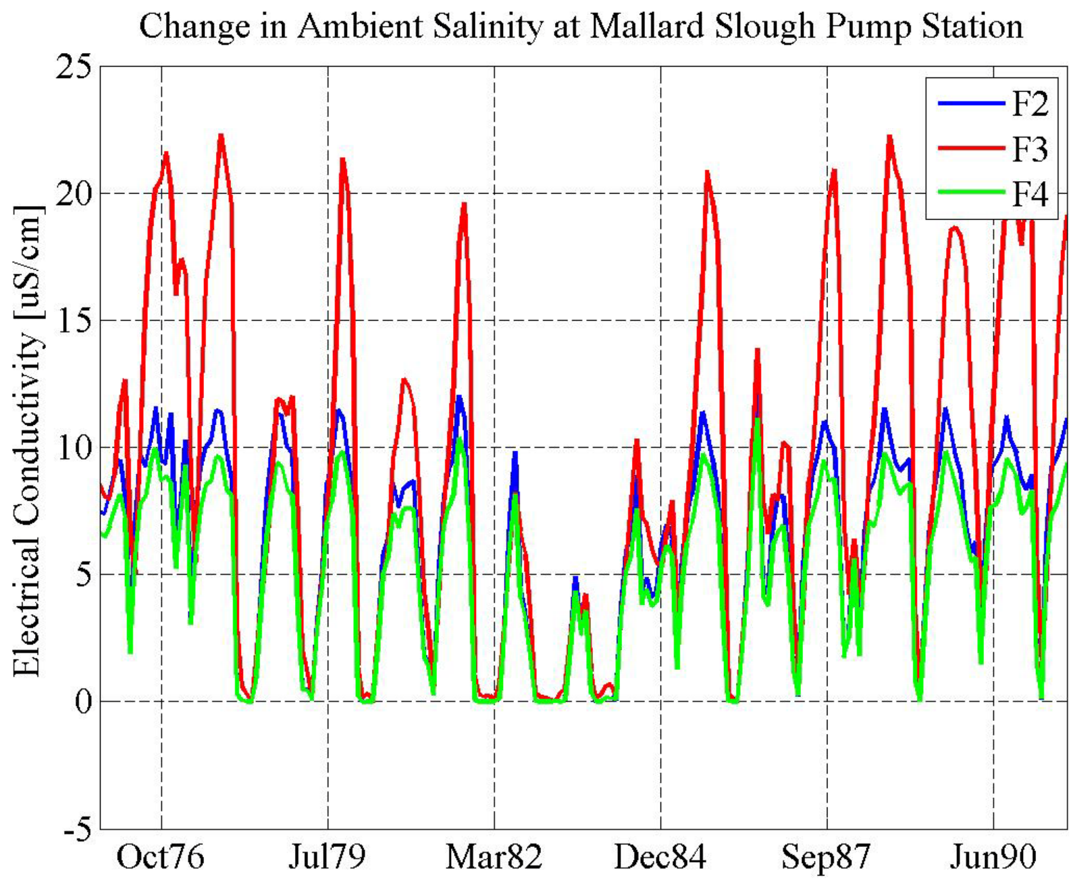


Change in Ambient Salinity near CCCSD Outfall
Percent Change
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
Oct76
Jul79
Mar82
Dec84
Sep87
Jun90
F2
F3
F4

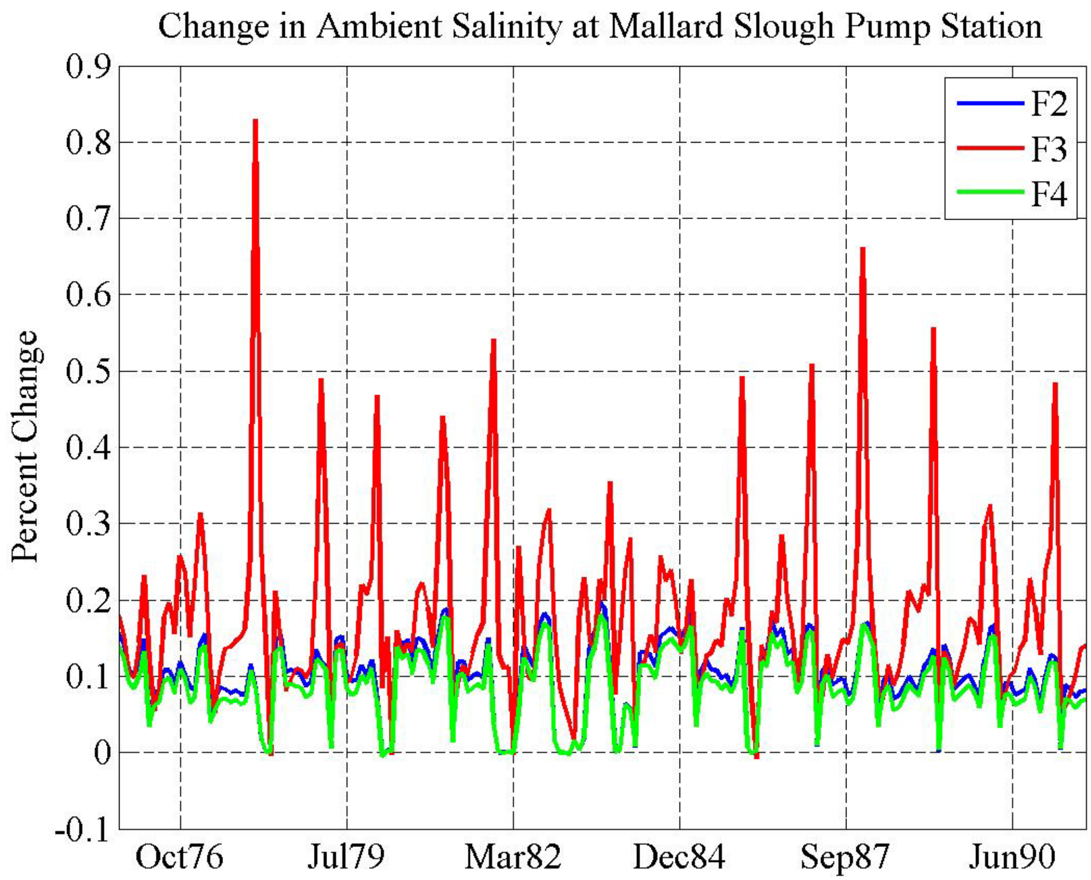

Change in Ambient Salinity near DDSD Outfall
Electrical Conductivity [uS/cm]
25
20
15
10
5
0
-5
Oct76
Jul79
Mar82
Dec84
Sep87
Jun90
F2
F3
F4



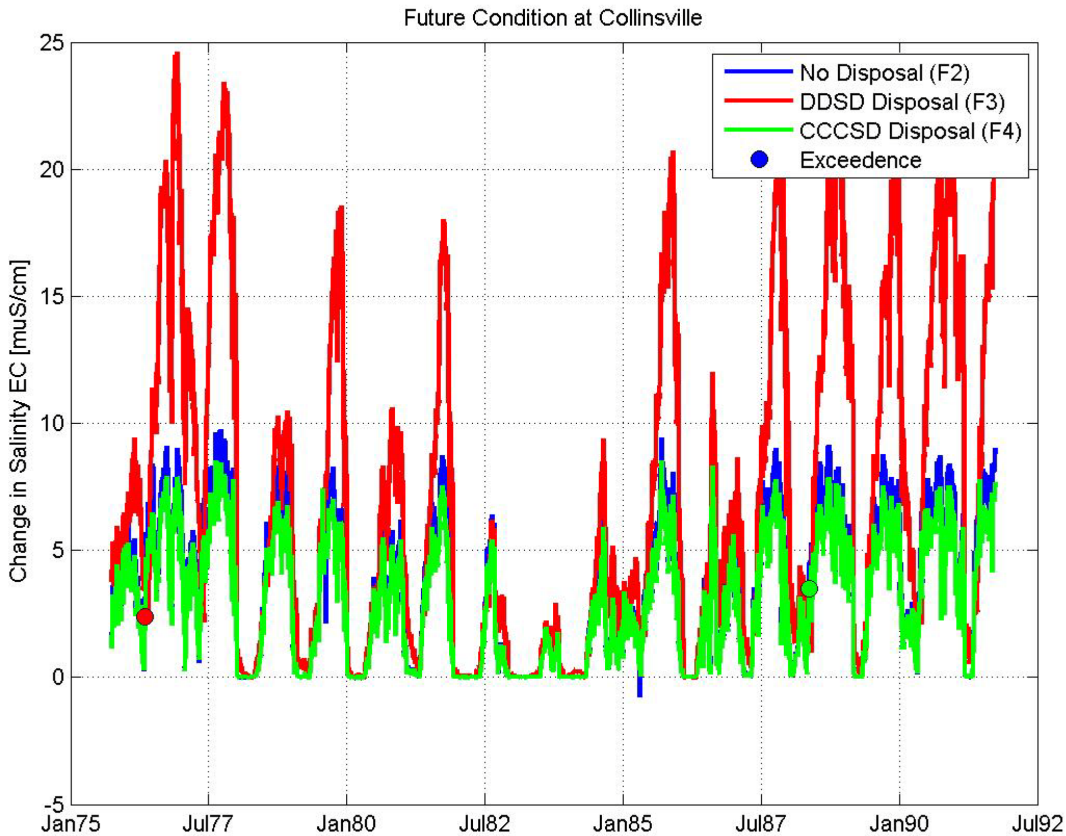
Change in Ambient Salinity near DDSD Outfall
Percent Change
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
Oct76
Jul79
Mar82
Dec84
Sep87
Jun90
F2
F3
F4

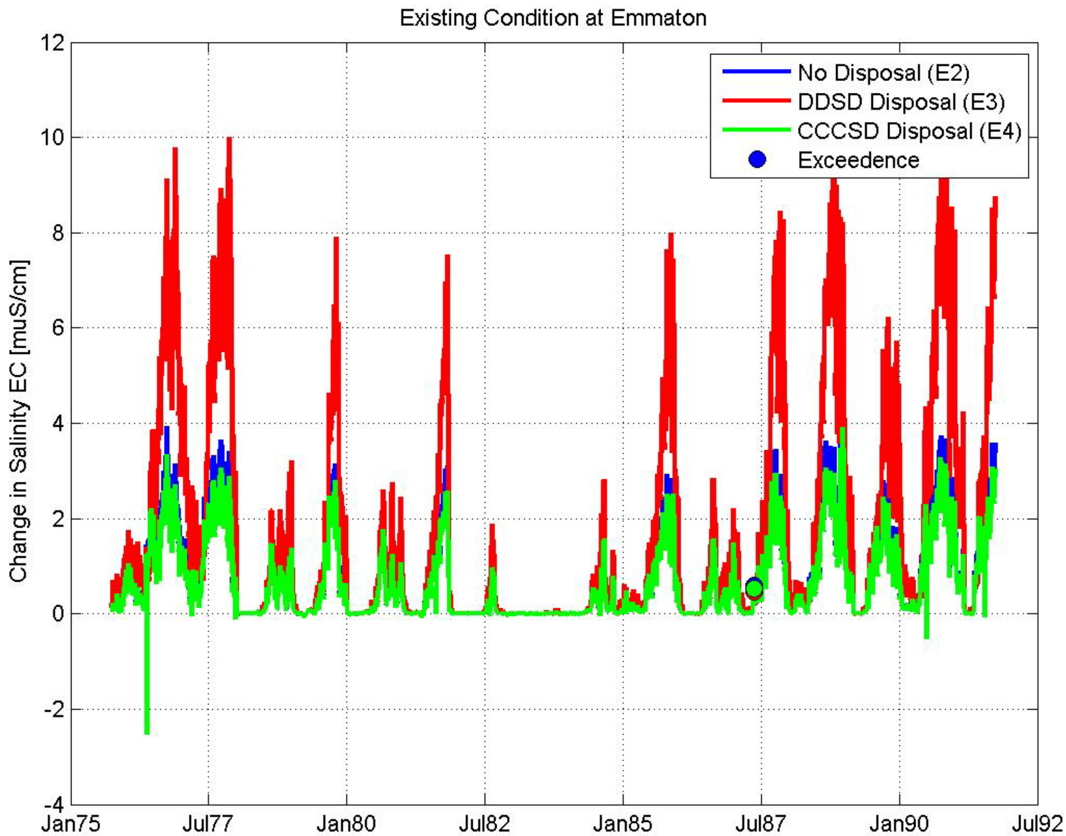


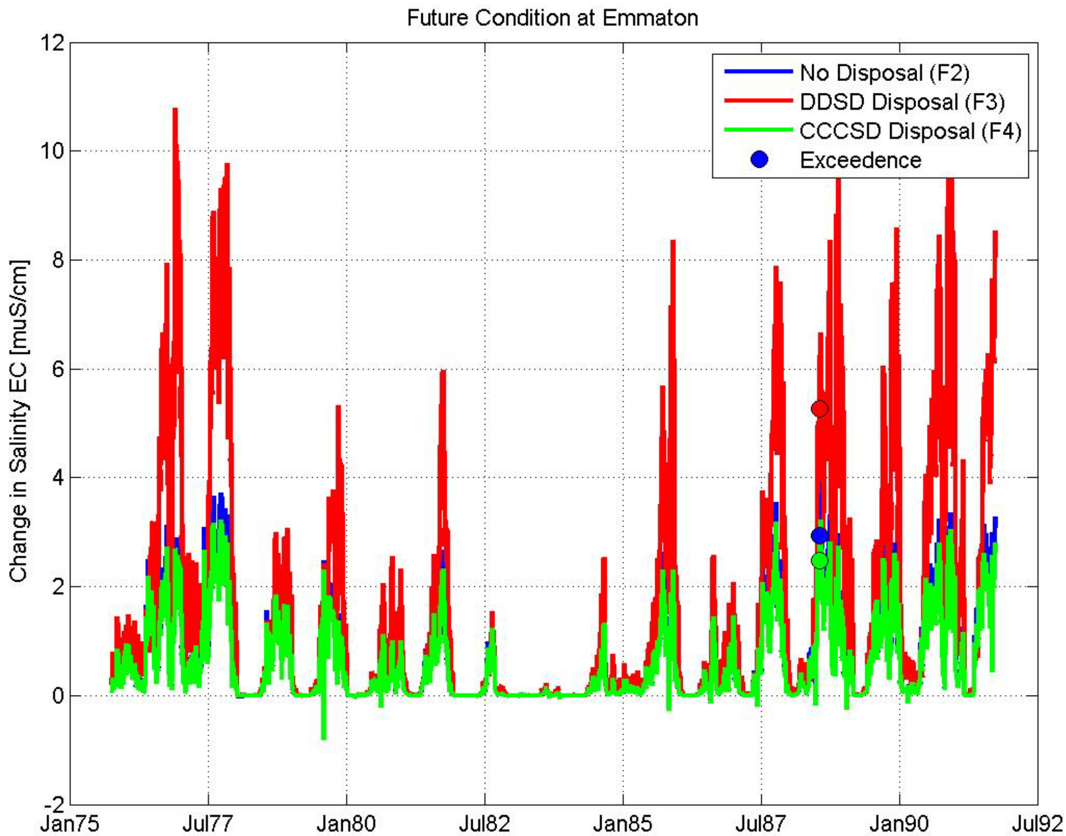
Change in Ambient Salinity at Mallard Slough Pump Station
Electrical Conductivity [uS/cm]
25
20
15
10
5
0
-5
Oct76
Jul79
Mar82
Dec84
Sep87
Jun90
F2
F3
F4



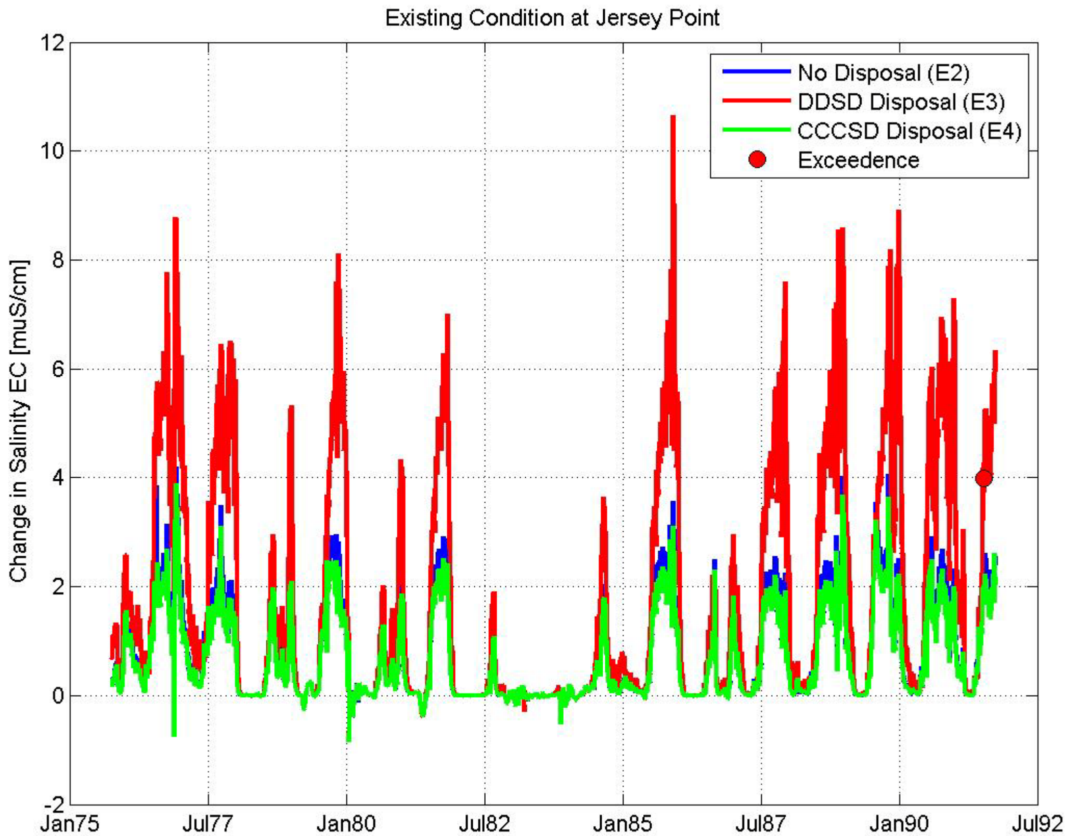
Change in Ambient Salinity at Mallard Slough Pump Station
Percent Change
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
Oct76
Jul79
Mar82
Dec84
Sep87
Jun90
F2
F3
F4


Future Condition at Collinsville
Change in Salinity EC [muS/cm]
25
20
15
10
5
0
-5
Jan75
Jul77
Jan80
Jul82
Jan85
Jul87
Jan90
Jul92
No Disposal (F2)
DDSD Disposal (F3)
CCCSD Disposal (F4)
Exceedence

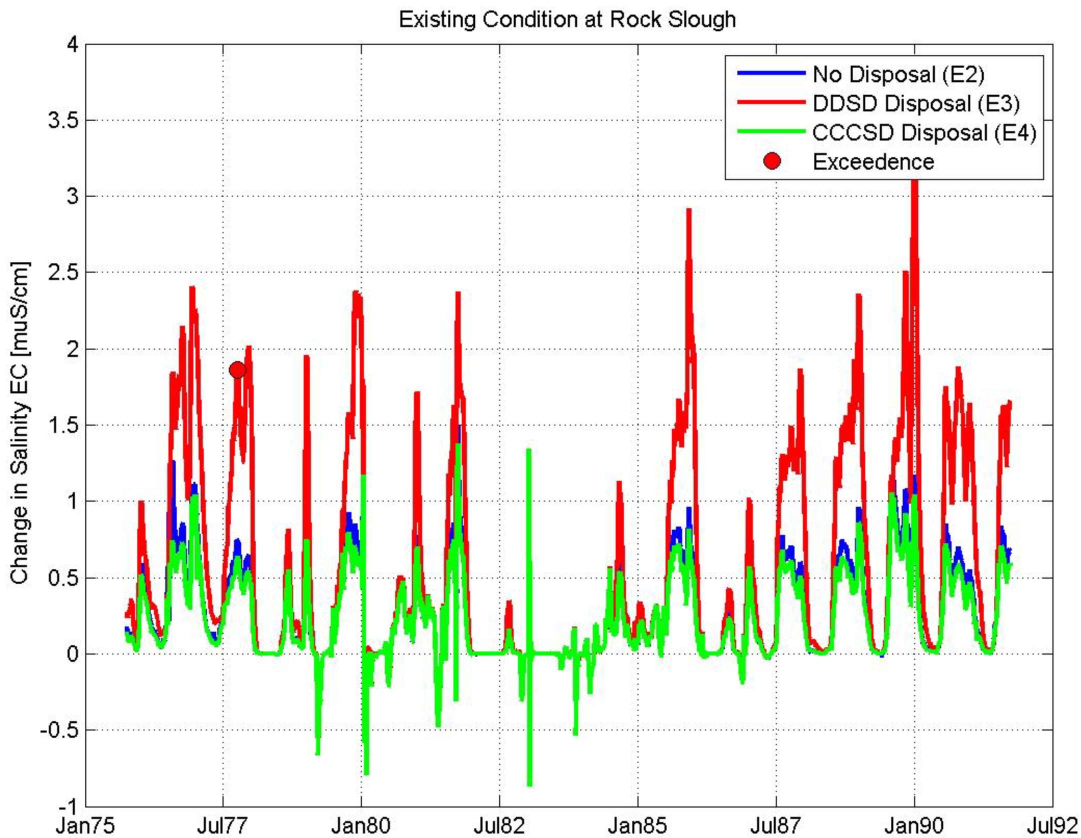

Existing Condition at Emmaton
No Disposal (E2)
DDSD Disposal (E3)
CCCSD Disposal (E4)
Exceedence
Change in Salinity EC [muS/cm]
12
10
8
6
4
2
0
-2
-4
Jan75
Jul77
Jan80
Jul82
Jan85
Jul87
Jan90
Jul92



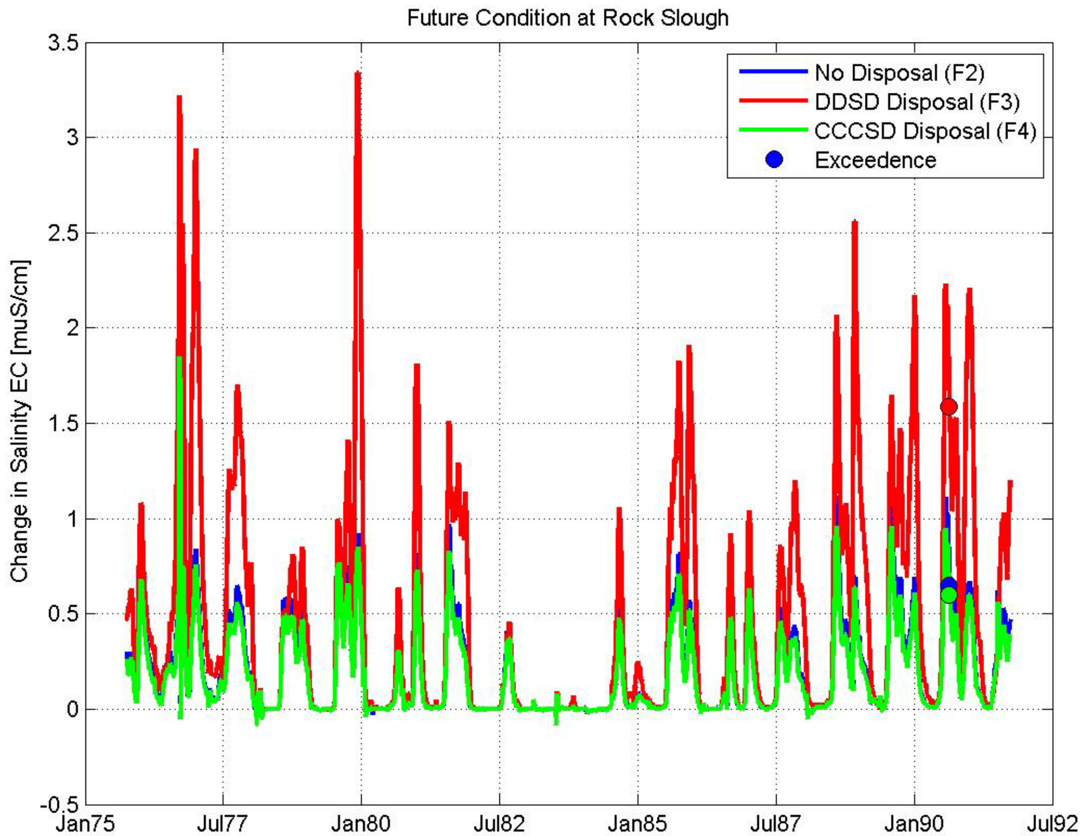
Future Condition at Emmaton
No Disposal (F2)
DDSD Disposal (F3)
CCCSD Disposal (F4)
Exceedence
Change in Salinity EC [muS/cm]
12
10
8
6
4
2
0
-2
Jan75
Jul77
Jan80
Jul82
Jan85
Jul87
Jan90
Jul92



Existing Condition at Jersey Point
Change in Salinity EC [muS/cm]
No Disposal (E2)
DDSD Disposal (E3)
CCCSD Disposal (E4)
Exceedence
12
10
8
6
4
2
0
-2
Jan75
Jul77
Jan80
Jul82
Jan85
Jul87
Jan90
Jul92



Existing Condition at Rock Slough
Change in Salinity EC [muS/cm]
No Disposal (E2)
DDSD Disposal (E3)
CCCSD Disposal (E4)
Exceedence
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
Jan75
Jul77
Jan80
Jul82
Jan85
Jul87
Jan90
Jul92


Future Condition at Rock Slough
Change in Salinity EC [muS/cm]
No Disposal (F2)
DDSD Disposal (F3)
CCCSD Disposal (F4)
Exceedence
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
Jan75
Jul77
Jan80
Jul82
Jan85
Jul87
Jan90
Jul92

2 Potential Impacts of the BARDP to Sensitive Fish Populations

2.1 Executive Summary

The Bay Area Regional Desalination Project (BARDP) considered in this study would draw its source water from the Contra Costa Water District's (CCWD) Mallard Slough Pump Station (MSPS) with a maximum pumping capacity of 25 million gallons per day (MGD) or 39 cubic feet per second (cfs). The MSPS source water is known to support a wide array of aquatic wildlife, including endangered, threatened, and special-status species. The existing intake has a positive barrier fish screen designed to exclude adult and juvenile fish, but larval fish could be entrained when the MSPS is operated. A variety of techniques were used to evaluate the potential fisheries impacts of the BARDP. Strategies to avoid and minimize fishery impacts to sensitive species were developed.

Biological monitoring data were analyzed to determine when listed species in a larval life stage have been present near MSPS. Two species that are listed by state and federal agencies as endangered or threatened are present at MSPS as larvae: delta smelt (*Hypomesus transpacificus*) and longfin smelt (*Spirinchus thaleichthys*). Longfin smelt larvae are typically found from January through March (CDFG 2009)[13] near MSPS with abundance peaking in February. Delta smelt larvae are typically found from March through July in the Estuary (Merz et al. 2011)[14] with abundance peaking in May.

Two methods were used to quantify the potential entrainment of larval fish: 1) the static entrainment method relies on biological monitoring data and 2) the PTM method incorporates a one dimensional hydrodynamic model of the Delta with a particle tracking module (PTM) to simulate larval transport and entrainment at BARDP. The results of theses analyses were then used to develop avoidance or mitigation strategies for potential fisheries impacts.

The static entrainment analysis predicted that the risk of entraining listed larval species through the BARDP intake is dependent upon the size of the larvae when present near the MSPS. The risk of entrainment is greatest when the population near MSPS consists mostly of early stage small larvae (<20 mm), as opposed to older larger individuals (>20 mm), because the fish screen is less effective at preventing entrainment of smaller individuals. Risk of entraining longfin smelt peaks in February and risk of entraining delta smelt peaks in May. Based on the static entrainment method, the probability of entraining one or both of these listed species is negligible in the late summer, fall, and early winter because the smelts have grown to a size large enough so that they are no longer susceptible to entrainment.

[13] CDFG. 2009. A status review of the longfin smelt (*Spirinchus thaleichthys*) in California. January 23, 2009.

[14] Merz, J.E., S. Hamilton, P. Bergman, and B. Cavallo. Spatial perspective for delta smelt: a summary of contemporary survey data. Cal. Fish Game 97(4):164-189;2011.

The hydrodynamic/PTM modeling indicates that the particle entrainment and by proxy larval entrainment at BARDP is very small; less than 0.23% of particles released from all locations under all hydrologic conditions were entrained at BARDP. On average, less than 0.05% of the particles released from all locations were entrained at BARDP. BARDP diversions could have a small local influence in the vicinity immediately surrounding the intake. Particle entrainment at BARDP was highest when particles were released close to the intake during low flow conditions (i.e., during the fall or a drought). However, biological monitoring indicates that sensitive species are not typically present near BARDP when the particle entrainment risk is high. When small larvae (<20 mm) are typically present near BARDP from January through June, particle entrainment at BARDP was low; on average less than 0.04% of total particles released were entrained during this period.

A variety of methods to avoid or minimize potential fisheries impacts were discussed at a BARDP partners workshop held in January 2013. Changes to operations and intake design could reduce or avoid impacts to fisheries. A preferred combination of minimization and avoidance measures will be evaluated if the project proceeds with an environmental impacts analysis at a later date in the future.

2.2 Study Objectives

To evaluate the potential fisheries impacts of the BARDP, the study sought to:

1) identify the spatial and seasonal trends of aquatic organisms in the vicinity of MSPS,
2) quantify the potential entrainment of larval fish resulting from the assumed BARDP operations, and
3) develop strategies that would avoid and otherwise minimize fishery impacts to listed species.

2.3 Background

The MSPS is on the western border of the Delta adjacent to Suisun Bay and just southeast of Suisun Marsh, as shown in Figure 2-1. This area is often termed the low salinity zone of the estuary because during certain times of the year salinity is around 2 parts per thousand (ppt). Low salinity habitats in the Delta (salinity around 2 ppt) have been shown to be important nursery areas for native threatened and endangered fish such as longfin and delta smelt.[15] MSPS is an active intake used by CCWD for municipal and industrial water supply when water quality is acceptable. The current MSPS intake and operations are designed to protect sensitive species in the region. Changes in operations associated with BARDP would require a re-evaluation of facilities and operations to ensure sensitive species remain protected.

[15]Hobbs et al, 2010. The use of otolith strontium isotopes (87Sr/86Sr) to identify nursery habitat for a threatened estuarine fish. Environ Biol Fish (2010) 89:557–569.

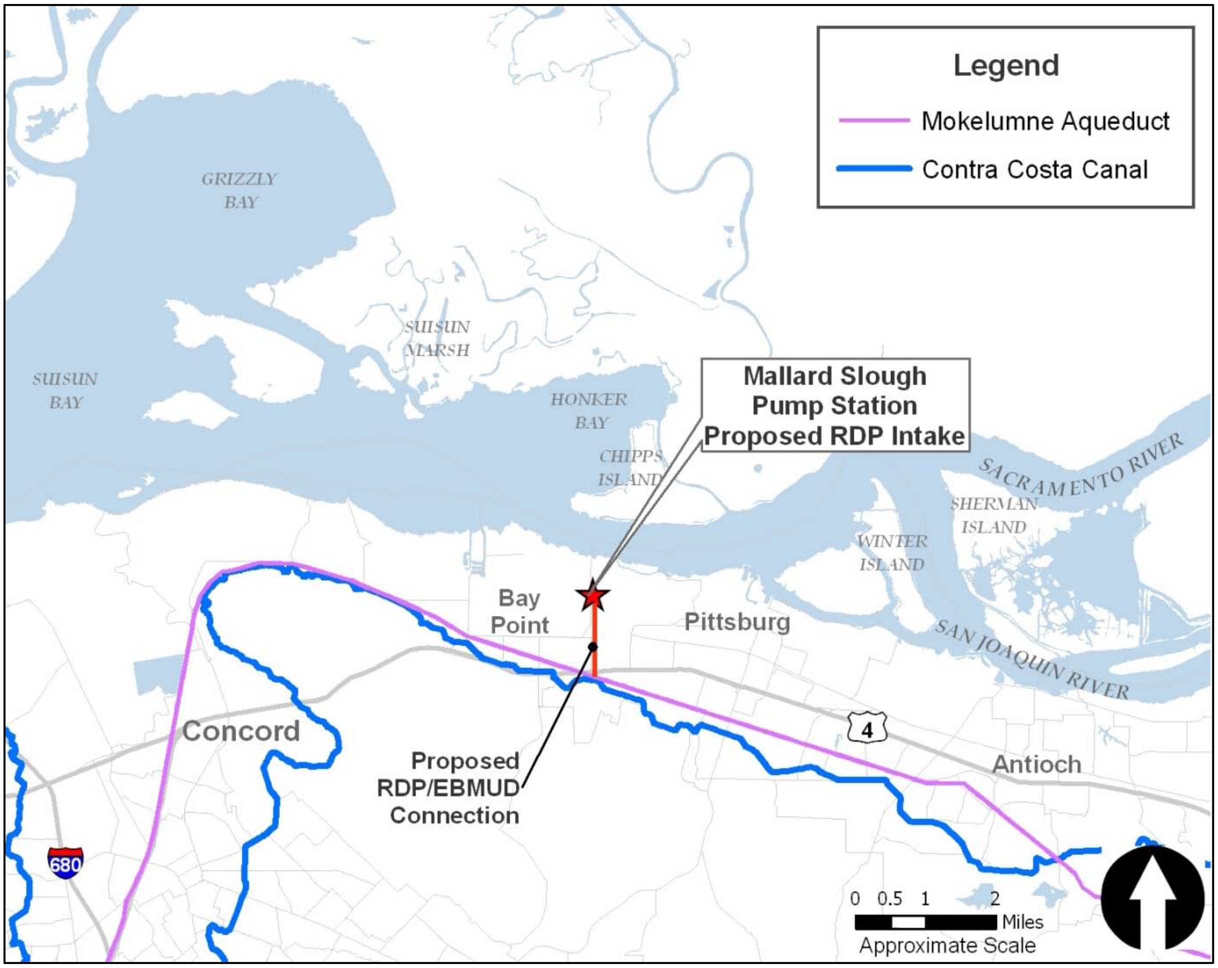


Figure 2-1. Mallard Slough Pump Station location and vicinity.

2.4 Existing MSPS Facilities and Operations

The MSPS is located within a dredged intake channel that extends approximately 3,000 feet south of Suisun Bay, as shown in Figure 2-2. Raw water is pumped by the MSPS from the Sacramento/San Joaquin Delta to the Contra Costa Canal for subsequent use as a municipal and industrial water supply. The intake channel is approximately 100 feet wide and was first excavated by dredging in the 1930s. Spoils from the original excavation were deposited along the edge of the channel to form a levee along the channel banks. The channel has been periodically dredged since its original construction to remove accumulated sediments. In January 2003, CCWD replaced the original pump station with the existing 40 mgd (25 mgd normal operation) pump station.

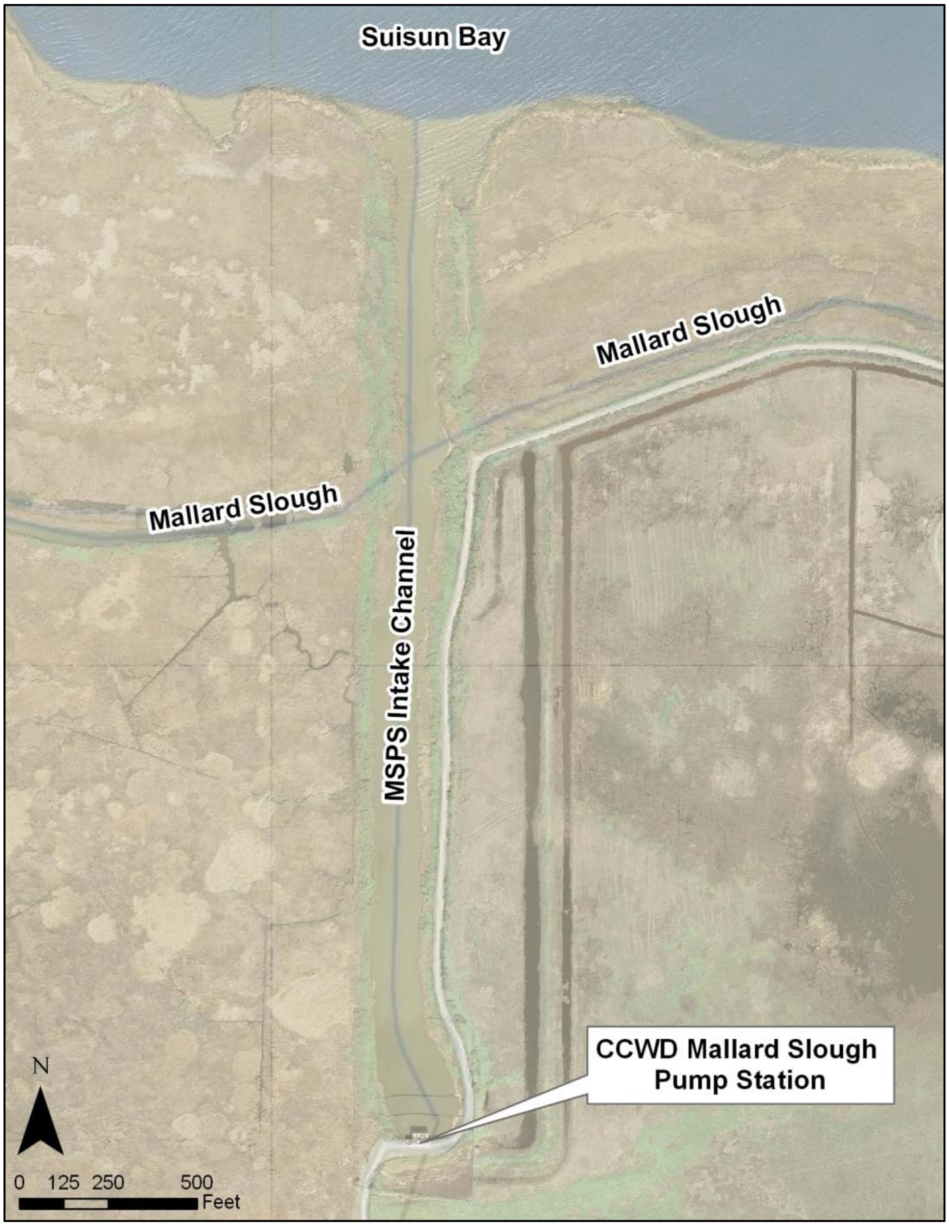


Figure 2-2. Mallard Slough Pump Station site map**.**

2.4.1 MSPS Fish Screen Description

The Mallard Slough Pump Station is equipped with a positive barrier fish screen to minimize the impact on sensitive fish in the area and to prevent fish from entering the intake structure. The fish screen panels are welded wedge wire in a flat plate configuration and are designed to conform to USFWS, NMFS, and CDFW screening criteria. They are located on an incline at the base of the pump station wetwell. Table 2-1 summarizes MSPS fish screen characteristics.

Table 2-1. Description of fish screen at MSPS.

Item	Value
Manufacturer	US Filter/Johnson
Size (W x L)	4.75 ft x 7.5 ft
Unit Designation	FS-1 through FS-8
Number of Units	8
Construction Material	70% Copper – 30% Nickel alloy
Top of Screen	3.5 ft below mean sea level (msl)
Bottom of Screen	6.0 ft below msl
Wetted Screen Area	35.6 sq ft
Maximum Screen Opening Size	3/32 inch (2.38 mm)
Maximum Approach Velocity	0.2 feet per second under normal operation (25 mgd*) *under pumping greater than 25 mgd, maximum approach velocity could exceed 0.2 ft/s

2.4.1.1 MSPS Fish Screen Cleaning System

The screen cleaning system provides automatic removal of debris trapped on the fish screen panels. The purpose of the screen cleaning system is to remove debris captured on the screen so that uniform flow with low headloss is maintained through the screen. To accomplish this, high pressure air is used to dislodge debris and push it away from the screen using air spargers. The fish screen is designed to be removed for periodic maintenance. The balcony over the fish screen is sized to allow screen sections to be lifted and wheeled on a cart through the pump station for transport or on-site maintenance.

2.4.2 MSPS Permit Requirements

CCWD has a License for Diversion and Use of Water issued in 1971 by the State Water Resources Control Board, based on rights dating from 1928 for the direct diversion of 39.3 cfs (25 mgd) from the MSPS, and 3,780 acre-feet per year to storage, from January 1 through December 31 of each year. The total volume authorized for diversion under this license is 14,880 acre-feet per calendar year. A second Permit for Diversion and Use of Water was issued in 1983 and authorizes an additional 11,900 acre-feet per year to be diverted from August 1 through December 31 at a rate not to exceed 39.3 cfs. Together, the two water rights authorize the District to divert 26,780 acre-feet per year from the Mallard Slough intake channel.

Operation of all CCWD intakes, including MSPS, is restricted during a 30-day no-diversion period pursuant to the biological opinions issued by USFWS and NFMS for the Los Vaqueros Project in 1994 and the Incidental Take Permit (ITP) issued by CDFW in 2009 for the Alternative Intake Project (now known as the Middle River Intake). The no-diversion period, during which CCWD ceases Delta diversions and relies on releases from Los Vaqueros Reservoir to meet its customer demand, is intended to protect sensitive fish species covered by the permits, such as delta smelt, longfin smelt, and Chinook salmon (*Onchorynchus* *tshawytscha*). The default timing of the no-diversion period is April 1-30th each year, but this timing can be changed by the fishery agencies (CDFW, USFWS, and NMFS). For the purposes of this work, the 30-day no-diversion period was assumed to occur from April 1-30th. When diverting water at MSPS, CCWD samples for ichthyoplankton (larval fish) behind the screen at the MSPS as outlined in the Proposed Program to Sample the Overflow Structure at the CCWD Mallard Slough Pumping Plant (circa 2000).

2.4.3 MSPS Historical Operations

Recent operation of MSPS has been limited because water quality at the MSPS site is highly variable and often has a chloride concentration exceeding the drinking water standard of 250 mg/L. Over the last 10 years, diversions by CCWD from MSPS have averaged less than 3,000 AF per year. Annual diversions have been as high as 18,900 AF per year (1983). Typically, CCWD diverts 39 cfs or less from MSPS for approximately 2 months when Delta outflow is high and salinity at the site is relatively low. Figure 2-3 shows MSPS diversions and salinity since 1995. The proposed operation of the BARDP, with a constant 39 cfs diversion year-round, would increase the amount of time the MSPS is used and the total amount of water diverted at this site.

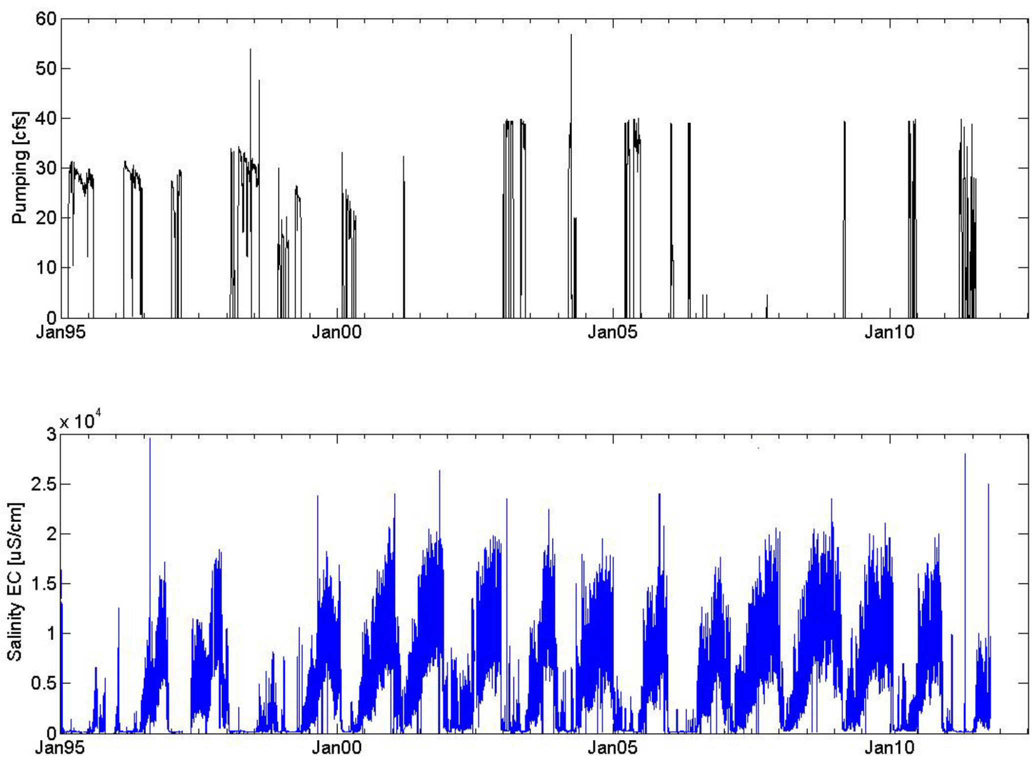


Figure 2-3. Historical pumping and water quality at MSPS from 1995 through October 2011.

2.5 Regulatory Background

Fish species identified for protection under the California Endangered Species Act (CESA) and/or Federal Endangered Species Act (FESA) that are known to occur in the Delta include green sturgeon (*Acipenser medirostris*), delta smelt, longfin smelt, winter-run Chinook salmon, spring-run Chinook salmon, and Central Valley steelhead (*Oncorhynchus mykiss*). USFWS and NMFS have designated all or part of the Delta as critical habitat for delta smelt, Central Valley steelhead, green sturgeon, and winter-run and spring-run Chinook salmon. Other special-status species include Sacramento splittail (*Pogonichthys macrolepidotus*), river lamprey (*Lampetra ayresii*), and hardhead (*Mylopharodon conocephalus*). Table 2-2 lists the special-status fish species that occur in the Delta for at least part of their lifecycle and a classification of their designated habitat in the Delta.

Table 2-2. Special-status species in the Delta near MSPS.

	Listing Status[a]		
Species	**Federal**	**State**	**Designated Habitat**
Sacramento River winter-run Chinook salmon	FE	CE	Critical Habitat
Central Valley spring-run Chinook salmon	FT	CT	Critical Habitat
Central Valley fall/late fall-run Chinook salmon	FSC	CSC	Essential Fish Habitat
Central Valley steelhead	FT	–	Critical Habitat
Delta smelt	FT	CE	Critical Habitat
North American green sturgeon (southern DPS)	FT	CSC	Critical Habitat
Longfin smelt	Candidate Species	CT	–
Sacramento splittail	–	CSC	–
River lamprey	–	CSC	–
Hardhead	–	CSC	–
Northern anchovy	–	–	Essential Fish Habitat
Pacific sardine	–	–	Essential Fish Habitat
Starry flounder	–	–	Essential Fish Habitat

[a] FE = Federal Endangered
FT = Federal Threatened
FSC = Federal Species of Concern
CE = California Endangered
CT = California Threatened
CSC = California Species of Special Concern

2.5.1 Federal Endangered Species Act

The Federal Endangered Species Act (FESA) applies to proposed federal, state, and local projects that may result in the "take" of a fish or wildlife species that is federally listed as threatened or endangered and to actions that are proposed to be authorized, funded, or undertaken by a federal agency and which may jeopardize the continued existence of any federally listed fish, wildlife, or plant species or which may adversely modify or destroy designated critical habitat for such species. "Take" is defined under the FESA as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct" (16 United States Code [USC] section 1532(19)). Under federal regulations, "harm" is defined as "an act which actually kills or injures wildlife," including significant habitat modification or degradation where it actually results, or is reasonably expected to result, in death or injury to wildlife by substantially impairing essential behavioral patterns, including breeding, feeding, sheltering, spawning, rearing, and migrating (50 Code of Federal Register (CFR) sections 17.3, 222.102). "Harass" is defined similarly broadly.

Under the FESA, NMFS has jurisdiction over anadromous fish, including green sturgeon and salmonids such as Central Valley steelhead, winter-run and spring-run Chinook salmon. The USFWS administers FESA for non-anadromous and non-marine fish species such as delta smelt.

USFWS and NMFS also are charged with designating "critical habitat" for threatened and endangered species, which the FESA defines as: (1) specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to a species' conservation, and those features may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation of the species (16 USC section 1532(5)(A)).

When a federally listed species is present and likely to be affected by a proposed project with a federal nexus, the project must receive authorization from USFWS and/or NMFS. Authorization may involve a letter of concurrence that the project will not result in the potential take of a listed species, or may result in the issuance of a Biological Opinion (BO) that describes measures that must be undertaken to minimize the likelihood of an incidental take of a listed species. A project that is determined by NMFS or USFWS to jeopardize the continued existence of a listed species cannot be approved under a BO.

2.5.2 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act (Public Law 104 to 297), requires that all federal agencies consult with NMFS on activities or proposed activities authorized, funded, or undertaken by that agency that may adversely affect Essential Fish Habitat (EFH) for commercially managed marine and anadromous fish species. EFH includes specifically identified waters and substrate necessary for fish spawning, breeding, feeding, or growing to maturity. EFH also includes all habitats necessary to allow the production of commercially valuable aquatic species, to support a long-term sustainable fishery, and contribute to a healthy ecosystem (16 USC section 1802(10)).

2.5.3 California Endangered Species Act

California Fish and Game Code sections 2050–2115.5, otherwise known as the California Endangered Species Act (CESA), states that all native species of fish, wildlife, and plants that are in danger of or threatened with extinction because their habitats are threatened with destruction, adverse modification, or severe curtailment, or because of overexploitation, disease, predation, or other factors, are of ecological, educational, historical, recreational, esthetic, economic, and scientific value to the people of the State, and that the conservation, protection, and enhancement of these species and their habitat is of statewide concern (Fish and Game Code section 2051).

An endangered species is a native species or subspecies that is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes including loss of habitat, change in habitat, overexploitation, predation, competition, or disease (Fish and

Game Code section 2062). A threatened species is a native species or subspecies that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts (Fish and Game Code section 2067). The California Fish and Wildlife Commission is responsible for listing species under CESA, and the California Department of Fish and Wildlife (CDFW) is responsible for implementing and enforcing and issuing permits under CESA.

Similar to the FESA, CESA strictly prohibits the "take" of any threatened or endangered fish, wildlife, or plant species listed as threatened or endangered under CESA. Under section 2081 of the Fish and Game Code, an incidental take permit from CDFW is required for projects that could result in the "take" of a species that is State-listed as threatened or endangered, or that is a candidate for listing. Under CESA, "take" is defined as an activity that would directly or indirectly kill an individual of a species, but the definition does not include "harm" or "harass," as the definition of FESA does.

Under CESA, the California Fish and Wildlife Commission maintains a list of threatened species and endangered species (Fish and Wildlife Code Section 2070). The California Fish and Wildlife Commission also maintains two additional lists:

- Candidate species (indicating that CDFW has issued a formal notice that the species is under review for addition to either the list of endangered species or the list of threatened species), and
- Species of special concern, which serves as a watch list.

CESA requires that a lead agency reviewing a proposed project within its jurisdiction must determine whether any state-listed endangered or threatened species may be present in a proposed project area and whether the proposed project may take a listed species. If a take would occur, an incidental take permit would be required from CDFW, including a mitigation plan that provides measures to minimize and fully mitigate the impacts of the take. The measures must be roughly proportional in extent to the impact of the taking and must be capable of successful implementation. Issuance of an incidental take permit may not jeopardize the continued existence of a state-listed species. For species that are also listed as threatened or endangered under the FESA, CDFW may rely on a federal incidental take statement or incidental take permit to authorize an incidental take under CESA.

2.5.4 Biological Opinions for the Operations Criteria and Plan

For purposes of consultation with USFWS and NMFS under Section 7 of the FESA for operation of the Central Valley Project (CVP), the United States Department of the Interior, Bureau of Reclamation prepared and periodically updates a CVP Operations Criteria and Plan (OCAP) that describes the facilities and operating environment of both the CVP and State Water Project (SWP). This plan identifies the factors influencing the physical, regulatory, and institutional conditions in which the CVP and SWP operate in coordination. The plan identifies and evaluates typical operating strategies under various hydrologic conditions.

USFWS issued an updated BO for OCAP in 2008 for delta smelt, and NMFS issued an updated BO for OCAP in 2009 for salmonids. These BOs are each currently being revised after being challenged in court. The court ordered a revised BO for delta smelt to be completed by December 1, 2013. The updated salmonids BO and a record of decision on the updated BO are required by April 29,

2016. Modeling analyses of BARDP operations and potential impacts relied on information and model tools updated in 2011, which includes the majority of the 2009 OCAP operations, as those were the most current versions publicly available at the time of the analysis.

2.5.5 Positive Barrier Fish Screens

CDFW, NMFS, and USFWS require fish screens on Delta intakes to meet certain construction and performance criteria so that sensitive species such as delta smelt and salmonids will be protected; it is important to note that these measures are designed to protect juvenile and adult life stages but not larvae. The primary performance criterion relevant at CCWD facilities, including MSPS, is the approach velocity (water velocity perpendicular to and entering the screens). All the fish screens on CCWD facilities have been designed to comply with the approach velocity requirement of less than 0.2 feet per second (ft/s) established by the USFWS to protect delta smelt. The approach velocity requirements for delta smelt are more stringent than those established to protect salmonids. Table 2-3 provides some of the design and performance criteria established for fish screens to protect these species.

Table 2-3. Fish screen design and performance criteria for Delta smelt and salmonids.

Criterion	Delta Smelt[1]	Salmonids[2]	Notes
Maximum Approach Velocity	0.2 ft/s[a]	0.33 ft/s	a. All CCWD screened intakes comply with the more stringent delta smelt requirements and therefore comply with salmon requirements as well.
Minimum Sweeping Velocity	Two times approach velocity[b]	Greater than approach velocity	b. Not applicable in tidal environments as sweeping velocity approaches zero four times per day during slack tide.
Porosity	27% minimum	40% minimum	c. The use of open areas less than 40% shall include consideration of increasing the screen surface area, to reduce slot velocities, assisting in both fish protection and screen cleaning.
Opening Size	3/32 inch	3/32 inch	

1. Delta smelt requirements are established by U.S. Fish and Wildlife Service and California Department of Fish and Wildlife.
2. Salmonid requirements are established by National Marine Fisheries Service.

2.6 Seasonal Trends of Special Status Species near MSPS

The CDFW maintains a number of fish monitoring programs throughout the Delta and throughout the year. These monitoring programs are designed to monitor population trends of sensitive species and inform operations of the CVP and SWP export facilities, as well as to determine the effectiveness of water management strategies in protecting sensitive species. The data from these monitoring programs in addition to data collected by CCWD were used to describe the seasonal and spatial trends of aquatic organisms near the MSPS. Table 2-4 lists the survey data used.

Table 2-4. Summary of biological survey data analyzed to determine seasonal trends of special-status species near MSPS.

Agency	Survey Name	Time of Year	Year Surveys Began	Years Used in BARDP Analyses
CA Department of Fish and Wildlife	20-mm Survey	March-July	1995	1985-2010
CA Department of Fish and Wildlife	Spring Kodiak Trawl Survey	January-May	2002	2002-2010
CA Department of Fish and Wildlife	Fall Mid-Water Trawl Survey	September-December	1967	1985-2010
CA Department of Fish and Wildlife	Smelt Larva Survey	January-March	2009	2009-2010
CCWD	MSPS Monitoring Survey	January–July (Required when in use)	2003	2003-2010

2.6.1 CDFW Biological Survey Data

Biological survey data collected by the CDFW near MSPS were used to determine the seasonal and spatial trends of specialstatus species that could potentially be impacted by BARDP. Figure 2-4 shows the stations generally used by the CDFW for fish surveys; Station 508 is just upstream of the MSPS intake in Suisun Bay, downstream of the confluence between the Sacramento and San Joaquin rivers. CCWD samples for larval fish at the MSPS when water is diverted at the intake.

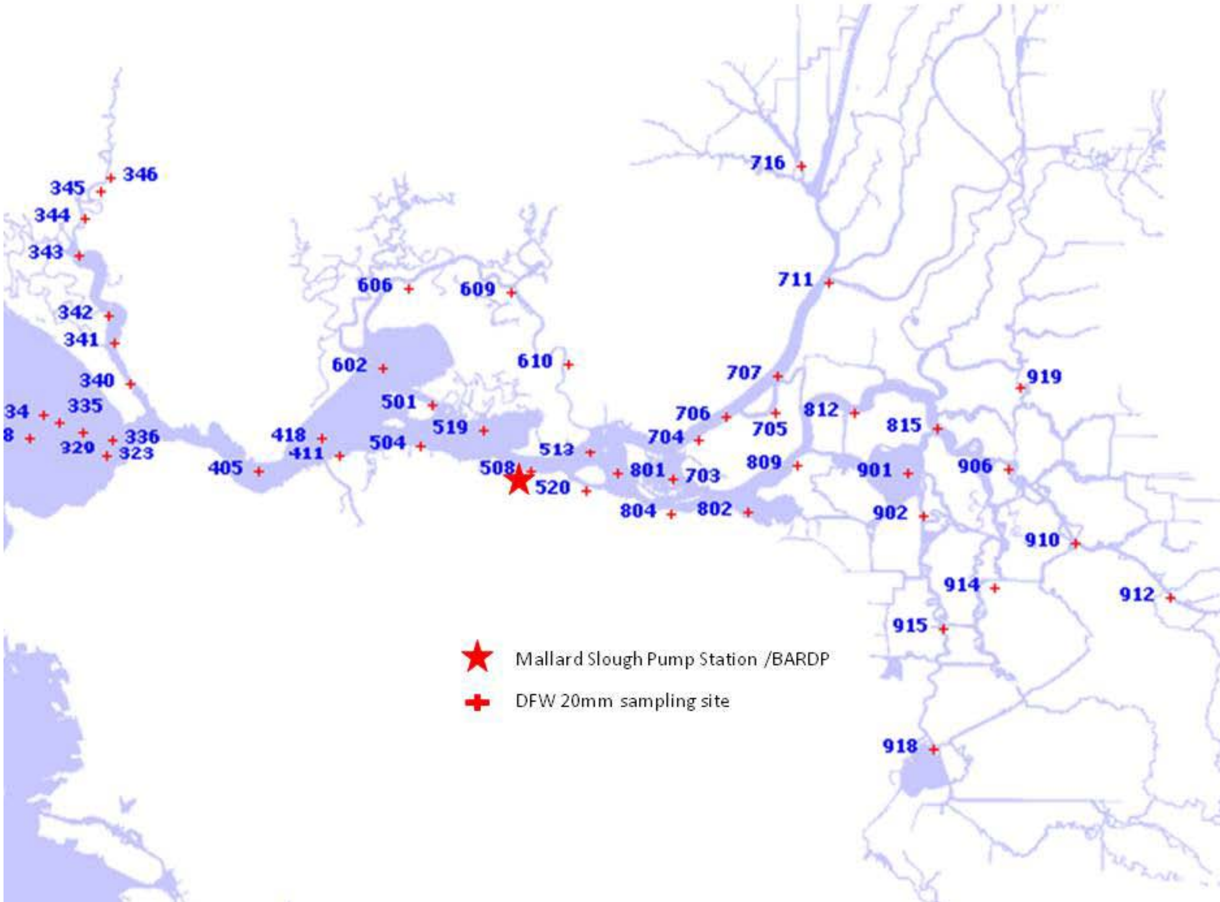


Figure 2-4. Map of CDFW biological monitoring stations and BARDP location.

2.6.2 Biological Monitoring at Station 508 near MSPS

Based on data available from CDFW Station 508, sensitive species can be found near MSPS almost year-round. Table 2-5 summarizes the timing and age class of sensitive species found at CDFW Station 508 based on data collected during the Fall Mid-water Trawl, Spring Kodiak Trawl, Smelt Larva Survey, and 20-mm surveys from 1985 through 2010. Some of the sensitive species, such as salmon, and steelhead, are only present near MSPS as juveniles and adults and are not at risk for entrainment at MSPS due to their large size.

Some of the sensitive species found near MSPS, such as northern anchovy (*Engraulis mordax*) and starry flounder (*Platichthys stellatus*), are listed as having designated essential fish habitat near BARDP but are not threatened or endangered species under either CESA or FESA. The remainder of the analysis focuses on endangered or threatened species that are present near MSPS as larvae, and therefore at the highest risk for entrainment at a BARDP intake. Of all the special-status species observed near the MSPS intake, delta smelt and longfin smelt are both present as larvae and either listed as endangered or threatened species.

Table 2-5. Monthly summary of sensitive species identified during CDFW biological field surveys at Station 508 near MSPS.

<table>
<tr><th></th><th>JAN</th><th>FEB</th><th>MAR</th><th>APR</th><th>MAY</th><th>JUN</th><th>JUL</th><th>AUG</th><th>SEP</th><th>OCT</th><th>NOV</th><th>DEC</th></tr>
<tr><td colspan="13">Chinook Salmon (Oncorhynchus tshawytscha)– (all runs)</td></tr>
<tr><td>Larval</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Juvenile</td><td colspan="6">30 - 400 mm</td><td></td><td></td><td colspan="4"></td></tr>
<tr><td>Adult</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">> 400 mm</td><td></td><td></td></tr>
<tr><td colspan="13">Northern Anchovy (Engraulis mordax) – EFH</td></tr>
<tr><td>Larval</td><td></td><td></td><td colspan="9">< 20 mm</td><td></td></tr>
<tr><td>Juvenile</td><td></td><td></td><td></td><td></td><td></td><td colspan="6">20 - 90 mm</td><td></td></tr>
<tr><td>Adult</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">> 90 mm</td><td></td><td></td><td></td></tr>
<tr><td colspan="13">Delta Smelt (Hypomesus transpacificus) – FT, CE</td></tr>
<tr><td>Larval</td><td></td><td></td><td colspan="5">< 20 mm</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Juvenile</td><td></td><td></td><td></td><td colspan="6">20 - 40 mm</td><td></td><td></td><td></td></tr>
<tr><td>Adult</td><td colspan="4">> 40 mm</td><td></td><td colspan="7"></td></tr>
<tr><td colspan="13">Longfin Smelt (Spirinchus thaleichthys) – FT candidate, CT</td></tr>
<tr><td>Larval</td><td colspan="7">< 20 mm</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Juvenile</td><td colspan="7">20 - 90 mm</td><td></td><td colspan="4"></td></tr>
<tr><td>Adult</td><td colspan="2">> 90 mm</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4"></td></tr>
<tr><td colspan="13">Sacramento Splittail (Pogonichthys macrolepidotus) - CSC</td></tr>
<tr><td>Larval</td><td></td><td></td><td>< 15 mm</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Juvenile</td><td></td><td></td><td></td><td></td><td colspan="2">15 - 115 mm</td><td></td><td></td><td colspan="4"></td></tr>
<tr><td>Adult</td><td></td><td></td><td>> 115 mm</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="13">Starry Flounder (Platichthys stellatus) - EFH</td></tr>
<tr><td>Larval</td><td></td><td></td><td colspan="3">< 20 mm</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Juvenile</td><td></td><td></td><td></td><td></td><td colspan="2">20 - 200 mm</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Adult</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">>200 mm</td><td></td><td></td></tr>
<tr><td colspan="13">Central Valley Steelhead (Oncorhynchus mykiss) - FT</td></tr>
<tr><td>Larval</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Juvenile</td><td colspan="3">190 - 270 mm</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Adult</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Note: No green sturgeon were collected at Station 508 during the surveys analyzed.

FE = Federal Endangered
FT = Federal Threatened
FSC = Federal Species of Concern
CE = California Endangered
CT = California Threatened
CSC = California Species of Special Concern
EFH = Essential Fish Habitat

Delta smelt are listed as endangered by CDFW (CE) and threatened by USFWS (FT). Delta smelt larvae are typically present near MSPS from March through July with the number of larvae collected typically peaking in May. Figure 2-5 shows the catch per unit effort (CPUE) of delta smelt less than 15 mm collected at Station 508 since 1985. CPUE is a metric of relative abundance of a species; it is calculated by normalizing the number of fish caught during a survey to the amount of water sampled. CDFW CPUE is expressed in number of fish per 10,000 m^3.

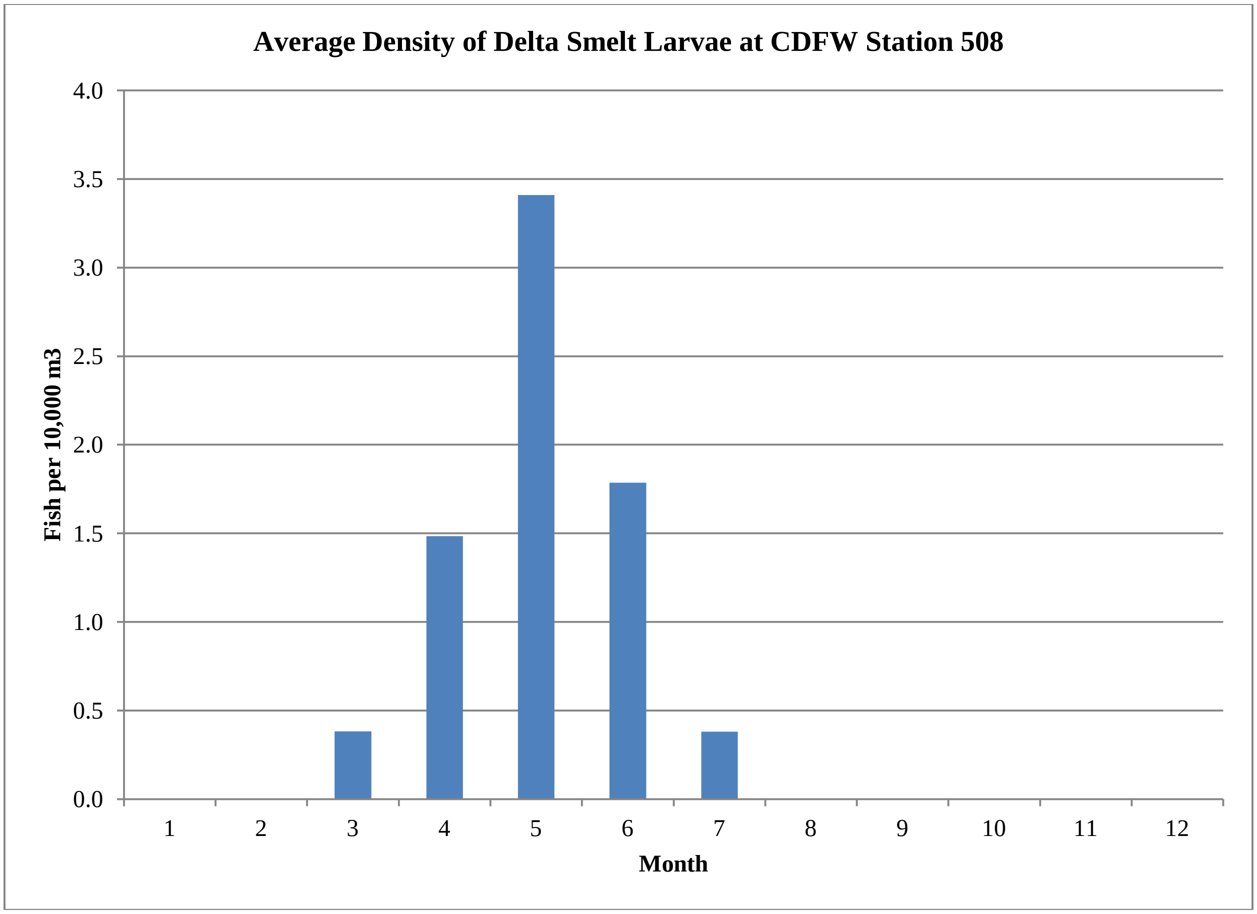


Figure 2-5. Average catch per unit effort (CPUE) of delta smelt larvae less than 15 mm in length at CDFW monitoring Station 508 since 1985.

Longfin smelt are listed as a candidate species by USFWS (FTC) and threatened by CDFW (CT). Longfin smelt larvae, based on CDFW survey data, are typically present near MSPS from January through May with the number of larvae sampled peaking in February. Figure 2-6 shows the catch per unit effort (CPUE) of longfin smelt larvae less than 15 mm collected at Station 508 during the Smelt Larva Survey (2009–2010) and 20-mm surveys since 1985. It should be noted that the CPUE of longfin smelt is two orders of magnitude greater than the CPUE of delta smelt. This means that longfin smelt are more abundant near MSPS than delta smelt.

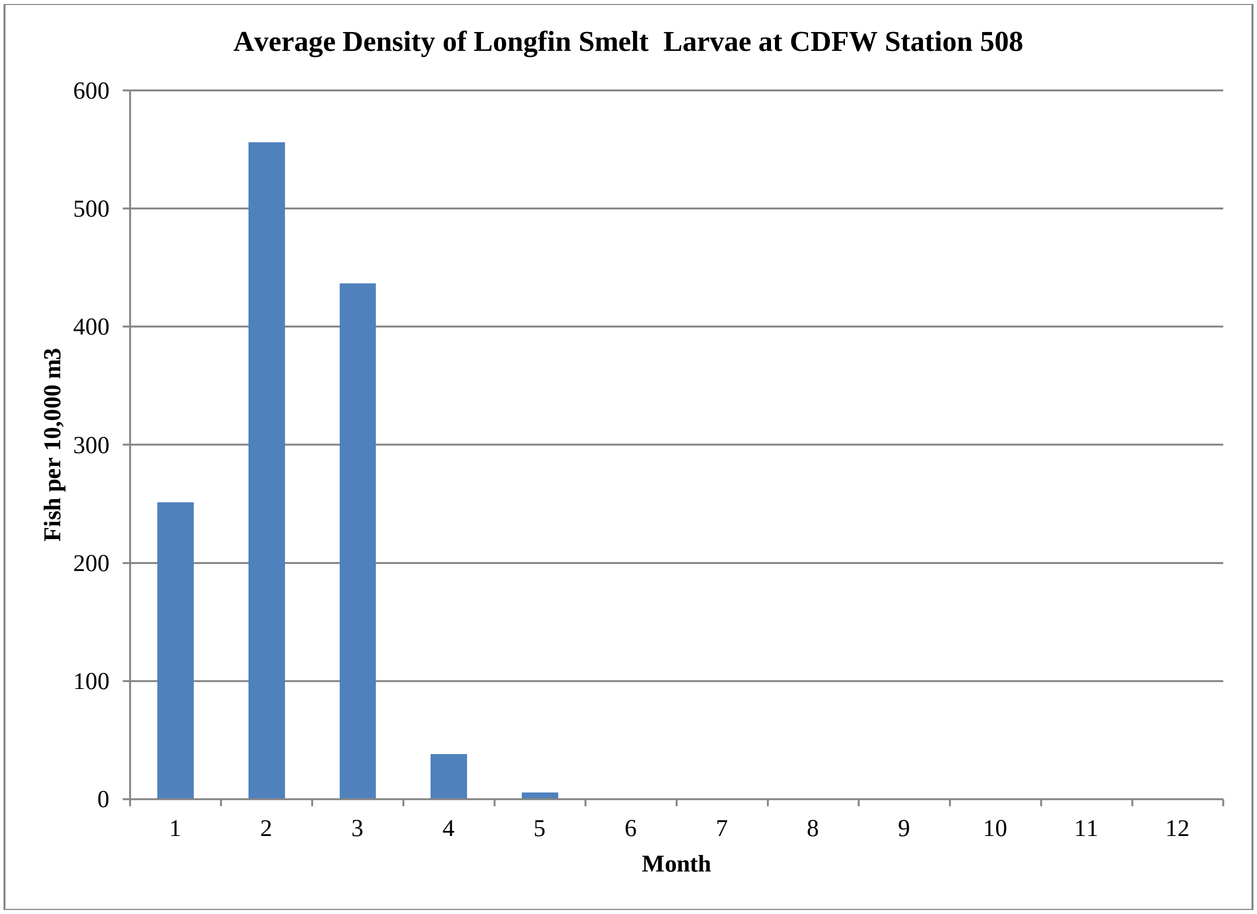


Figure 2-6. Average catch per unit effort (CPUE) of longfin smelt larvae less than 15 mm in length at CDFW monitoring Station 508 since 1985.

2.6.3 CCWD Monitoring Behind Fish Screen at MSPS

Since MSPS was upgraded in 2003, biological monitoring behind the screen has been required when the intake is in use. As described previously, the intake is used on average one to two months per year due to elevated salinity levels during most of the year. Since 2003, 40 sampling events have been conducted during which ichthyoplankton samples were collected from behind the screen at MSPS. No surveys were conducted in 2007, 2008, and 2012, because CCWD did not operate MSPS during these years. Figure 2-7 shows the monthly distribution of surveys; no surveys have been conducted during the months of February and August through December.

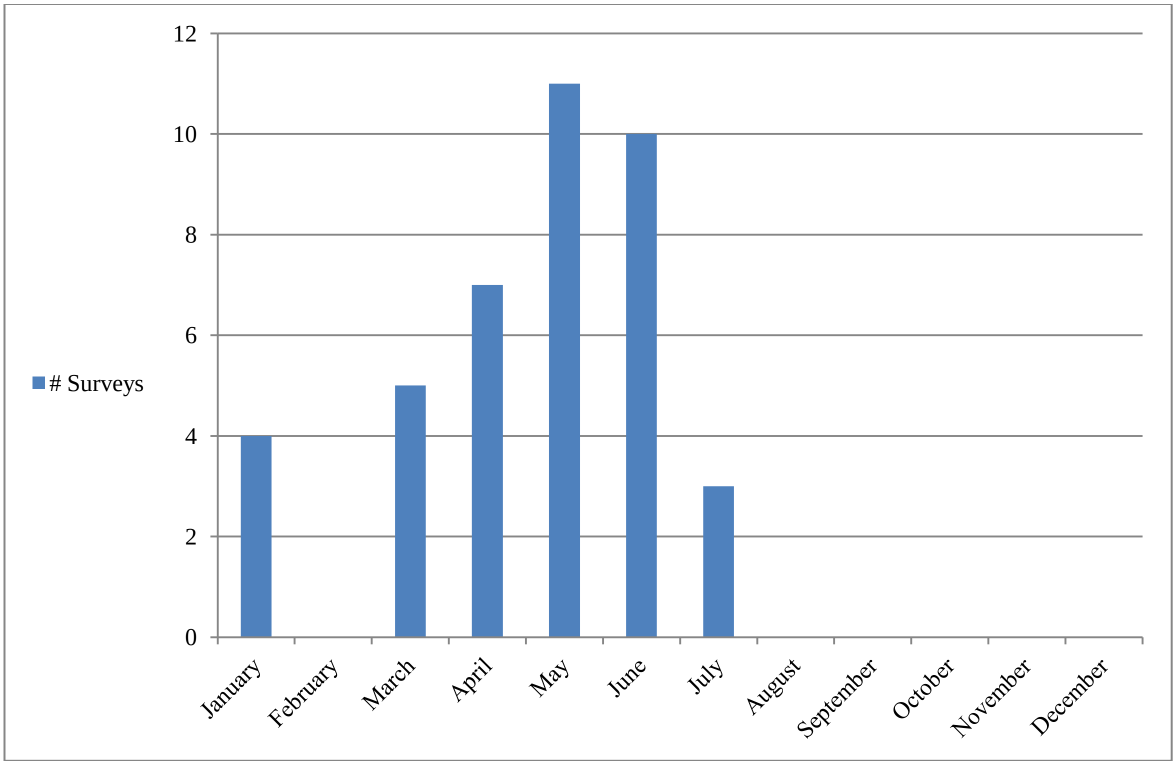


Figure 2-7. Monthly distribution of Biological Monitoring Surveys when sampling was conducted from behind the screen at MSPS during normal operations from 2003–2012. No surveys were conducted in 2007, 2008, and 2012, because CCWD did not operate MSPS during these years.

Five native species in their larval life stage have been collected at MSPS from behind the existing fish screen: delta smelt, longfin smelt, Sacramento splittail, prickly sculpin, and Sacramento sucker. As noted above, delta smelt, longfin smelt, and Sacramento splittail are special-status species. Prickly sculpin and Sacramento sucker are not special-status species.

Figure 2-8 shows the different species collected behind the screen at MSPS as a percentage of the total number of larvae collected. Prickly sculpin account for over 95% of the larval fish collected at MSPS. Prickly sculpin are native to California but are not special-status species and have a wide habitat range. Prickly sculpin reach sexual maturity after 2, 3, or 4 years of age and spawn in freshwater between February and June. Based on monitoring data at CDFW Station 508 prickly sculpin have been found near MSPS from January through July.

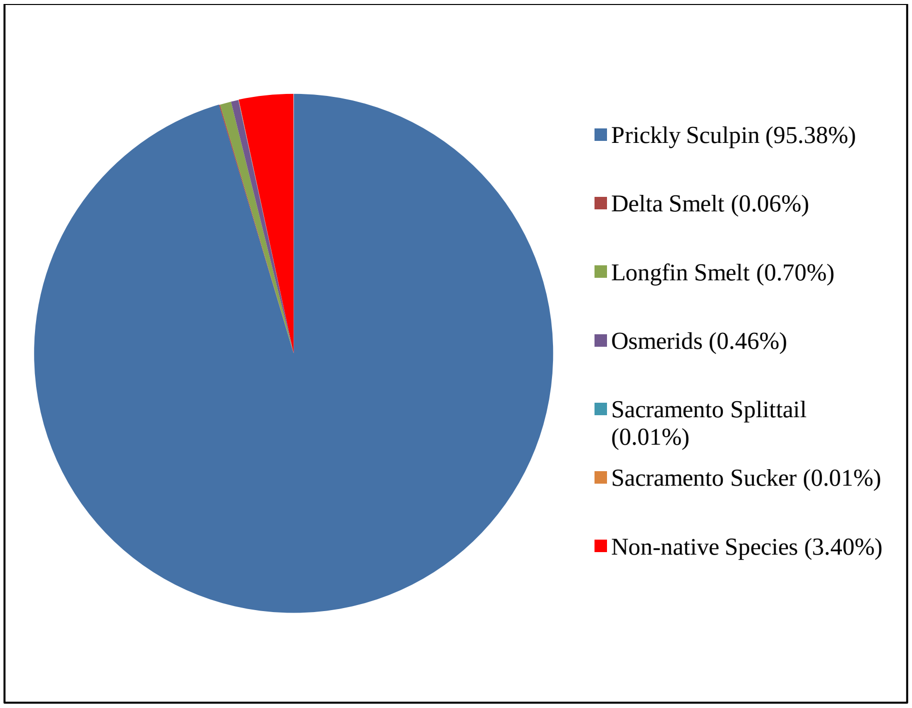


Figure 2-8. Larval fish collected during entrainment sampling at MSPS during normal operation as a percentage of the total number of larvae collected.

Delta smelt have accounted for 0.06% of the larvae collected at MSPS. Longfin smelt have accounted for 0.7% of the larvae collected. Osmerids, or members of the smelt family that could not be identified at the species level, accounted for 0.46% of the larvae collected. All smelts combined accounted for 1.2% of the total number of larvae collected at MSPS. Sacramento splittail accounted for 0.01% of larvae collected. Table 2-6 shows when the sensitive species have been observed behind the screen at MSPS during normal operation. Delta smelt have been observed in March and April. Longfin smelt have been observed March through May, and Sacramento Splittail were observed in April through May. The patterns of the collection of these species at MSPS match the seasonal patterns seen at CDFW biological monitoring Station 508 on the mainstem of the channel.

Table 2-6. Timing of special-status species entrained at MSPS during normal operations.

<table>
<tr><th></th><th>Jan</th><th>Feb*</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th></tr>
<tr><td colspan="7">Delta Smelt</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">5.6 – 20 mm total length (TL)</td><td></td><td></td></tr>
<tr><td colspan="7">Longfin Smelt</td></tr>
<tr><td></td><td></td><td></td><td colspan="3">3.8 – 15 mm TL</td><td></td></tr>
<tr><td colspan="7">Sacramento Splittail</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">6 – 7.5 mm TL</td><td></td></tr>
</table>

*No surveys have ever been conducted during February because CCWD has not operated MSPS during this month since monitoring began.

2.7 Potential Impacts to Aquatic Resources Examined

The entrainment analysis presented in this study is not a comprehensive examination of all of the potential impacts to aquatic resources that could result from BARDP. The objectives and analyses contained within this study focus on estimating the direct take (entrainment) of state and federal threatened and endangered species' larvae at BARDP - specifically delta smelt and longfin smelt larvae. Direct take or entrainment of larger individuals at BARDP are less of a concern because there is a positive barrier fish screen designed to exclude organisms greater than about 20 mm in length. All listed runs of Chinook salmon, steelhead, and green sturgeon, and species with designated essential fish habitat are excluded from the entrainment analyses presented in the subsequent sections of this report.

Potential impacts to all runs of Chinook salmon, Central Valley steelhead, and green sturgeon are not addressed in the entrainment analyses because direct take is not anticipated. All runs of Chinook salmon, Central Valley steelhead, and green sturgeon are present near MSPS when they are juveniles or adults, not larvae, and are too large to be entrained through the positive barrier 3/32-inch mesh fish screen at MSPS.

The direct take of starry flounder and northern anchovy is not considered in the entrainment analyses. Starry flounder and northern anchovy are not listed as endangered or threatened but do have designated essential fish habitat near MSPS. A complete evaluation of essential fish habitat is outside the scope of this study. The entrainment analyses could be used in the future as part of a comprehensive environmental impact report to evaluate potential impacts to food sources in the region which is a component of essential fish habitat assessment.

2.7.1 Proposed BARDP Operations

To evaluate the potential impacts of BARDP operation on listed species' larvae, a maximum diversion rate of 39 cfs, year-round except for the month of April, was assumed. This operational scenario was designed to simulate the maximum potential impact that operation of the BARDP could have; actual BARDP diversions could vary given demand, conveyance constraints, and conjunctive operation with storage, in addition to fisheries considerations. The proposed BARDP diversions are a small fraction of the daily or monthly average flow past the intake. Table 2-7 shows that proposed BARDP diversions are less than 1.5% of the minimum net Delta outflow and less than 0.2% of the average net Delta outflow.

Table 2-7. Proposed BARPD diversions compared to monthly minimum, average, and net Delta outflow from 1929-2012.

	Minimum Net Delta Outflow Monthly	**Average Net Delta Outflow Monthly**	**Maximum Net Delta Outflow Monthly**
Flow (cfs)	3,000	22,000	279,000
MSPS Diversions (cfs)	39	39	39
MSPS Diversions as Percentage of Flow	1.3%	0.18%	0.01%

2.8 Static Entrainment Method

Two methods were used to estimate the potential entrainment of larvae at the MSPS facility resulting from BARDP operations. The first method combines local fish sampling data and the BARDP diversion rate to estimate potential entrainment. The second method utilized the DSM2 Particle Tracking Module to track the fate of neutrally buoyant particles released in the Delta, assuming the fate of those particles is analogous to the fate of larval fish. The following sections describe the methodology and results of both analyses.

As noted above, the potential entrainment analyses will focus on endangered or threatened species that are present near MSPS and most at risk for entrainment during BARDP operations. Delta smelt and longfin smelt are both present as larvae and either listed as endangered or threatened species so the entrainment analyses will focus exclusively on these two species.

2.8.1 Static Entrainment Analysis

The static entrainment method utilizes biological monitoring data, the exclusion efficiency of the fish screen and the diversion rate at the intake to calculate potential entrainment of larval fish associated with BARDP operations. The equation used to calculate potential entrainment is provided below:

$$Fish\ Present\ at\ Intake = CPUE\left[\frac{Fish}{10{,}000\ m^3}\right] * \ Q_{diversion}[m^3]$$

$$Fish\ Entrained\ at\ Intake = CPUE\left[\frac{Fish}{10{,}000\ m^3}\right] * \ Q_{diversion}[m^3] * (1 - Screen\ Efficiency)$$

The monthly average CPUEs of delta and longfin smelt larvae (less than 15 mm total length) at CDFW Station 508 were used to calculate the potential entrainment. BARDP diversions were assumed to be a constant 39 cfs for all months except during April when CCWD observes a no-diversion period. Fish entrainment estimated by this method varies in direct proportion to the CPUE of fish in the immediate vicinity of the intake.

2.8.1.1 Assumptions and Limitations

The static entrainment analysis incorporates both historical data from fish surveys near the MSPS and proposed BARDP diversion rates. The static entrainment analysis relied on fish survey data analyzed in Section 2.6.2. The fish sampling data are normalized by converting raw catch data into terms of catch per unit effort (CPUE). These normalized sample data are then converted to units of fish density, or number of fish per unit volume of water sampled. The fish densities generated from survey data do not necessarily represent fish presence near MSPS. For example, the density of fish from survey results in the main channel of the Sacramento River at CDFW sampling Station 508 do not necessarily represent the density of fish at the intake channel leading to the side of the MSPS or to the densities of fish at the point of MSPS withdrawal.

One of the greatest limitations of this method is the assumption that the monthly average fish densities are constant throughout the month and entrained at an equal rate the entire month. In reality, fish distributions are patchy and highly variable over short time periods. Although the CPUE used in the calculation are long-term averages rather than data from a single survey, the inconsistency of CPUE compared to number of fish caught for any individual survey means the results should be interpreted as relative.

Fish screens are designed to avoid taking juvenile and adult fish but are not capable of screening out the larval life stage. The passive larval phase for many of the special status species is relatively short; delta smelt are typically in a larval phase between 30-70 days (after which time they are typically 15-40 mm in length and are considered juveniles),[16] longfin smelt can be in a larval phase for several weeks and up to three months depending on conditions (after which time they are typically greater than 16 mm in length and are considered juveniles).[17]

An exclusion efficiency study was conducted with cylindrical screens equipped with wedge-wire, which is the same screening material installed at the MSPS. The slot size at MSPS is 3/32 inch (2.4 mm). Weisberg et al. (1987a)[18] conducted a study to examine the exclusion efficiency of three prototype cylindrical wedge-wire screens in the intake canal of the Chalk Point Steam Electric Station in Aquasco, Maryland. Larval fish entrainment densities from the screened samples were compared to fish densities collected from an unscreened port and also to fish densities collected in the nearby canal using oblique tows through the water column. Weisberg et al. (1987a) reported that "wedge-wire screens reduce entrainment by two mechanisms: 1)

[16]Nobriga, M., 2009.The Little Fish in California's Water Supply: A Literature Review and Life-History Conceptual Model for delta smelt (*Hypomesus transpacificus*) for the Delta Regional Ecosystem Restoration and Implementation Plan.
[17]Rosenfield, J.A., 2010. Life History Conceptual Model and Sub-Models Longfin Smelt, San Francisco Estuary Population for the Delta Regional Ecosystem Restoration and Implementation Plan.
[18] Weisberg, S.B., Burton, W.H., Jacobs, F., and E.A. Ross. 1987. Reductions in Ichthyoplankton Entrainment with Fine-Mesh, Wedge-Wire Screens, North American Journal of Fisheries Management 7:386-393.

physical exclusion, which occurs when the slot size of the screen is smaller than the organism susceptible to entrainment; and 2) hydrodynamic exclusion, whereby the screen's cylindrical configuration quickly dissipates the flow field and allows ichthyoplankton with sufficient swimming ability to escape. The second mechanism is enhanced when ambient water velocity perpendicular to the screen surface exceeds the velocity through the screen." Sweeping velocities during their study were nearly equal to or slightly less than the through-slot velocities during testing (sweeping velocity=15 cm/sec; through-screen velocity=13 cm/sec in 1982 and 20 cm/sec in1983[19]. Weisberg et al. (1987) found that when compared to an unscreened port, the exclusion efficiency of the 5-7 mm size class of bay anchovy larvae was approximately 56%. Exclusion rates improved to 78%, 78%, and 100% for the 8-10 mm, 11-14 mm and ≥15 mm size classes, respectively (Table 8). Although at MSPS, there is no comparable sweeping velocity, this difference was set aside and Weinberg et al.'s findings (Table 2-8) were used to roughly approximate entrainment.

Table 2-8. Estimates of exclusion efficiency for bay anchovy by size class using a positive barrier 2-mm slot wedge-wire fish screen. [20]

Size Class	Exclusion Efficiency for 2-mm Wedge-wire Screen (compared with unscreened intake)
5–7 mm	55.5.%
8–10 mm	77.8%
11–14 mm	77.8%
≥15 mm	80.0%

Source: Weisberg et al. 1984a.

2.8.2 Static Entrainment Results

Appendix 2-A contains the complete static entrainment calculations. Figure 2-9 shows that delta smelt larvae are typcially present from March through July density and entrainment risk is greatest in May. The likelihood of entraining delta smelt larvae in April is zero since it was assumed that CCWD's April no-diversion period would apply to the BARDP. The static entrainment analysis predicts that the probability of entraining delta smelt is essentially negligible from July through February.

[19] Weisberg, S., W.H. Burton, E.A. Ross, F. Jacobs. 1984b. The effects of screen slot size, screen diameter, and through-slot velocity of entrainment of estuarine ichthyoplankton through wedge-wire screens.
[20] Weisberg, S.B., Burton, W.H., Jacobs, F., and E.A. Ross. 1987. Reductions in Ichthyoplankton Entrainment with Fine-Mesh, Wedge-Wire Screens, North American Journal of Fisheries Management 7:386-393.
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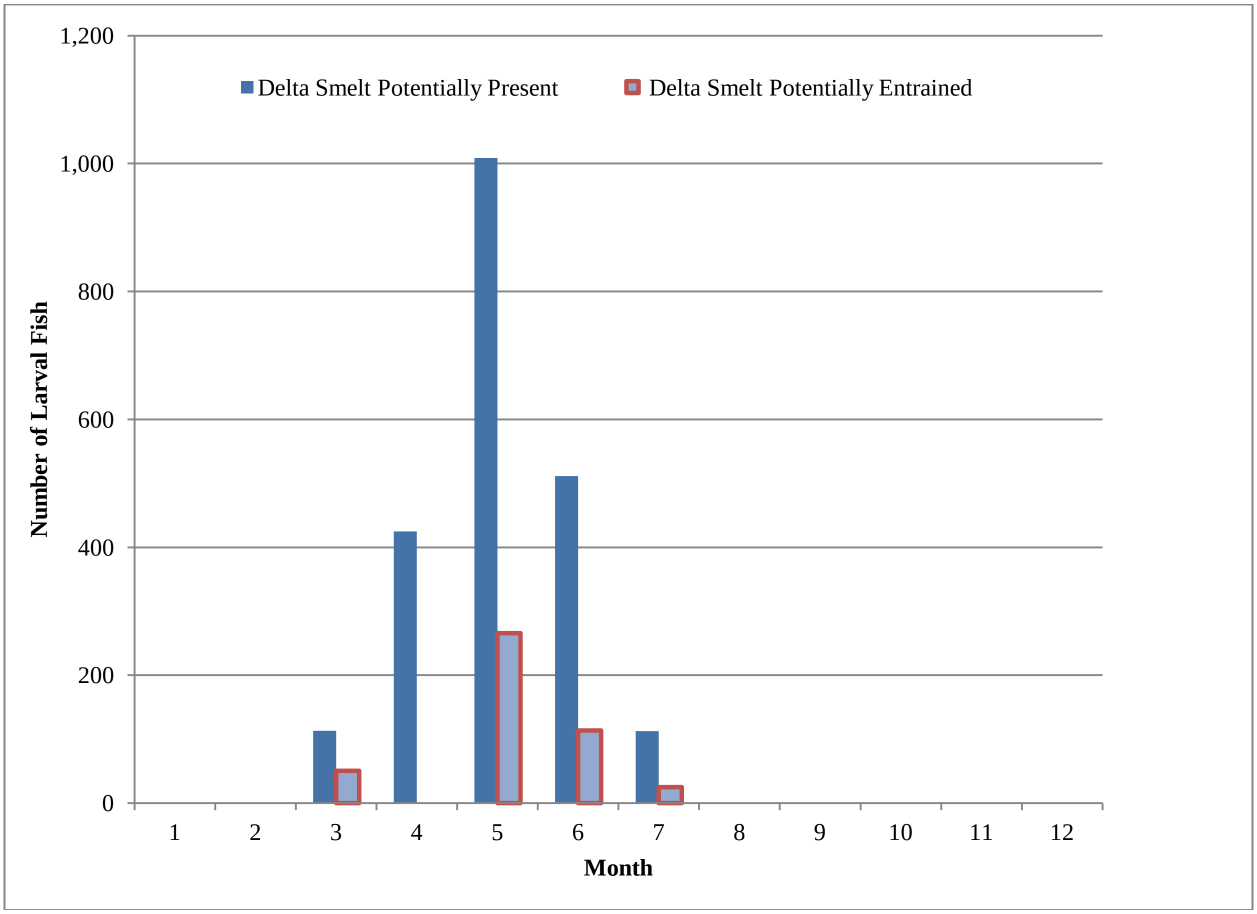

Figure 2-9. Average number of delta smelt larvae less than 15mm in length that could be present based on CDFW Station 508 historical surveys compared to the number that could be entrained at BARDP.

Figure 2-10 shows that longfin smelt larvae are found at MSPS from January through May and the risk of entrainment peaking in February. The probability of entraining longfin smelt larvae is very low from May through December. The likelihood of entraining longfin smelt in April is zero since since it was assumed that CCWD's April no-diversion period would apply to the BARDP.

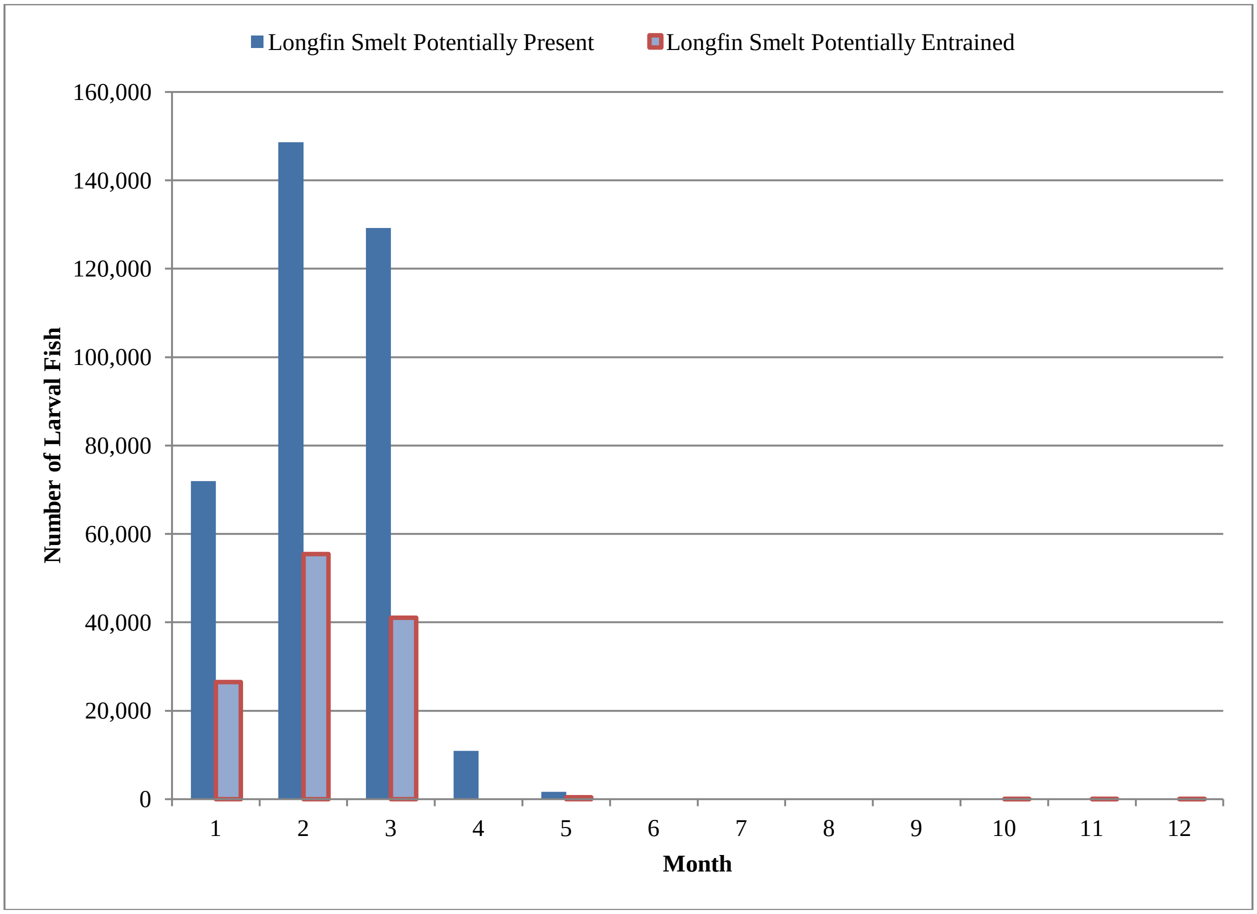

Figure 2-10. Average number of longfin smelt larvae less than 15mm in length that could be present based on CDFW Station 508 historical surveys compared to the number that could be entrained at BARDP.

2.8.3 Static Entrainment Conclusion

Two species listed by state and federal agencies as threatened or endangered are present at MSPS as larvae and are most at risk of entrainment at MSPS: delta smelt and longfin smelt. Delta smelt larvae are typically found near MSPS from March through July and the risk of entrainment is greatest in May when the greatest numbers of small larvae are present. Longfin smelt are typically found January through May near MSPS and risk of entraining longfin smelt larvae is greatest in February when small young larvae are present.

In general terms, the probability of entraining one or both of these larval smelt species is relatively high in the winter and spring during 'normal' hydrologic conditions when ambient conditions are fresh. The probability of entraining one or both of these larval species is very low in the late summer and fall because they are typically not present. Conditions from year to year can change depending on a wide variety of factors so the presence and abundance of these species is best determined by local monitoring data.

The magnitude of impacts estimated in using this method should be considered with caution because there are limitations associated with this method. The method assumes that historical average fish desities are constant throuhgout a month without consideration of biological changes such as growth or changes in ambient flow conditions associated with the tides and freshwater inflow. Using this analytical method, the magintude of fish potentially entrained is proportional to the average abundance of small larvae present found at station 508 in the mainstem channel of the river. As noted above the abundance of species at this station may not reflect the abudance or species composition of fish near MSPS intake which is located off the mainstem at the end of a shallow man made channel. Very few smelt have been collected at MSPS when the intake has operated historically (Section 2.6.3). This may indicate that the abundance of smelt near the MSPS intake is less than in the mainstem channel and therefore impacts to smelt could be less than predicted using this method.

2.9 Particle Tracking Model

A DSM2 Particle Tracking Module (PTM) was used to simulate the transport and fate of neutrally buoyant particles in the Delta. The PTM relies on velocity, flow, and water surface elevation information from the DSM2-Hydro model run to simulate the movement of virtual particles in the Delta on a 15-minute time-step throughout the simulation period. The Hydro run used for the PTM analysis was the same as used in the 2012 BARDP water quality impacts modeling in the E2 scenario. The CVP and SWP operations and Delta inflows were based on the CalSim modeling performed for the 2011 SWP Reliability Report,[21] BARDP diversions were added to the DSM2 PTM model but brine disposal at local wastewater treatment plants was not included. For more complete information about the DSM2 assumptions please refer to Section 1 of this report. A constant 39 cfs diversion rate, except in April, was withdrawn from node 375 in the model grid (Figure 2-11).

Neutrally buoyant particles were released at different locations in the DSM2 model under a wide range of hydrologic conditions. Once released, particles can remain in the Delta channels, become entrained at water diversion intakes, or leave the modeling domain with flow past the model boundary (i.e., out to the San Francisco Bay). For each model run, 10,000 particles were released from one of the designated nodes at the beginning of each month and particles were tracked for 30 days. Separate model runs were performed for each release location and each month of the 16-year DSM2 simulation (1975-1991). The phase of the tide at the time particles were released can significantly affect particle fate but for this study particles were released continuously over a full tidal cycle (25-hour period) on the first day of each model run so there was limited tidal bias on particle fate.

2.9.1 Particle Release

Figure 2-9 summarizes the particle release locations. These locations were chosen based on proximity to the MSPS and proximity to CDFW biological monitoring stations. Six of the twelve release locations were downstream of MSPS in Suisun Bay, three of the release locations were upstream of the BARDP intake at MSPS and one was located at the same node as the BARDP intake. Figure 2-11 shows the DSM2 grid, the release locations are identified with purple circles, and the MSPS intake is indentified with a red star.

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[21]*State Water Project Delivery Reliability Report 2011.*http://baydeltaoffice.water.ca.gov/swpreliability/

Table 2-9. Description of DSM2 nodes and corresponding CDFW sampling sites.

CDFW 20-mm Survey Station Number	DSM2 Node	Location Description
411	359	Suisun Bay West of Point Edith
418	367	Suisun Bay near Mothball Fleet
501	238	Suisun Bay between Roe and Ryer Islands
602	356	Suisun Bay off Chipps Island
504	358	Suisun Bay at Port Chicago
519	227	Honker Bay
508	357	Mallard Slough Pump Station
513	365	Grizzly Bay Northeast of Suisun Slough
519	465	Sacramento River near Van Sickle Island
520	463	New York Slough
704	354	Sacramento River at Sherman Lake
804	467	San Joaquin River at West Island

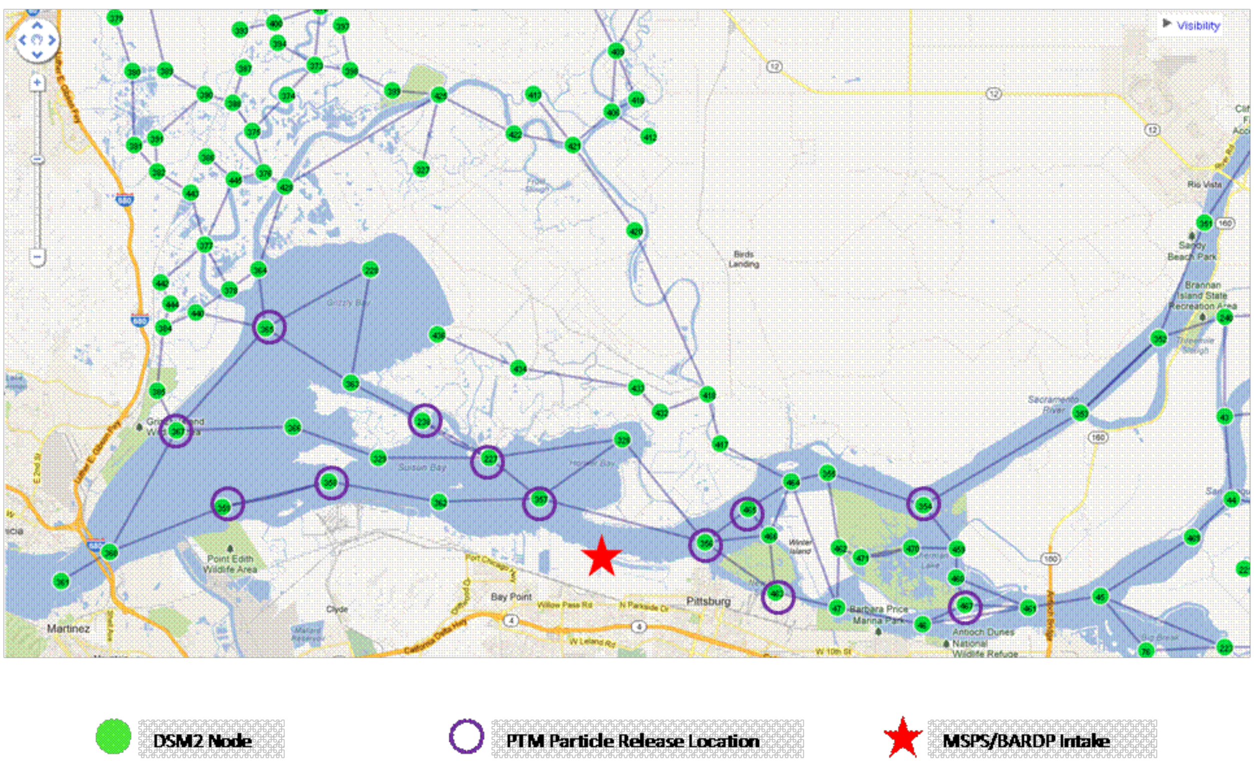


Figure 2-11. Green dots are the DSM2 node network, the purple circles indicate locations where particles were released for the BARDP PTM simulation. Five release points were upstream of the MSPS, six were downstream, and one was at the same location as the BARDP/MSPS intake.

As noted above, 10,000 particles were released at each location on the first day of each month over a 25-hour period. The 25-hour cycle ensures that particles are released during all phases of the tides so the results are not tidally biased. Separate model runs were performed for each release location and each month of the 16-year DSM2 simulation.

2.9.2 Assumptions and Limitations

Use of PTM for fishery analysis has gained popularity over the last decade; however, the PTM tool has a number of limitations in its application to fishery analysis. Chiefly, since the particles simulated in the model are neutrally buoyant (and therefore have no swimming behavior or other independent movement), results of these analyses are most relevant to the planktonic early larval stages of various organisms that do not move independently in the water column. The particles are not considered to reflect movements of juvenile or adult fish within the Delta, or of larvae that are able to move independently in the water column (for example, by varying their buoyancy). Assumptions that would allow accurate representation of behavior of adult or juvenile fish have not been developed for the PTM tool. The application of DSM2/PTM to predict aquatic resource movement is limited by several factors: the life stage of the fish, the efficiency of fish screens at the intake with respect to size-specific exclusion of fish from entrainment, and modeling artifacts. The interpretation of these factors is described in the following sections.

2.9.2.1 Movement of aquatic organisms

PTM studies estimate the influence of modeled Delta hydrodynamics on neutrally buoyant particles. As such, the studies are only appropriate to represent the influence of Delta hydrodynamics on organic material and planktonic organisms (such as phytoplankton and zooplankton) that would behave as passively drifting particles. The interpretation is often extended to apply to the larval stages of some fish species rearing in the Delta, which may be advected (i.e., transported) by Delta tidal flows prior to developing the ability to swim and control their position in the water column. The particles are not considered to reflect movements of juvenile or adult fish within the Delta.

2.9.2.2 Biological interpretation of particle release timing and location

In considering specific aquatic organisms, the seasonal timing and location where particle releases are simulated should be interpreted appropriately. As discussed above, a practical application of PTM results for specific fish species must be limited to use for larval stages of Delta fish. It follows that this application of PTM should only be used at times and locations when larval stages are likely to occur. For example, particle release locations in early spring on the lower Sacramento River may be interpreted to represent delta smelt spawning locations, from which passively drifting larvae would be expected to emerge.

2.9.2.3 Positive barrier fish screens

The PTM simulation assumes that particles are entrained at water diversion intakes without regard for fish protection facilities. Therefore, raw PTM results must be further processed to account for the efficiency of the positive barrier fish screen at MSPS, as discussed in Section 2.8.1.1. Both delta smelt and longfin smelt larvae hatch at sizes (approximately 4-5 mm total length) that would be partially excluded from entrainment by positive barrier screens, making the use of screen efficiency assumptions appropriate for these species at screened water intakes. As noted in Table 2-8, the screening efficiency of larvae 5 mm in length from the Weisberg et al. (1987) study was approximately 56%. Using their results, 56% of the particles that PTM predicts would be entrained by BARDP would instead be excluded by the existing fish screen. Using the screen efficiency assumptions for 5 mm larvae still provides a conservatively high estimate of potential entrainment because larvae growth is not accounted for in the simulation. Larval growth (larger larvae) would result in higher exclusion efficiencies.

2.9.2.4 Geometry of Water Intakes

Because DSM2 is a one-dimensional model, it does not recognize the difference between an intake at the end of a channel and an intake on the side of a channel. Particles are entrained at water intakes in a PTM simulation based on advection and dispersion calculations made where the intake boundary intersects the one-dimensional arc that represents the Delta channel. This does not reflect the strong influence of longitudinal flow in the actual three-dimensional river, which tends to sweep neutral particles past side-of-channel intakes that have low approach velocities (e.g., intakes have been designed to achieve an approach velocity of 0.2 ft/sec for the protection of delta smelt and other fish species). This site-specific difference is not reflected in the larval fish entrainment analysis performed using PTM for this project and could contribute to an over-estimate of larval entrainment.

2.9.2.5 Dispersion of particles

PTM has limitations regarding the dispersion of particles, including the simplistic assumed velocity profiles that do not adjust for channel geometry or bottom roughness and the mixing of particles at channel nodes. These factors may have a significant effect on particle dispersion. The open water areas of the Delta (e.g., Franks Tract and Mildred Island) are not well represented in the particle tracking analysis. The model assumes these regions are completely mixed environments, such that a particle that enters on one side of the flooded lake has the possibility of exiting on the other side of the lake in a short time period. In reality, these environments have complicated dynamics that effectively “trap” particles within the regions or move particles in ways the model cannot predict.

2.9.3 PTM Entrainment Results

The PTM modeling shows that the rate of entrainment at BARDP was very small, less than 0.22%, under all conditions and from all release locations. Appendix 2-B contains complete results of PTM entrainment at BARDP. The greatest entrainment rates were observed when particles were released near the BARDP intake from nodes 357, 356 and 465; on average, 0.10%, were entrained from those nodes, up to a maximum of 0.22%. When particles were released upstream from Sherman Lake, a greater percentage of particles ended up in the interior Delta and 0.08% were entrained at BARDP on average. When particles were released downstream of BARDP near Honker Bay, nodes 227, 238, 358, 0.05% of particles were entrained at BARDP on average. When particles were released farther downstream in Suisun Bay, nodes 365, 367, 359, the majority of particles quickly left the modeling domain past the western Martinez boundary and only 0.01% of particles were entrained on average. Table 2-10 shows the average and maximum entrainment rate at BARDP for release nodes grouped by region. Figure 2-12 shows the average rate of entrainment at BARDP of particles released from different regions.

Table 2-10. Average particle entrainment at BARDP by geographic region of release location.

Release Location Geographic Region	Nodes Included	Average Entrainment Rate at BARDP	Maximum Entrainment Rate at BARDP
Upstream Sherman Lake	354, 467	0.08%	0.19%
Near MSPS	357, 356, 465	0.10%	0.22%
Honker Bay	227, 238, 358	0.05%	0.14%
Suisun Bay	365, 367, 359	0.01%	0.03%

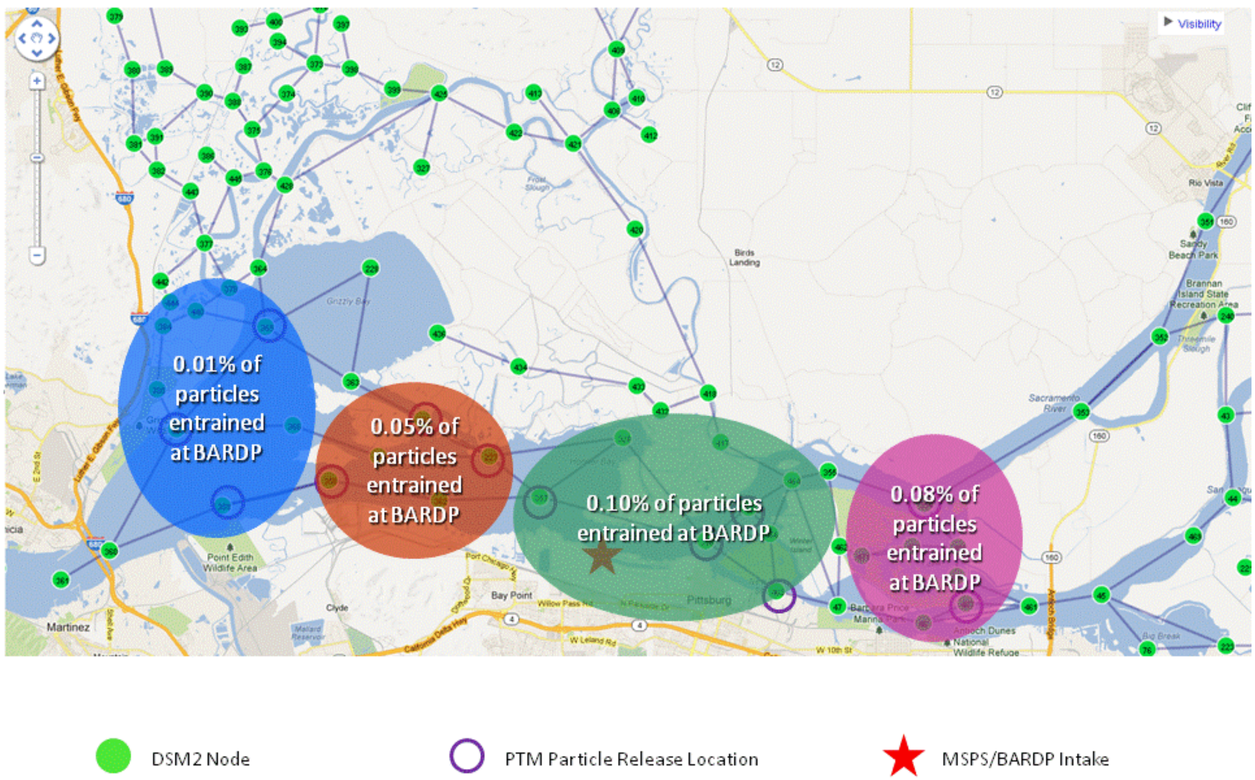


Figure 2-12. Average entrainment rate at BARDP by geographic region of release location.

The majority of particles released from all locations left the modeling domain without being entrained at BARDP or other intakes. On average, 90% of the particles released between December and May from all locations left the modeling domain past Martinez by the end of the 30-day simulation. During the summer and fall, June through November, over 75% of the particles released from all locations left the modeling domain past Martinez by end the of the 30-day simulation. Table 2-11 shows the percentage of particles that remained in the Delta channels and the percentage that exited the model domain by the end of the 30-day simulation. The percentages shown in Table 2-11 are seasonal averages over all months simulated and all release locations. On average 15% of the particles released remained in channels within the Delta.

The entrainment at BARDP is calculated by applying the fish screen efficiency for larvae 5-7 mm in length (see Table 8) to the raw PTM entrainment results at the BARDP intake. The second row in Table 2-11 shows the portion of the particles that were entrained at BARDP in the PTM model but that would be screened out if the particles were greater than 5 mm in length. Those particles do not remain in the dynamic model so the ultimate fate of those particles is not tracked in PTM. On average 0.07% of particles were screened out by the fish screen.

Table 2-11. Aggregate average particle fate at end of 30 days (10,000 particles released).

	Winter Dec-Feb	**Spring** Mar-May	**Summer** Jun-Aug	**Fall** Sept-Nov	**Annual Average**
Entrained through Screen at BARDP Intake	0.05%	0.03%	0.08%	0.08%	0.06%
Screened out at BARDP Intake	0.06%	0.04%	0.10%	0.10%	0.07%
Entrained at Other CCWD Intakes	0.00%	0.00%	0.00%	0.00%	0.00%
Entrained at All Other Delta Intakes (Agricultural + CVP/SWP)	0.33%	0.10%	1.40%	0.43%	0.57%
Suisun Marsh	0.18%	0.15%	0.29%	0.34%	0.24%
Remain in Channels	10.89%	7.34%	21.65%	21.71%	15.40%
Past Martinez (out of system, to SF Bay)	88.48%	92.34%	76.47%	77.35%	83.66%

The entrainment rate at BARDP was dependent on the magnitude of diversions at the intake compared to flows past the intake. The passive particles 'go with the flow' so when flow past the intake is much larger than the diversion rate, very few particles are entrained. As shown in Table 2-7, BARDP diversions are approximately 0.18% of average monthly net Delta outflow. BARDP diversions are less than 0.01% of the maximum daily tidal flow which is up to 400,000 cfs. If river flow was large (>100,000 cfs) during the simulation, a very small percentage (< 0.01 %) of particles released were entrained at BARDP because the majority of particles were quickly transported out of the modeling domain past Martinez.

Figure 2-13 shows the average percent entrainment at BARDP during dry and wet conditions compared to the average of all runs. For example, the average entrainment in March for all years and from all release locations was 0.03%. During March 1982, one of the wettest months on record, the average particle entrainment from all release locations was 0.006% and during March 1976, one of the driest months on record, the average particle entrainment from all release locations was 0.07%.

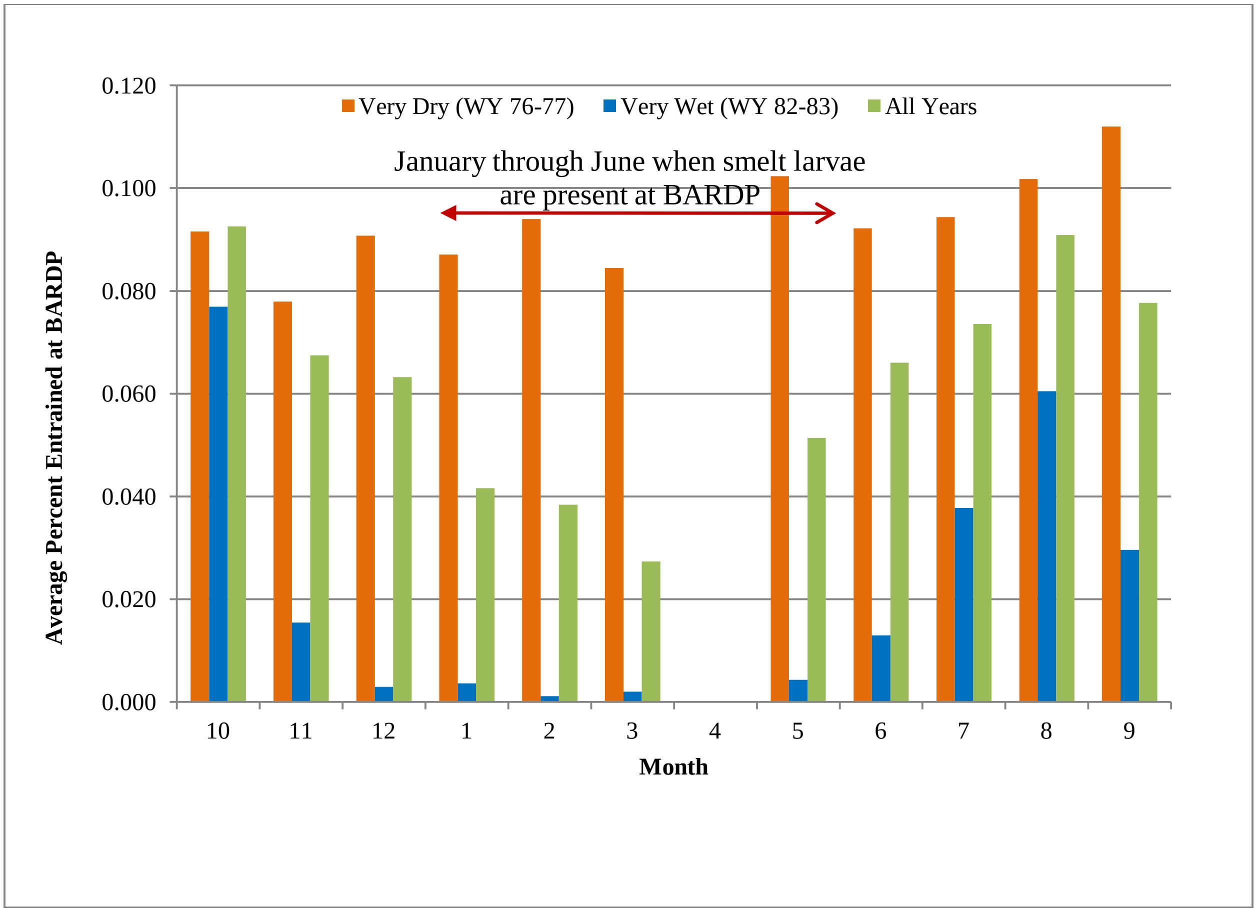


Figure 2-13. Average percent entrainment at BARDP from all release locations. Wet conditions equal less entrainment, dry conditions equals more entrainment. (WY = water year).

2.9.4 PTM Conclusions

The PTM modeling indicates that the particle entrainment at BARDP is very small; less than 0.22% of particles released from all location under all hydrologic conditions were entrained. The low entrainment rate at BARDP is due to the relatively small diversion rate; 39 cfs is less than 0.01% of the maximum tidal daily flows past the intake and less than 0.2% of the average net Delta outflow. BARDP had the greatest influence on particles immediately surrounding the intake (nodes 357, 356, 465). Entrainment risk at BARDP was highest when particles were released close to the intake during low flow conditions. However, the biological monitoring results in Section 4 indicate that larval delta and longfin smelts are not typically present near BARDP when the entrainment risk based on PTM modeling is high (e.g., July through November). Biological monitoring shows that small larvae are typically present near BARDP from January through June when particle entrainment at BARDP was at the lowest levels, < 0.04% on average. This suggests that impacts to delta and longfin smelts between January and June would be small if BARDP diverted during that time. A full range of measures to minimize or avoid potential impacts to sensitive species is described in Section 2.10.

2.10 Minimization and Avoidance Measures

CCWD held a workshop January 11, 2013 with BARDP partners and fisheries experts from the consulting firm Tenera Environmental to develop avoidance and minimization measures for the potential fisheries impacts of BARDP. Tenera Environmental has been contracted by CCWD in the past to perform biological monitoring and make recommendations regarding fisheries protections; they are widely recognized by the State Water Resources Control Board and other regulatory agencies as experts in the field. Together the BARDP partners and Tenera Environmental developed the following suite of strategies that are intended to inform the BARDP of project alternatives if it moves forward towards the next phase of planning. The identified strategies generally apply to potential operational modifications or engineering/design modifications.

2.10.1 Potential Operational Modifications

- **Adaptively determine BARDP diversion based on real-time field monitoring**
  A network of monitoring stations already exists near BARDP and BARDP operations could be managed based on the presence or absence of larval delta and longfin smelts. When those species/life stages are present, BARDP diversion could be reduced. Monitoring behind the screen at the intake would continue to confirm take of these species is minimized and documented.

  Pros: Provides high level of fisheries protection, and provides a long diversion window while adaptively avoiding/minimizing impacts to smelts.

  Cons: Uncertainty in any year about a committed, stable supply from BARDP, relatively high monitoring cost, and ongoing coordination with fisheries agencies increases difficulty for operation and operation cost.

- **Establish a fixed no-diversion period**
  To avoid fisheries impacts, BARDP could have a set 'no-diversion' period similar in concept to CCWD's existing April 'no-diversion' period. Based on historical monitoring results, a 'no-diversion' period that would span a specified period of time when larval delta and longfin smelts have been present in the region in the past.

  Pros: Provides high level of fisheries protection, more certainty of the minimum annual supply from the project, and less costly and easier to operate than real-time monitoring based operations.

  Cons: Inflexible approach could reduce total amount of supply available by reducing diversions when larval delta and longfin smelts are not present.

2.10.2 Potential Engineering/Design Modifications

- **Decrease the slot size of the MSPS screen**
  The existing screen has a slot size of 3/32 inch. CCWD's and EBMUD's recently completed Delta intakes have a slot size of 2/32 inch. Decreasing the existing MSPS screen slot size to 2/32 inch would make the screen more effective at screening out larvae and therefore would reduce entrainment.

  Pros: Reduced entrainment risk.
  Cons: Additional cost of new screen panels.

- **Seasonally deploy aquatic filter barrier**
  An aquatic filter barrier or other fine-mesh net, could be seasonally deployed across the front of the intake channel to reduce the ability of sensitive fish species to enter the MSPS intake channel, while continuing to allow the flow of water into the channel.

  Pros: Reduced entrainment risk.
  Cons: Recent installations of these systems have had a high occurrence of fouling.

- **Relocate intake to the main channel**
  The intake to the pump station could be re-located to the end of the intake channel and draw water directly from Suisun Bay. The sweeping velocity across the face of the intake would be dramatically increased and the entrainment risk would decrease. However, it is possible the existing design is equally as protective because the habitat conditions within the existing intake channel are not ideal for either delta or longfin smelts. Relocating the pump station intake could expose the diversion to a higher density of sensitive fish species. Additional information and studies would be necessary to evaluate the benefits of this alternative.

  Pros: May reduce entrainment risk.
  Cons: Possible increase in number of sensitive species exposed to entrainment risk and thereby potentially increasing overall number of entrained larvae.

- **Install fish return system**
  The project could install an engineered apparatus outside of the intake that artificially creates a sweeping flow across the screen face which sends fish to a collection system that then returns collected fish back to the river.[22] [23]

  Pros: May reduce entrainment.
  Cons: Handling of 'returned' fish may be detrimental for sensitive species.

[22] An example of a fish return system on a river can be seen on the Tule River in Sequoia National Park. http://bcf-engr.com/index.php/portfolio/tule-river-fish-return-SCE
[23] An analysis of fish diversion efficiency and survivorship in the fish return system at San Onofre nuclear generation station. http://spo.nwr.noaa.gov/tr76.pdf

2.11 Conclusions

Two listed species are present at MSPS as larvae: delta smelt and longfin smelt. Longfin smelt are typically found January through March near MSPS with the catch per unit effort (CPUE) peaking in February. Delta smelt larvae have been found March through July with the catch per unit effort near MSPS peaking in May.

Based on the static entrainment results, the risk of entraining longfin smelt larvae is greatest in February and the risk of entraining delta smelt is greatest in May. The risk of entrainment peaks when the population near MSPS consists of mostly of small young larvae. Based on the static entrainment method, the probability of entraining one or both of these listed species is negligible in the late summer and fall because they are not present near the intake as small larvae during that time.

The hydrodynamic/PTM modeling indicates that the particle entrainment and by proxy larval entrainment at BARDP is very small; less than 0.22% of particles released from all locations under all hydrologic conditions were entrained at BARDP. BARDP diversions would have a local influence in the vicinity immediately surrounding the intake, but would be negligible downstream of Honker Bay. Particle entrainment at BARDP was highest when particles were released close to the intake during low flow conditions, i.e., during the late summer or during a drought. However, the biological monitoring indicates that larval delta and longfin smelts are not typically present near BARDP when the particle entrainment risk was high. Small smelt larvae are typically present near BARDP from January through June when particle entrainment at BARDP was at low levels, < 0.04% on average.

A variety of methods to avoid or minimize potential fisheries impacts was discussed at a BARDP partners workshop held in January 2013. Changes to operations and intake design could reduce or avoid impacts to fisheries. A preferred combination of minimization and avoidance measures will be evaluated if an environmental impacts analysis is completed at a later date in the future.

2.12 Appendix 2-A: Static Entrainment Results

Table 2-12. Average fish density of special-status species by month at Station 508 just upstream of MSPS. Units are fish per 10,000 m^3.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Northern Anchovy												
<5mm	NA	0.00	0.00	NA	0.00	0.07	0.00	0.40	0.04	0.00	0.10	NA
5 - 7 mm	NA	0.00	4.37	NA	0.00	0.08	0.11	0.00	0.00	0.00	0.00	NA
8 - 10 mm	NA	0.00	0.00	NA	0.36	0.57	0.54	0.00	0.00	0.00	0.00	NA
11 - 14 mm	NA	0.00	0.00	NA	0.00	0.75	0.73	0.00	0.00	0.00	0.00	NA
Total	NA	0.00	4.37	NA	0.36	1.46	1.38	0.40	0.04	0.00	0.10	NA
Delta Smelt												
< 5mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5 - 7 mm	0.00	0.00	0.38	1.03	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8 - 10 mm	0.00	0.00	0.00	0.21	1.07	0.54	0.00	0.00	0.00	0.00	0.00	0.00
11 - 14 mm	0.00	0.00	0.00	0.24	1.71	1.25	0.38	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.38	1.48	3.41	1.79	0.38	0.00	0.00	0.00	0.00	0.00
Longfin Smelt												
< 5mm	0.00	21.70	3.84	0.00	0.00	0.00	0.00	NA	0.00	0.06	0.22	0.14
5 - 7 mm	164.89	301.12	173.63	4.36	0.58	0.00	0.00	NA	0.00	0.00	0.00	0.00
8 - 10 mm	86.38	217.55	121.78	9.40	1.09	0.00	0.00	NA	0.00	0.00	0.00	0.00
11 - 14 mm	0.00	15.82	137.48	24.45	3.81	0.00	0.00	NA	0.00	0.00	0.00	0.00
Total	251.27	556.19	436.73	38.21	5.47	0.00	0.00	NA	0.00	0.06	0.22	0.14
Sacramento Splittail												
< 5mm	NA	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00	0.00	0.00
5 - 7 mm	NA	NA	0.20	NA	0.00	NA	NA	NA	0.00	0.00	0.00	0.00
8 - 10 mm	NA	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00	0.00	0.00
11 - 14 mm	NA	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00	0.00	0.00
Total	NA	NA	0.20	NA	0.00	NA	NA	NA	0.00	0.00	0.00	0.00
Starry Flounder												
<5mm	NA	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00	NA	NA
5 - 7 mm	NA	NA	0.00	0.09	0.00	0.00	NA	0.00	0.00	0.00	NA	NA
8 - 10 mm	NA	NA	1.01	2.08	0.13	0.00	NA	0.00	0.00	0.00	NA	NA
11 - 14 mm	NA	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00	NA	NA
Total	NA	NA	1.01	2.17	0.13	0.00	NA	0.00	0.00	0.00	NA	NA

Table 2-13 Number of fish larvae < 15 mm in length potentially present at BARDP intake.

Number of Fish Potentially Present	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Northern Anchovy												
<5mm	NA	0	0	NA	0	19	0	120	11	0	29	NA
5 - 7 mm	NA	0	1293	NA	0	24	34	0	0	0	0	NA
8 - 10 mm	NA	0	0	NA	107	162	159	0	0	0	0	NA
11 - 14 mm	NA	0	0	NA	0	214	215	0	0	0	0	NA
Total	NA	0	1293	NA	107	419	408	120	11	0	29	NA
Delta Smelt												
< 5mm	0	0	0	0	0	0	0	0	0	0	0	0
5 - 7 mm	0	0	113	295	187	0	0	0	0	0	0	0
8 - 10 mm	0	0	0	61	315	154	0	0	0	0	0	0
11 - 14 mm	0	0	0	69	507	357	113	0	0	0	0	0
Total	0	0	113	425	1009	511	113	0	0	0	0	0
Longfin Smelt												
< 5mm	0	5799	1136	0	0	0	0	NA	0	17	62	40
5 - 7 mm	47206	80459	51365	1249	170	0	0	NA	0	0	0	0
8 - 10 mm	24731	58130	36027	2690	323	0	0	NA	0	0	0	0
11 - 14 mm	0	4226	40671	7000	1126	0	0	NA	0	0	0	0
Total	71937	148614	129199	10938	1619	0	0	NA	0	17	62	40
Sacramento Splittail												
< 5mm	NA	NA	0	NA	0	NA	NA	NA	0	0	0	0
5 - 7 mm	NA	NA	60	NA	0	NA	NA	NA	0	0	0	0
8 - 10 mm	NA	NA	0	NA	0	NA	NA	NA	0	0	0	0
11 - 14 mm	NA	NA	0	NA	0	NA	NA	NA	0	0	0	0
Total	NA	NA	60	NA	0	NA	NA	NA	0	0	0	0
Starry Flounder												
<5mm	NA	NA	0	0	0	0	NA	0	0	0	NA	NA
5 - 7 mm	NA	NA	0	24	0	0	NA	0	0	0	NA	NA
8 - 10 mm	NA	NA	300	596	37	0	NA	0	0	0	NA	NA
11 - 14 mm	NA	NA	0	0	0	0	NA	0	0	0	NA	NA
Total	NA	NA	300	620	37	0	NA	0	0	0	NA	NA

Table 2-14 Number of larvae < 15mm in length potentially entrained at BARDP with positive barrier fish screen.

Fish Potentially Entrained	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Northern Anchovy												
<5mm	NA	0	0	NA	0	19	0	120	11	0	29	NA
5 - 7 mm	NA	0	575	NA	0	11	15	0	0	0	0	NA
8 - 10 mm	NA	0	0	NA	24	36	35	0	0	0	0	NA
11 - 14 mm	NA	0	0	NA	0	48	48	0	0	0	0	NA
Total	NA	0	575	NA	24	113	98	120	11	0	29	NA
Delta Smelt												
< 5mm	0	0	0	0	0	0	0	0	0	0	0	0
5 - 7 mm	0	0	50	0	83	0	0	0	0	0	0	0
8 - 10 mm	0	0	0	0	70	34	0	0	0	0	0	0
11 - 14 mm	0	0	0	0	112	79	25	0	0	0	0	0
Total	0	0	50	0	266	113	25	0	0	0	0	0
Longfin Smelt												
< 5mm	0	5799	1136	0	0	0	0	NA	0	17	62	40
5 - 7 mm	21007	35804	22857	0	76	0	0	0	0	0	0	0
8 - 10 mm	5490	12905	7998	0	72	0	0	0	0	0	0	0
11 - 14 mm	0	938	9029	0	250	0	0	0	0	0	0	0
Total	26497	55446	41020	0	397	0	0	0	0	17	62	40
Sacramento Splittail												
< 5mm	NA	NA	0	NA	0	NA	NA	NA	0	0	0	0
5 - 7 mm	NA	NA	27	NA	0	NA	NA	NA	0	0	0	0
8 - 10 mm	NA	NA	0	NA	0	NA	NA	NA	0	0	0	0
11 - 14 mm	NA	NA	0	NA	0	NA	NA	NA	0	0	0	0
Total	NA	NA	27	NA	0	NA	NA	NA	0	0	0	0
Starry Flounder												
<5mm	NA	NA	0	0	0	0	NA	0	0	0	NA	NA
5 - 7 mm	NA	NA	0	0	0	0	NA	0	0	0	NA	NA
8 - 10 mm	NA	NA	67	0	8	0	NA	0	0	0	NA	NA
11 - 14 mm	NA	NA	0	0	0	0	NA	0	0	0	NA	NA
Total	NA	NA	67	0	8	0	NA	0	0	0	NA	NA

2.13 Appendix 2-B: PTM Entrainment Results at BARDP

Table 2-15 Percent of particles entrained at BARDP 30 days after release from specified node and release date

Release Node	359	367	238	358	356	465	227	463	365	357	354	467
January-75	0.02	0.00	0.05	0.04	0.18	0.16	0.10	0.12	0.00	0.16	0.11	0.10
February-75	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.02	0.00	0.01	0.02	0.02
March-75	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.02	0.01	0.01
April-75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-75	0.00	0.00	0.00	0.00	0.02	0.02	0.01	0.03	0.00	0.02	0.04	0.05
June-75	0.00	0.00	0.00	0.00	0.08	0.09	0.02	0.07	0.00	0.05	0.07	0.05
July-75	0.01	0.00	0.03	0.03	0.15	0.15	0.08	0.12	0.01	0.14	0.14	0.06
August-75	0.01	0.00	0.06	0.07	0.17	0.16	0.12	0.14	0.02	0.19	0.14	0.05
September-75	0.00	0.00	0.01	0.02	0.07	0.07	0.04	0.05	0.00	0.06	0.08	0.05
October-75	0.02	0.00	0.05	0.03	0.15	0.16	0.11	0.14	0.01	0.14	0.13	0.06
November-75	0.01	0.00	0.01	0.03	0.09	0.10	0.05	0.08	0.00	0.05	0.08	0.07
December-75	0.03	0.00	0.05	0.06	0.15	0.15	0.11	0.11	0.02	0.15	0.12	0.07
January-76	0.02	0.00	0.07	0.07	0.16	0.15	0.10	0.14	0.00	0.16	0.16	0.08
February-76	0.02	0.00	0.06	0.05	0.20	0.16	0.15	0.14	0.01	0.15	0.14	0.08
March-76	0.00	0.00	0.02	0.05	0.15	0.15	0.07	0.15	0.00	0.13	0.16	0.11
April-76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-76	0.02	0.00	0.06	0.07	0.20	0.17	0.14	0.16	0.01	0.18	0.14	0.08
June-76	0.02	0.00	0.07	0.03	0.17	0.16	0.12	0.15	0.01	0.18	0.15	0.08
July-76	0.02	0.00	0.06	0.06	0.15	0.18	0.18	0.13	0.01	0.18	0.09	0.08
August-76	0.02	0.00	0.06	0.06	0.19	0.17	0.13	0.18	0.01	0.16	0.14	0.10
September-76	0.04	0.01	0.08	0.07	0.18	0.18	0.17	0.17	0.01	0.18	0.15	0.07
October-76	0.01	0.00	0.08	0.05	0.20	0.19	0.16	0.15	0.01	0.17	0.11	0.08
November-76	0.05	0.02	0.13	0.08	0.16	0.17	0.17	0.13	0.04	0.21	0.08	0.05
December-76	0.03	0.01	0.06	0.05	0.15	0.16	0.17	0.14	0.01	0.20	0.11	0.07
January-77	0.02	0.00	0.06	0.06	0.15	0.16	0.11	0.13	0.01	0.15	0.11	0.08
February-77	0.01	0.00	0.07	0.06	0.17	0.19	0.10	0.16	0.02	0.16	0.14	0.10
March-77	0.01	0.00	0.08	0.04	0.19	0.20	0.11	0.15	0.01	0.15	0.15	0.14
April-77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-77	0.04	0.01	0.05	0.06	0.20	0.17	0.15	0.15	0.02	0.17	0.17	0.13
June-77	0.05	0.01	0.04	0.08	0.18	0.17	0.09	0.15	0.01	0.15	0.15	0.12
July-77	0.02	0.00	0.05	0.05	0.18	0.17	0.10	0.18	0.01	0.13	0.17	0.12
August-77	0.02	0.00	0.07	0.07	0.18	0.22	0.13	0.16	0.01	0.20	0.14	0.10
September-77	0.02	0.02	0.07	0.06	0.23	0.22	0.14	0.17	0.01	0.21	0.14	0.10
October-77	0.03	0.01	0.08	0.09	0.20	0.21	0.16	0.15	0.03	0.20	0.10	0.08
November-77	0.04	0.01	0.07	0.09	0.18	0.18	0.19	0.12	0.01	0.20	0.09	0.06

Release Node	359	367	238	358	356	465	227	463	365	357	354	467
December-77	0.01	0.00	0.05	0.04	0.18	0.17	0.10	0.12	0.00	0.15	0.11	0.07
January-78	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.02	0.00	0.02	0.02	0.02
February-78	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.00	0.02	0.01	0.01
March-78	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.02	0.00	0.01	0.02	0.01
April-78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-78	0.00	0.00	0.00	0.00	0.05	0.05	0.02	0.05	0.00	0.03	0.07	0.05
June-78	0.00	0.00	0.02	0.01	0.10	0.10	0.06	0.10	0.00	0.08	0.12	0.10
July-78	0.02	0.00	0.05	0.04	0.16	0.14	0.09	0.12	0.00	0.09	0.14	0.08
August-78	0.02	0.00	0.06	0.07	0.18	0.17	0.10	0.15	0.01	0.17	0.14	0.08
September-78	0.01	0.00	0.02	0.03	0.13	0.15	0.06	0.13	0.00	0.08	0.13	0.09
October-78	0.04	0.01	0.07	0.06	0.16	0.17	0.16	0.19	0.01	0.17	0.12	0.09
November-78	0.02	0.00	0.04	0.05	0.11	0.13	0.08	0.14	0.00	0.12	0.14	0.10
December-78	0.01	0.00	0.04	0.06	0.16	0.16	0.08	0.16	0.01	0.14	0.13	0.07
January-79	0.00	0.00	0.01	0.02	0.06	0.08	0.04	0.05	0.00	0.07	0.05	0.06
February-79	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.03	0.00	0.02	0.06	0.05
March-79	0.00	0.00	0.00	0.00	0.04	0.04	0.01	0.04	0.00	0.02	0.05	0.04
April-79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-79	0.00	0.00	0.00	0.00	0.07	0.06	0.02	0.08	0.00	0.05	0.06	0.09
June-79	0.01	0.00	0.03	0.04	0.17	0.21	0.07	0.17	0.00	0.13	0.15	0.12
July-79	0.01	0.00	0.05	0.05	0.16	0.21	0.14	0.13	0.01	0.17	0.12	0.06
August-79	0.04	0.01	0.07	0.09	0.20	0.17	0.15	0.14	0.02	0.17	0.13	0.05
September-79	0.03	0.01	0.07	0.06	0.20	0.18	0.15	0.15	0.01	0.18	0.12	0.06
October-79	0.04	0.01	0.09	0.07	0.18	0.18	0.15	0.14	0.03	0.17	0.11	0.08
November-79	0.04	0.00	0.05	0.08	0.16	0.16	0.14	0.10	0.01	0.16	0.10	0.06
December-79	0.01	0.00	0.04	0.05	0.14	0.10	0.06	0.11	0.00	0.11	0.11	0.07
January-80	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00
February-80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March-80	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.01	0.00	0.01	0.01	0.01
April-80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-80	0.00	0.00	0.00	0.00	0.07	0.07	0.01	0.06	0.00	0.05	0.06	0.07
June-80	0.00	0.00	0.02	0.01	0.14	0.14	0.05	0.14	0.00	0.10	0.12	0.14
July-80	0.01	0.00	0.04	0.03	0.13	0.15	0.07	0.15	0.00	0.13	0.17	0.14
August-80	0.02	0.00	0.05	0.06	0.18	0.18	0.17	0.16	0.02	0.20	0.13	0.10
September-80	0.01	0.00	0.02	0.04	0.12	0.12	0.07	0.14	0.00	0.08	0.14	0.14
October-80	0.02	0.00	0.08	0.04	0.18	0.18	0.11	0.16	0.02	0.17	0.12	0.11
November-80	0.01	0.00	0.03	0.04	0.15	0.17	0.10	0.13	0.00	0.16	0.14	0.10
December-80	0.03	0.02	0.06	0.07	0.15	0.14	0.14	0.09	0.02	0.17	0.11	0.05

Release Node	359	367	238	358	356	465	227	463	365	357	354	467
January-81	0.00	0.00	0.00	0.02	0.07	0.07	0.02	0.06	0.00	0.05	0.07	0.06
February-81	0.00	0.00	0.01	0.01	0.06	0.05	0.03	0.07	0.00	0.05	0.06	0.07
March-81	0.00	0.00	0.00	0.00	0.05	0.06	0.01	0.07	0.00	0.03	0.06	0.06
April-81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-81	0.01	0.00	0.02	0.03	0.15	0.14	0.07	0.15	0.00	0.10	0.13	0.11
June-81	0.02	0.00	0.04	0.05	0.15	0.15	0.06	0.14	0.00	0.11	0.14	0.12
July-81	0.01	0.00	0.03	0.04	0.15	0.15	0.08	0.11	0.01	0.12	0.13	0.07
August-81	0.02	0.00	0.06	0.06	0.18	0.19	0.11	0.14	0.01	0.15	0.13	0.05
September-81	0.01	0.00	0.06	0.06	0.20	0.21	0.18	0.16	0.02	0.22	0.14	0.08
October-81	0.05	0.02	0.09	0.07	0.20	0.18	0.20	0.13	0.02	0.17	0.09	0.08
November-81	0.00	0.00	0.00	0.01	0.05	0.04	0.01	0.05	0.00	0.04	0.06	0.05
December-81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00
January-82	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.02
February-82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00
March-82	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.02	0.01
April-82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-82	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.01	0.00	0.01	0.01	0.01
June-82	0.00	0.00	0.00	0.00	0.05	0.07	0.01	0.05	0.00	0.05	0.06	0.07
July-82	0.01	0.00	0.02	0.03	0.15	0.14	0.08	0.13	0.00	0.10	0.15	0.12
August-82	0.02	0.00	0.06	0.06	0.15	0.16	0.12	0.16	0.02	0.13	0.13	0.08
September-82	0.00	0.00	0.01	0.02	0.08	0.08	0.04	0.09	0.00	0.05	0.06	0.10
October-82	0.00	0.00	0.01	0.01	0.08	0.09	0.06	0.10	0.00	0.06	0.12	0.08
November-82	0.00	0.00	0.00	0.00	0.03	0.02	0.02	0.03	0.00	0.01	0.04	0.03
December-82	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.01
January-83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
February-83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March-83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April-83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.01
June-83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.01
July-83	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.02	0.00	0.03	0.04	0.05
August-83	0.00	0.00	0.01	0.01	0.08	0.07	0.03	0.07	0.00	0.06	0.10	0.09
September-83	0.00	0.00	0.00	0.00	0.05	0.05	0.02	0.05	0.00	0.04	0.05	0.06
October-83	0.00	0.00	0.01	0.01	0.09	0.10	0.03	0.10	0.00	0.07	0.09	0.07
November-83	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.01	0.02	0.01
December-83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
January-84	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.02	0.00	0.01	0.01	0.01

Release Node	359	367	238	358	356	465	227	463	365	357	354	467
February-84	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.02	0.00	0.01	0.04	0.06
March-84	0.00	0.00	0.00	0.00	0.02	0.03	0.00	0.04	0.00	0.01	0.04	0.06
April-84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-84	0.00	0.00	0.01	0.03	0.10	0.10	0.04	0.09	0.00	0.08	0.10	0.08
June-84	0.01	0.00	0.03	0.03	0.15	0.15	0.07	0.13	0.00	0.09	0.15	0.12
July-84	0.02	0.00	0.01	0.04	0.12	0.09	0.05	0.12	0.00	0.10	0.09	0.09
August-84	0.01	0.00	0.05	0.05	0.19	0.15	0.13	0.14	0.02	0.14	0.13	0.08
September-84	0.00	0.00	0.01	0.02	0.05	0.07	0.04	0.07	0.00	0.07	0.06	0.05
October-84	0.01	0.00	0.02	0.02	0.15	0.18	0.08	0.18	0.00	0.13	0.16	0.13
November-84	0.00	0.00	0.00	0.01	0.07	0.08	0.05	0.06	0.00	0.07	0.07	0.08
December-84	0.00	0.00	0.02	0.03	0.11	0.10	0.05	0.10	0.00	0.10	0.07	0.05
January-85	0.01	0.00	0.04	0.05	0.14	0.15	0.09	0.12	0.00	0.13	0.10	0.08
February-85	0.01	0.00	0.02	0.03	0.13	0.12	0.07	0.12	0.00	0.09	0.11	0.09
March-85	0.00	0.00	0.02	0.01	0.11	0.12	0.04	0.13	0.00	0.07	0.12	0.12
April-85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-85	0.01	0.00	0.02	0.03	0.12	0.12	0.05	0.14	0.00	0.12	0.16	0.12
June-85	0.02	0.00	0.03	0.05	0.17	0.17	0.06	0.14	0.01	0.11	0.15	0.12
July-85	0.03	0.00	0.04	0.04	0.16	0.15	0.05	0.12	0.00	0.10	0.13	0.08
August-85	0.02	0.00	0.06	0.05	0.15	0.18	0.10	0.11	0.01	0.15	0.13	0.06
September-85	0.02	0.00	0.06	0.08	0.20	0.19	0.15	0.14	0.02	0.19	0.13	0.08
October-85	0.04	0.01	0.09	0.07	0.18	0.18	0.19	0.15	0.03	0.17	0.08	0.06
November-85	0.03	0.00	0.08	0.06	0.18	0.17	0.10	0.10	0.02	0.16	0.09	0.06
December-85	0.02	0.00	0.04	0.05	0.13	0.12	0.08	0.11	0.00	0.10	0.12	0.07
January-86	0.00	0.00	0.00	0.01	0.08	0.07	0.03	0.07	0.00	0.05	0.06	0.05
February-86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March-86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April-86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-86	0.00	0.00	0.00	0.00	0.05	0.04	0.01	0.06	0.00	0.04	0.06	0.06
June-86	0.00	0.00	0.02	0.02	0.14	0.11	0.06	0.15	0.00	0.10	0.12	0.14
July-86	0.01	0.00	0.05	0.04	0.15	0.13	0.10	0.11	0.00	0.11	0.14	0.06
August-86	0.01	0.00	0.05	0.04	0.15	0.20	0.11	0.18	0.02	0.15	0.18	0.08
September-86	0.00	0.00	0.01	0.01	0.07	0.07	0.03	0.07	0.00	0.07	0.10	0.08
October-86	0.02	0.00	0.03	0.05	0.15	0.18	0.12	0.15	0.00	0.15	0.12	0.12
November-86	0.01	0.00	0.04	0.04	0.10	0.11	0.07	0.10	0.00	0.10	0.09	0.11
December-86	0.03	0.00	0.05	0.05	0.17	0.13	0.08	0.13	0.01	0.13	0.10	0.06
January-87	0.02	0.00	0.01	0.04	0.10	0.10	0.05	0.15	0.00	0.07	0.13	0.09
February-87	0.01	0.00	0.02	0.02	0.10	0.10	0.05	0.09	0.00	0.07	0.09	0.07

Release Node	359	367	238	358	356	465	227	463	365	357	354	467
March-87	0.00	0.00	0.00	0.01	0.06	0.07	0.02	0.06	0.00	0.06	0.06	0.04
April-87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-87	0.01	0.00	0.02	0.02	0.15	0.19	0.08	0.12	0.00	0.11	0.15	0.10
June-87	0.02	0.00	0.04	0.04	0.15	0.18	0.07	0.16	0.00	0.12	0.13	0.11
July-87	0.01	0.00	0.04	0.04	0.17	0.17	0.09	0.11	0.00	0.14	0.10	0.05
August-87	0.04	0.00	0.06	0.07	0.16	0.13	0.12	0.11	0.02	0.18	0.10	0.07
September-87	0.04	0.00	0.07	0.05	0.19	0.15	0.12	0.17	0.01	0.14	0.16	0.11
October-87	0.03	0.00	0.07	0.05	0.17	0.16	0.12	0.15	0.03	0.17	0.12	0.08
November-87	0.02	0.00	0.07	0.06	0.15	0.15	0.15	0.14	0.02	0.17	0.13	0.06
December-87	0.02	0.00	0.05	0.05	0.10	0.10	0.06	0.09	0.00	0.09	0.07	0.08
January-88	0.00	0.00	0.00	0.02	0.04	0.04	0.01	0.04	0.00	0.04	0.05	0.03
February-88	0.01	0.00	0.03	0.03	0.14	0.14	0.06	0.15	0.00	0.09	0.16	0.12
March-88	0.00	0.00	0.03	0.01	0.18	0.15	0.04	0.12	0.00	0.09	0.15	0.18
April-88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-88	0.02	0.00	0.04	0.06	0.17	0.11	0.08	0.17	0.01	0.13	0.16	0.08
June-88	0.01	0.00	0.01	0.03	0.13	0.17	0.06	0.15	0.00	0.10	0.20	0.11
July-88	0.02	0.00	0.04	0.05	0.19	0.17	0.08	0.15	0.01	0.10	0.15	0.08
August-88	0.02	0.00	0.07	0.08	0.19	0.19	0.17	0.15	0.02	0.23	0.13	0.07
September-88	0.04	0.01	0.08	0.07	0.18	0.19	0.14	0.16	0.02	0.16	0.12	0.09
October-88	0.04	0.01	0.07	0.07	0.21	0.15	0.15	0.16	0.01	0.18	0.11	0.07
November-88	0.02	0.00	0.07	0.03	0.18	0.16	0.15	0.12	0.02	0.18	0.10	0.07
December-88	0.01	0.00	0.06	0.05	0.16	0.13	0.17	0.13	0.01	0.19	0.08	0.06
January-89	0.03	0.00	0.04	0.07	0.12	0.15	0.09	0.11	0.00	0.12	0.13	0.08
February-89	0.01	0.00	0.03	0.03	0.14	0.14	0.09	0.15	0.00	0.10	0.14	0.11
March-89	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.01	0.00	0.01	0.02	0.02
April-89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-89	0.00	0.00	0.02	0.02	0.16	0.13	0.08	0.14	0.00	0.10	0.11	0.10
June-89	0.04	0.01	0.04	0.07	0.15	0.17	0.07	0.14	0.00	0.13	0.15	0.11
July-89	0.02	0.00	0.05	0.04	0.14	0.13	0.07	0.13	0.00	0.11	0.13	0.07
August-89	0.02	0.00	0.04	0.06	0.15	0.17	0.10	0.14	0.01	0.13	0.11	0.07
September-89	0.02	0.00	0.08	0.06	0.22	0.17	0.15	0.17	0.01	0.20	0.15	0.06
October-89	0.04	0.00	0.06	0.09	0.18	0.16	0.19	0.12	0.02	0.18	0.09	0.07
November-89	0.02	0.00	0.04	0.04	0.17	0.16	0.07	0.14	0.00	0.15	0.15	0.10
December-89	0.04	0.00	0.06	0.05	0.15	0.15	0.11	0.10	0.01	0.15	0.09	0.07
January-90	0.00	0.00	0.01	0.03	0.11	0.11	0.05	0.10	0.00	0.08	0.10	0.07
February-90	0.00	0.00	0.02	0.03	0.12	0.15	0.07	0.11	0.00	0.12	0.13	0.11
March-90	0.01	0.00	0.02	0.05	0.11	0.13	0.06	0.13	0.00	0.11	0.14	0.12

Release Node	**359**	**367**	**238**	**358**	**356**	**465**	**227**	**463**	**365**	**357**	**354**	**467**
April-90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-90	0.01	0.00	0.06	0.04	0.19	0.17	0.08	0.17	0.00	0.14	0.13	0.10
June-90	0.01	0.00	0.06	0.08	0.16	0.18	0.16	0.14	0.03	0.17	0.14	0.08
July-90	0.02	0.00	0.05	0.08	0.16	0.17	0.15	0.10	0.02	0.15	0.13	0.05
August-90	0.02	0.00	0.05	0.05	0.17	0.19	0.08	0.16	0.01	0.15	0.15	0.10
September-90	0.03	0.01	0.10	0.06	0.19	0.21	0.15	0.15	0.02	0.20	0.11	0.09
October-90	0.04	0.02	0.11	0.06	0.16	0.16	0.15	0.13	0.02	0.21	0.08	0.08
November-90	0.03	0.00	0.06	0.09	0.15	0.16	0.15	0.12	0.02	0.15	0.12	0.09
December-90	0.04	0.00	0.04	0.07	0.17	0.16	0.11	0.12	0.01	0.14	0.12	0.08
January-91	0.02	0.00	0.03	0.06	0.13	0.14	0.08	0.13	0.00	0.10	0.13	0.11
February-91	0.03	0.00	0.05	0.06	0.18	0.20	0.13	0.15	0.01	0.17	0.16	0.10
March-91	0.00	0.00	0.00	0.00	0.03	0.03	0.01	0.05	0.00	0.02	0.03	0.03
April-91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-91	0.02	0.00	0.04	0.03	0.16	0.14	0.06	0.19	0.00	0.12	0.17	0.10
June-91	0.02	0.00	0.07	0.05	0.17	0.16	0.09	0.16	0.01	0.16	0.14	0.06
July-91	0.02	0.00	0.06	0.06	0.20	0.17	0.13	0.12	0.02	0.16	0.10	0.06
August-91	0.03	0.00	0.08	0.09	0.17	0.18	0.14	0.15	0.01	0.16	0.13	0.08
Average	0.01	0.00	0.03	0.03	0.11	0.11	0.07	0.10	0.01	0.10	0.09	0.07
Max	0.05	0.02	0.13	0.09	0.23	0.22	0.20	0.19	0.04	0.23	0.20	0.18

3 Conjunctive Operation of the BARDP with Los Vaqueros Reservoir

3.1 Executive Summary

Contra Costa Water District undertook modeling studies to analyze the use of Los Vaqueros storage in conjunction with BARDP operations. BARDP plant production exceeds partner demands in non-drought years but falls short of the higher combined partner demands in drought years. Interannual storage of BARDP water increases the amount of water available to meet dry year partner demands. The excess BARDP production can be stored in Los Vaqueros Reservoir in non-drought years through an exchange with CCWD, and the stored BARDP water can be released from Los Vaqueros Reservoir in drought years. Only 54% of drought year partner demands can be met without storage. Under current EBMUD system limitations on timing and flow rates, 71% of drought year demands can be met with the use of interannual storage in the 160 TAF Los Vaqueros Reservoir. Pre-treatment of releases from storage, to make that water compatible with EBMUD's in-line water treatment plants, could increase the amount of drought year demands met to 84%. This study does not make any assumptions as to how water is allocated among the partners during shortages. It is expected that the allotment of water during shortages would be negotiated if the BARDP partnership continues forward.

Cost estimates were also provided for BARDP's use of Mallard Slough Pump Station and Los Vaqueros Reservoir. The cost estimation approach is composed of a capital recovery component and a reimbursement of fixed and variable operation and maintenance (O&M) costs, taking into consideration both CCWD's additional costs and avoided costs. The preliminary cost estimate for BARDP use of the Mallard Slough Pump Station and associated water rights is approximately $86-121/AF. The preliminary cost estimate for BARDP use of storage in Los Vaqueros Reservoir, based on this annual cost model is approximately $70-105/AF per year. Delivery of water from Los Vaqueros storage into the EBMUD system through the existing raw water intertie is approximately $16/AF; this does not include EBMUD's costs for wheeling water through their system for final delivery to the other BARDP partners.

3.2 Background

Following the approach described in the February 2012 Technical Memorandum Contra Costa Water District (CCWD) modeled and analyzed the use of storage in Los Vaqueros Reservoir (LV) in conjunction with the proposed Bay Area Regional Desalination Project (BARDP) operations. Proposed BARDP plant production exceeds partner demands in non-drought years. Interannual storage of BARDP water increases dry year water deliveries from the project by increasing the amount of water available to meet dry year partner demands. The modeling performed defines a suite of potential operations and estimates the timing and quantity of water available for partners from the BARDP by incorporating the conjunctive operation of CCWD's Los Vaqueros Reservoir. The total amount of water received by partners depends on: 1) the availability of storage, 2) the timing of demands relative to production, 3) CCWD and EBMUD system conveyance constraints, and 4) source water quality. CCWD's cost estimation for BARDP use of CCWD facilities was also developed.

3.3 Modeling Assumptions

The proposed BARDP would divert source water through CCWD's Mallard Slough Pump Station, at a capacity of 39.3 cubic feet per second (cfs), or 25 million gallons per day (MGD). Diversions are assumed to occur for 11 months each year, for an annual diversion of 26.1 thousand acre-feet per year (TAF/yr), since CCWD's permits do not allow Delta diversions at any of its intakes during the month of April unless storage in Los Vaqueros Reservoir is at or below emergency levels. Based on results from the BARDP pilot test plant[24], an 80% recovery rate from the desalination process is assumed, for a maximum annual BARDP production capacity of 20.9 TAF/yr, or 20 MGD.

3.3.1 Regional Desalination Project Capacity

CCWD has two water rights at Mallard Slough: Water Right License 10514 authorizes diversion of 14.88 TAF/yr, and Water Right Permit 19856 authorizes diversion of 11.9 TAF/yr, for a total of 26.78 TAF/yr. CCWD's Mallard Slough permit is subject to limitations under Water Rights Standard Permit Term 91 that may prevent diversion of the full 26.78 TAF/yr in some years, assuming all diversions are made under CCWD's Mallard Slough license and permit. However, based on the historical record since 1984, BARDP diversions under CCWD's Mallard Slough permit could be curtailed for only a few weeks in August in the years that Term 91 is invoked, with an average shortfall over the historical record of 1.8 TAF/yr. Diversions under other existing water right permits or licenses could be used to meet any shortfalls caused by Term 91.

The modeling summarized in this report assumes 25 MGD of source water is available, and does not specify the source water supply to the BARDP facility (e.g., CCWD water right, new water right, or transfer water). The project has a stated goal of 20 MGD of plant production. Modeling the maximum diversion will provide an upward limit of the potential water supply benefit to the project partners as well as of the potential impacts the BARDP could have on water quality and fisheries; this is intended to be useful for any future environmental impact analysis.

3.3.2 Partner Demand

The time series of partner demands for BARDP water, corresponding to the standard 82-year hydrology beginning in 1922 and commonly used in the CalSim II planning horizon, are summarized in Figure 3-1. Demands were provided by the BARDP partner agencies (Zone 7, SFPUC, SCVWD, EBMUD, and CCWD) and have been revised since the February 2012 Technical Memorandum. The annual demands are applied to each water year, beginning in October of the previous year.

SFPUC and Zone 7 estimate a demand for BARDP water every year, creating a minimum BARDP partner demand of 15.7 TAF/yr in all years. EBMUD, SCVWD, and CCWD demands for BARDP water would occur less frequently and are based on water year type and other

[24] BARDP Pilot Testing at Mallard Slough, Pilot Plant Engineering Report, June 2010.

factors, creating a maximum demand up to 51.5 TAF/yr in some drought years. For the purposes of this discussion, "drought" refers to years in which one or more of EBMUD, SCVWD, or CCWD have a demand for BARDP water. Since BARDP production is 20.9 TAF/year, SFPUC and Zone 7's demand can be fully met in non-drought years. In drought years, the full partner demand cannot be met with BARDP production alone, but unused production stored via exchange in Los Vaqueros Reservoir during non-drought years (at a maximum rate of 5.2 TAF/year) could be used to augment deliveries to partners in drought years. The total partner demand over the 82 modeled years is 1,754 TAF, while the maximum BARDP production is 1,714 TAF; therefore, at most 98% of partner demand can be met. The 98% is an upper limit that assumes all excess production can be stored in Los Vaqueros Reservoir. The amount of excess plant production that can be stored over the longer non-drought periods is limited by reservoir capacity and reduces the percent of partner demand that can be met.

If BARDP production capacity does not exceed non-drought year partner demand there is no opportunity to store water for use by partners during droughts. This situation would arise if a smaller plant is constructed or if partners have larger non-drought demands. This analysis assumes that up to 5.2 TAF/year will be produced by the desalination facility in excess of partner demands, and that water will be available to store in LV via exchange with CCWD.

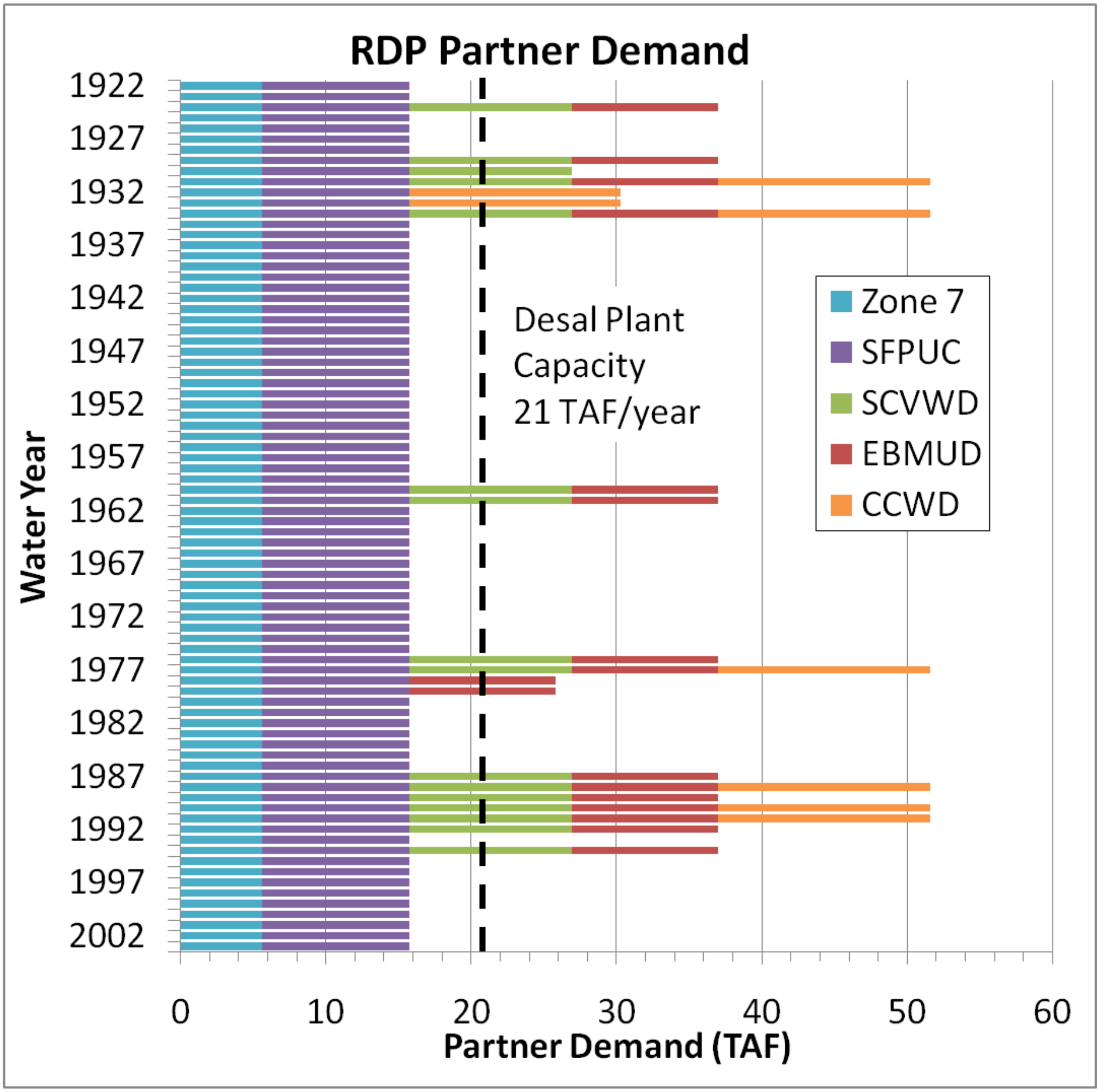


Figure 3-1. Partner Demand for BARDP Water

3.3.3 Los Vaqueros Reservoir and CCWD Operations

The original Los Vaqueros Reservoir project was completed in 1997 to improve the quality of water delivered to CCWD customers, protect sensitive fish species by enabling CCWD to limit Delta diversions during certain times of year, and to provide emergency storage for CCWD. The primary operating objective of Los Vaqueros Reservoir is to improve the water quality delivered to CCWD customers. In winter and spring, when the Delta is relatively fresh (generally January through July), CCWD diverts water from the Delta to meet customer demand directly and also stores low salinity water in Los Vaqueros Reservoir. In the late summer and fall months, CCWD releases water from the Los Vaqueros Reservoir to blend with higher-salinity direct diversions from the Delta to meet CCWD water quality goals.

CCWD operates in a manner consistent with Biological Opinions from the U.S. Fish and Wildlife Service (USFWS) and from the National Marine Fisheries Service (NMFS), and consistent with CCWD's Incidental Take Permit from the California Department of Fish and Wildlife (CDFW). These permits require fish protection measures, including an annual 75 to 90-day "no-fill" period, during which no diversions to storage are made, and a concurrent 30-day "no-diversion" period, during which no Delta diversions are made unless storage in Los Vaqueros Reservoir is at or below emergency levels. Customer demand during the no-diversion period is met through releases from LV. The default dates for the no-fill and no-diversion periods are March 15 through May 31 and April 1 through April 30, respectively, with an additional 0-15 days of no-fill from February 14 through February 28, depending upon storage level in Los Vaqueros Reservoir on February 1; USFWS, NMFS, and CDFW can change these dates to best protect covered species.

CCWD recently completed a project to expand the capacity of Los Vaqueros Reservoir from 100 TAF to 160 TAF. Future expansion of the reservoir to 275 TAF or 500 TAF for the benefit of regional partners is currently being studied by CCWD and the Bureau of Reclamation.

3.3.4 EBMUD System Constraints

SFPUC, Zone 7, and SCVWD's shares of BARDP water, whether in the form of direct deliveries from the BARDP plant or of releases from LV storage, all must be wheeled through the EBMUD conveyance system. EBMUD's hydraulic modeling found that it was feasible to wheel up to 30 MGD through their system for delivery to SFPUC, Zone 7, and SCVWD in most circumstances. When EBMUD system demands are high, wheeling capacity to the Hayward intertie is limited, on average to 10 MGD or less for 20 days of the year and to 20 MGD for an additional 16 days a year. This hydraulic modeling assumed meeting EBMUD 2040 demands, and since EBMUD BARDP demand is included in that baseline, there are no wheeling constraints in the EBMUD system for moving EBMUD's share of BARDP water. No EBMUD facilities are used to deliver CCWD its share of BARDP water, so EBMUD's wheeling constraints also do not limit deliveries to CCWD.

There are also EBMUD system limitations on delivery of water from LV storage to the BARDP partners (except CCWD). EBMUD's primary water source from Pardee Reservoir in the Sierra foothills does not require conventional filtration, and for most of the year EBMUD only operates their in-line water treatment plants, which cannot process water from the Delta. Water produced at the BARDP plant can be conveyed to the in-line treatment plants, but BARDP water from Los Vaqueros Reservoir is Delta water and would need to be conveyed to EBMUD's conventional filtration treatment facilities. EBMUD can only accommodate releases from BARDP storage in years when they are already treating Delta water from their Freeport water supply. EBMUD diverts its CVP contract supply through the Freeport intake, and diversions under their CVP contract are only allowed during dry years, which are assumed to coincide with the years EBMUD specified a drought demand for BARDP water.

EBMUD and CCWD have an existing intertie between EBMUD's Mokelumne Aqueduct #2 and CCWD's Los Vaqueros Pipeline, which can be used to deliver stored BARDP water to EBMUD when EBMUD has a drought demand for BARDP water. The capacity in Mokelumne Aqueduct #2 not taken up by EBMUD's Freeport diversions can be used for BARDP deliveries. Based on

EBMUD system constraints, deliveries from Los Vaqueros Reservoir can be made through the Mokelumne/ LV Pipeline intertie during drought years for a maximum of six months within three consecutive CVP contract years (the CVP contract year goes from March through February). The delivery can occur from July through October during the first year of a drought and from May through October in subsequent years of a drought, and at a maximum delivery rate of 45 MGD (approximately 70 cfs).

3.3.5 Modeled Scenarios

CCWD modeled eight scenarios, grouped into three categories, as summarized in Table 3-1. The 'No Storage' scenario (SY1) does not include storage of BARDP water in Los Vaqueros Reservoir. The 'Fixed Share of Storage' scenarios (SY2) store BARDP water in three different fixed shares of storage (15, 30, and 45 TAF) within the existing 160 TAF Los Vaqueros Reservoir. The 'Flexible Share of Storage' scenarios (SY3) stores BARDP water more flexibly in three different sizes of Los Vaqueros Reservoir, at the existing 160 TAF and potential further expansions to 275 and 500 TAF.

The flexible storage scenarios allow an integration of BARDP and CCWD storage operations by allowing an exchange of stored water between the BARDP and CCWD to improve overall reservoir performance. The flexible storage scenarios do not dedicate a fixed volume of storage to the BARDP, instead allowing partners to maximize storage contributions during non-drought years. Similarly, when storage is depleted during sequential drought years, partners can borrow on credit stored water from CCWD if supply is available.

An additional run (SY3_160lim) operates under the same rules as SY3_160, the flexible storage run with Los Vaqueros Reservoir capacity of 160 TAF, with the addition of EBMUD system constraints on receiving water from LV storage, in order to quantify the effects of the EBMUD limitations on project yield. All of the other runs in this study only consider CCWD system limitations on the delivery of BARDP water.

Figure 3-2 is a map of the major facilities whose operations are modeled in this analysis.

Table 3-1. Summary of Model Runs

Category	Scenario Name	Los Vaqueros Reservoir Capacity	Partner Share of Storage	Delivery Method
No Storage	SY1	Not applicable	Not applicable	BARDP/Mokelumne Aqueduct Connection
Fixed Share of Storage	SY2_15	160 TAF	15 TAF fixed share	BARDP/Mokelumne Aqueduct Connection & LV/MokelumneAqueduct Intertie
	SY2_30		30 TAF fixed share	
	SY2_45		45 TAF fixed share	
Flexible Share of Storage	SY3_160	160 TAF	Variable share	
	SY3_160lim	160 TAF		
	SY3_275	275 TAF		
	SY3_500	500 TAF		

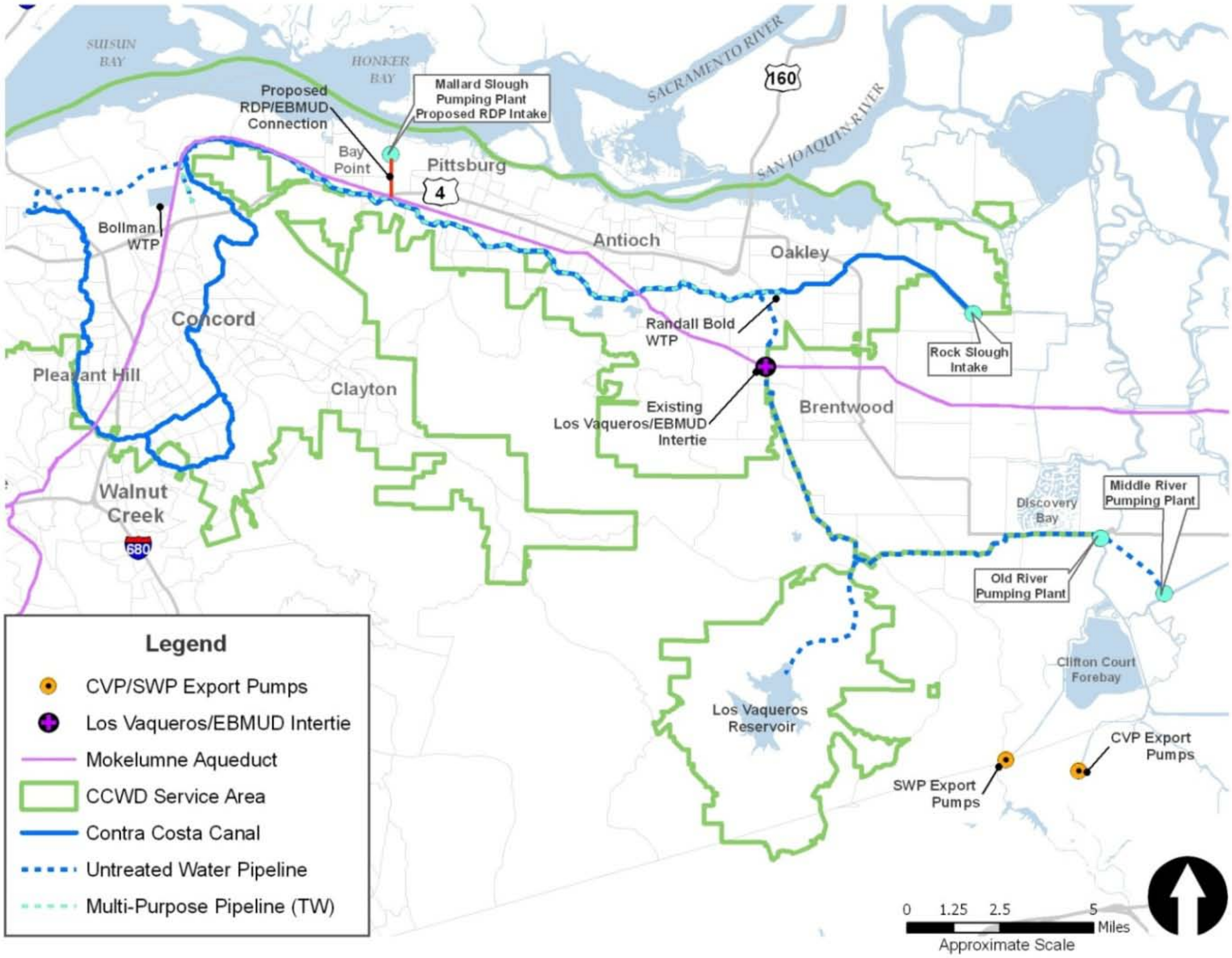


Figure 3-2. Major facilities either modeled directly or mentioned in the proposed BARDP Los Vaqueros Reservoir storage analysis.

In SY1, the without-storage scenario, deliveries to BARDP partners (except for CCWD) are only made via a direct connection between the desalination plant at Mallard Slough and EBMUD's Mokelumne Aqueduct #3. Deliveries to CCWD are made directly from the desalination plant into CCWD's treated water distribution system. BARDP production capacity in excess of the total partner demand in any given year goes unused.

In SY2 and SY3, the with-storage scenarios, deliveries to BARDP partners are made as in SY1 and also via the existing intertie between Los Vaqueros Pipeline and Mokelumne Aqueduct #2 (Los Vaqueros/EBMUD Intertie in Figure 3-2). BARDP production in excess of total partner demand in non-drought years can be stored in Los Vaqueros Reservoir through an exchange with CCWD. The excess production is delivered directly to CCWD's treated water service area using CCWD's conveyance facilities, and an equivalent amount of water is assigned to BARDP partner storage in LV. The total amount of BARDP partner storage in LV is limited, even in SY3, in order to avoid partner storage accumulating to encompass all of the capacity in LV during long non-drought periods. Note that CCWD does not need to be filling LV in order for water in LV to be assigned to BARDP partner storage. When partner demand is greater than BARDP production capacity in drought years, water is released from the BARDP partner storage in LV and delivered to the partners through the Mokelumne/ LV Pipeline intertie to meet the partner demand in excess of the BARDP production capacity, to the extent possible.

In SY2, the fixed storage scenario, releases are limited to the amount of water in the BARDP partner share of LV storage. In SY3, with flexible storage, releases to meet partner demands can be made up to an agreed upon limit as long as there is water available in LV, even if all of the previously-stored BARDP has already been depleted.. Under this scenario, CCWD can deliver water from LV storage to partners during drought years when supplies are available, and the BARDP can return that water to CCWD by refilling LV with unused plant production during the next non-drought period. Similarly, when BARDP storage is sufficient and there is no BARDP partner demand, CCWD can use water from BARDP storage and replace it during the next filling opportunity.

When the annual partner demand exceeds both the available BARDP production capacity and storage (or flexible storage limit, in SY3 scenarios), partner deliveries are less than the demand. The analysis does not make any assumptions as to how water is allocated among partners during shortages.

3.4 Model Results and Discussion

Table 3-2 summarizes the project yield from BARDP operations for the three model categories, and seven model scenarios, in terms of percentage of overall demand met. The percent of overall demand met is also presented by water year type and by partner agency in a summary table in Appendix 3-A. Figures depicting the time series of partner deliveries and storage in Los Vaqueros Reservoir for all of the model scenarios are included in Appendix 3-A.

In SY1, the without-storage scenario, all of the partner demands in non-drought years are met, but only a little over half (54%) of the drought year demands can be met; thus, only about three-quarters of the total partner demand over all the years (79%) can be met. This is the average amount of partner demand met over all years, since, even though the BARDP plant capacity is constant, the partner drought demand varies by year. Up to 81% of demand can be met in some drought years (when only EBMUD adds 10 TAF/year of demand), but in others only 41% of demand can be met (when CCWD, EBMUD, and SCVWD all specify a drought demand for a total of 36 TAF/year of demand in addition to the non-drought year demand).

As expected, incorporating storage in the operation of the BARDP increases the water supply to partners. Increasing the amount of fixed storage dedicated to the BARDP increases the partner deliveries in drought years, with a maximum of approximately 77% of drought year demands met with 45 TAF of fixed storage within the 160 TAF reservoir (SY2_45). With conjunctive operations where storage is flexibly used in LV for the benefit of both CCWD and BARDP, the project yield increases further to 84% of drought year demands met with the 160 TAF reservoir (SY3_160). Increasing the size of Los Vaqueros Reservoir from 160 TAF to 275 TAF or 500 TAF, with a flexible share of storage, further increases the percent of drought year partner demand met through the BARDP project to 93% and 100%, respectively. In SY3_160lim, EBMUD system limitations reduce both the window of time and the flow rate for releases of stored BARDP water through the Mokelumne/ LV Pipeline intertie, reducing the percent of drought year demand met to 71%.

The results are summarized in terms of the percentage of the total drought demand met over all the modeled years, as opposed to the percentage of drought demand met in each drought year. Any available partner storage (or flexible storage limit in the SY3 scenarios) is used to meet drought demand as it occurs, without reserving partner storage for possible use in the next year. Whether an individual partner could be allowed to defer delivery of drought supplies until another year by decreasing their individual agency drought demand in a particular year is beyond the scope of this analysis but is mentioned here as a possibility for further discussion. After partner storage is depleted during a multi-year drought, further demands during that drought can only be met directly from BARDP plant production, since partner storage can only be replenished in non-drought years.

All partner drought demands are met in SY3_500 because the model assumes that BARDP storage in LV is initially full at the beginning of each simulation. The storage modeling reflects a hypothetical 82-year planning window and not the first 82-years of actual project operations. For reference, the difference between non-drought year partner demand and plant capacity is about 5.2 TAF/year, so it would take just under 3 non-drought years to fill a 15 TAF fixed partner share of the reservoir and 8.7 non-drought years to fill a 45 TAF share of the reservoir.

Table 3-2. Summary of Project Yield

Category	Model Run	Average Annual Project Yield (TAF)	Percent of Overall Partner Demand Met	Average Annual Drought Yield (TAF)	Percent of Partner Drought Demand Met
No Storage	SY1	17	79%	21	54%
Fixed Storage	SY2_15	18	84%	25	64%
	SY2_30	19	87%	28	72%
	SY2_45	19	90%	30	77%
Variable Storage	SY3_160	20	93%	33	84%
	SY3_160lim	19	87%	28	71%
	SY3_275	21	97%	36	93%
	SY3_500	21	100%	39	100%

3.5 Discussion

In years when water stored in LV is used to meet partner demands, the model optimizes BARDP partner storage deliveries by making bulk releases in a schedule compatible with other CCWD system operating rules within the given year, up to the maximum Mokelumne/ LV Pipeline intertie capacity of 150 cfs (system limitations on EBMUD's side of the intertie impose the 70 cfs maximum intertie capacity used in SY3_160lim). Because all of the BARDP partners specify their demands as an annual quantity, the model seeks to deliver the stored BARDP water that will be needed in a given year to meet specified demands at the earliest available opportunity each year. This operation assumes EBMUD has sufficient flexibility to wheel water to the other partners on this schedule, or otherwise exchange the BARDP deliveries with local storage for short periods of time, and that the other partners have local storage or other flexibility within their systems to absorb the water when it is delivered. The CCWD system contains sufficient flexibility to allow some modifications to the delivery schedule (both timing and volume) without changing the project performance. The partners' annual demands can, for instance, be assumed to occur uniformly throughout the year or in some other specified pattern.

The flexibility within the CCWD system cannot make up for the reduced BARDP deliveries from LV storage due to EBMUD system limitations on accepting Delta water into their system. One solution would be to pre-treat releases from LV, to make that water compatible with EBMUD's in-line water treatment plants. Pre-treatment would provide additional flexibility for deliveries from LV into the EBMUD system and the benefit, in terms of increased yield, is the difference between the SY3_160 and SY3_160lim scenarios. With pre-treatment, partners could expect the percent of drought year partner demand met to increase from 71% to 84%.

As mentioned previously, when the annual partner demand exceeds both the available BARDP production capacity and storage (or flexible storage limit in the SY3 scenarios), deliveries to the partners are less than the demand. This analysis does not make any assumptions about how water is allocated among partners during shortages. It is expected that the allotment of water during shortages would be negotiated if the BARDP partnership continues forward. Possible options when demand exceeds supply include all partners receiving an equal percent reduction of their stated demand, all partners equally dividing the available supply, or only a subset of partners receiving water during drought years.

3.6 Preliminary Cost Estimation for BARDP use of CCWD Facilities

CCWD has estimated the cost for the Bay Area Regional Desalination Project's (BARDP) use of the Mallard Slough Pump Station (MSPS) and for storage in Los Vaqueros Reservoir. The analysis assumes that desalinated water produced in excess of partner demands would be conveyed from the desalination facility into CCWD's Multi-Purpose Pipeline (MPP). Through an exchange, CCWD would convey (or assign) an equal amount of water into Los Vaqueros Reservoir. When needed by partners, water would be released from Los Vaqueros and delivered to EBMUD's Mokelumne Aqueduct for further conveyance to project partners.

3.6.1 Conveyance and Storage Options

The conveyance and storage options being considered by the BARDP partners would involve the use of CCWD's Mallard Slough, Transfer, Old River, and Middle River pumping plants and CCWD's Old River, Transfer and Los Vaqueros pipelines, as well as storage in the expanded Los Vaqueros Reservoir (Figure 3-2). If the BARDP project incorporates storage in Los Vaqueros Reservoir, CCWD anticipates both additional and avoided costs as a result of the partnership. In general terms, the cost estimation approach is composed of a capital recovery component and a reimbursement of fixed and variable operation and maintenance (O&M) costs.

Additional Costs. There is no direct connection between CCWD's MSPS and the Los Vaqueros Reservoir; therefore, all water conveyed to storage would be through an exchange. CCWD would take BARDP water into its treated water distribution system and in exchange pump water from either its Old River or Middle River intakes through the Old River pipeline to the Transfer pump station. From Transfer, the exchange water would be pumped up to Los Vaqueros Reservoir through the Transfer pipeline.

Avoided Costs. As a result of receiving BARDP treated water, CCWD would avoid the cost of source water and pumping at one of its three intakes. In addition, because CCWD would receive treated water, variable treatment costs would be avoided.

Capital Recovery. The reimbursement of capital costs to the agency with ownership of facilities used would be achieved through a 'rental' fee or a 'buy-in' to specific shared facilities. A rental fee would be applied based on facility use, whereas a buy-in fee would allow partners to purchase a capacity right to specific facilities.

Fixed and Variable O&M. Examples of fixed O&M costs that might apply include labor, administrative costs, insurance and regulatory fees if applicable. Variable O&M at facilities being considered for use by the BARDP include the cost of water (CVP or other), power and fish monitoring activities.

3.6.2 Cost Estimate

Using the methodology described above, CCWD has developed a cost estimate for the BARDP use of the Mallard Slough Pump Station (MSPS), conveyance to Los Vaqueros storage, storage in Los Vaqueros and delivery from storage to the Mokelumne Aqueduct. The preliminary cost estimates were developed using methodology established in existing CCWD agreements for rental and use of facilities. Final costs would require further analysis and approval of CCWD's Board of Directors.

Mallard Slough Pump Station Component – CCWD completed rebuilding the Mallard Slough Pump Station in 2001 at an estimated cost of $13.1 million. The 2013 depreciated value of MSPS is approximately $12.9 million. The following calculations assume BARDP would use 100% of the MSPS facility. Table 3-3 provides an example of the cost calculation for the Mallard Slough Pump Station component.

Capital Recovery. The approximate rental fee is $6/acre-foot (AF) and the approximate wear and tear fee is $12/AF

Fixed and Variable O&M. Variable O&M costs at MSPS include water, power and fish monitoring. The October 2011 Wagner and Bonsignore Brackish Water Valuation Memo estimated the water value at MSPS to range from $23 to $58/AF. Power and fish monitoring costs are approximately $38/AF and $6/AF respectively. Fixed costs are estimated to be $1/AF.

Table 3-3 Example Costs for Mallard Slough Pump Station Component

Capital Recovery		
Rental Fee	Based on interest on debt service, no principal (i.e. no "buy-in")	$6/AF
Wear & Tear	Based on depreciation (renewal/replacement costs)	$12/AF
Fixed Costs		
	Administrative, facility O&M, property taxes and fees	$1/AF
Variable Costs		
	Includes water, power and fish monitoring	$67-102/AF
Total Mallard Slough Pump Station Costs		**$86-$121/AF**

The preliminary cost estimate for BARDP use of the Mallard Slough Pump Station and associated water rights is approximately $86-121/AF.

Conveyance to Los Vaqueros Storage Component – There is no direct connection between CCWD's Mallard Slough Pump Station and the Los Vaqueros Reservoir, nor is one proposed. All water conveyed to storage would be through an exchange, whereby CCWD would take desalinated water into its treated water distribution system and store an equal amount of water in Los Vaqueros Reservoir for BARDP partner use at a later time.

Additional CCWD Costs. To convey water to storage on behalf of the BARDP partners, CCWD would incur additional capital recovery and fixed and variable costs. Additional variable costs include approximately $40/AF for CVP contract water, $60/AF for power and $2/AF for fish monitoring. Rental and wear and tear costs are approximately $24/AF, for a total of approximately $126/AF of additional costs.

Avoided CCWD Costs. In exchange for placing water into Los Vaqueros on BARDP's behalf, CCWD would take desalinated water into its treated water distribution system and avoid source water pumping ($56/AF) and variable water treatment costs ($70/AF), for a total of approximately $126/AF of avoided costs.

The preliminary cost estimate for CCWD conveying water to Los Vaqueros for BARDP partners, in exchange for CCWD receiving water directly from a desalination facility at MSPS, nets out to a total cost of less than $1/AF.

Los Vaqueros Storage Rental Component – CCWD completed construction of the original Los Vaqueros Project in 1998 at a cost of $448.6 million. It is estimated that approximately 60% of the facilities constructed as part of the 1998 project would be used by BARDP in a storage rental arrangement. Table 3-4 provides an example cost for the Los Vaqueros Reservoir storage component.

In 2012, CCWD completed an expansion of the Los Vaqueros Reservoir from 100,000 acre-feet to 160,000 acre-feet at an estimated cost of $95.6 million.

The following storage costs are based on an annual model for shorter term storage scenarios. For longer term storage, an alternative model may be more cost effective and can be evaluated if partners are interested.

Capital Recovery. The approximate rental fee is $50-75/AF per year and the approximate wear and tear fee is $10-15/AF per year.

Fixed Costs. Fixed costs include administrative, watershed O&M, property taxes and fees and are estimated to be $10-15/AF per year.

Table 3-4 Example Costs for Los Vaqueros Storage Component

Capital Recovery		
Rental Fee	Based on interest on debt service, no principal (i.e. no "buy-in")	$50-$75/AF per year
Wear & Tear	Based on depreciation (renewal/replacement costs)	$10-$15/AF per year
Fixed Costs		
	Administrative, watershed O&M, property taxes and fees	$10-$15/AF per year
Total Storage Rental Costs		**$70-$105/AF per year**

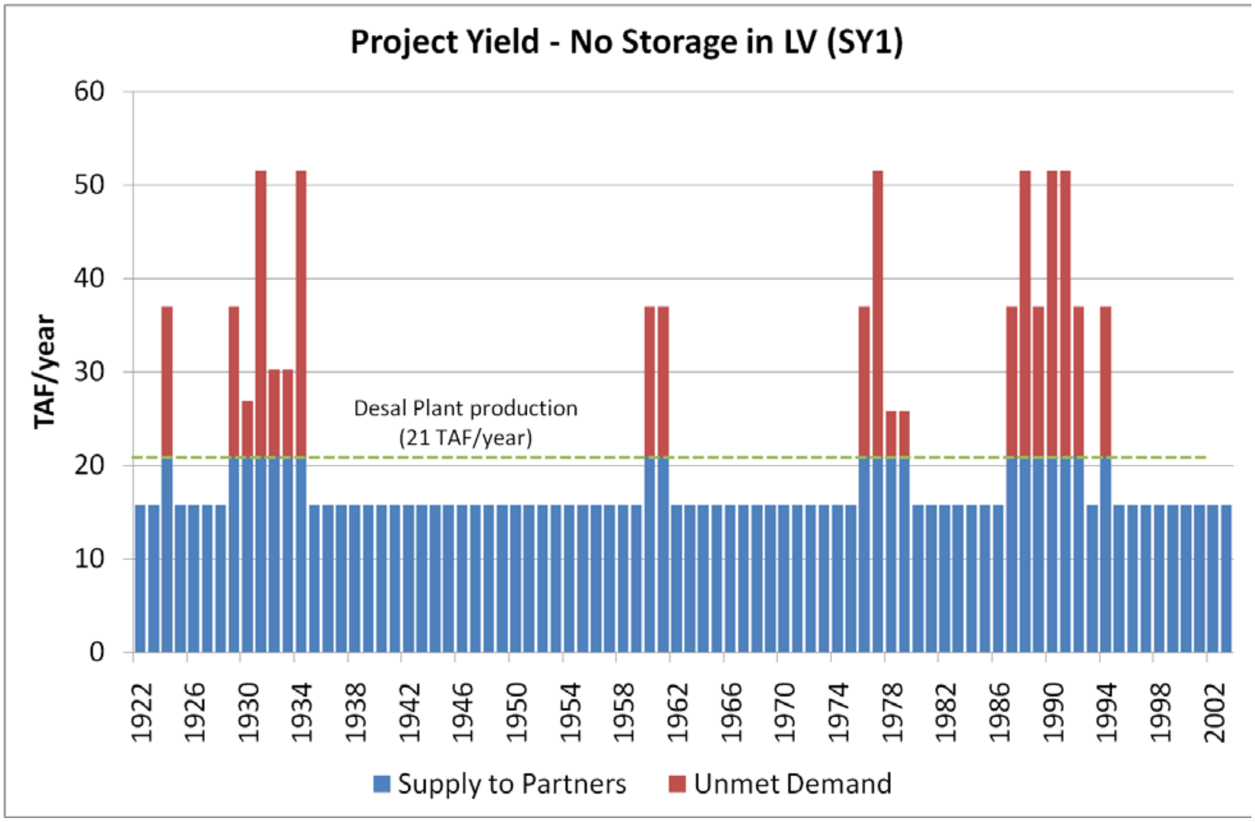
The preliminary cost estimate for BARDP use of storage in Los Vaqueros Reservoir, based on this annual cost model is approximately $70-105/AF per year.

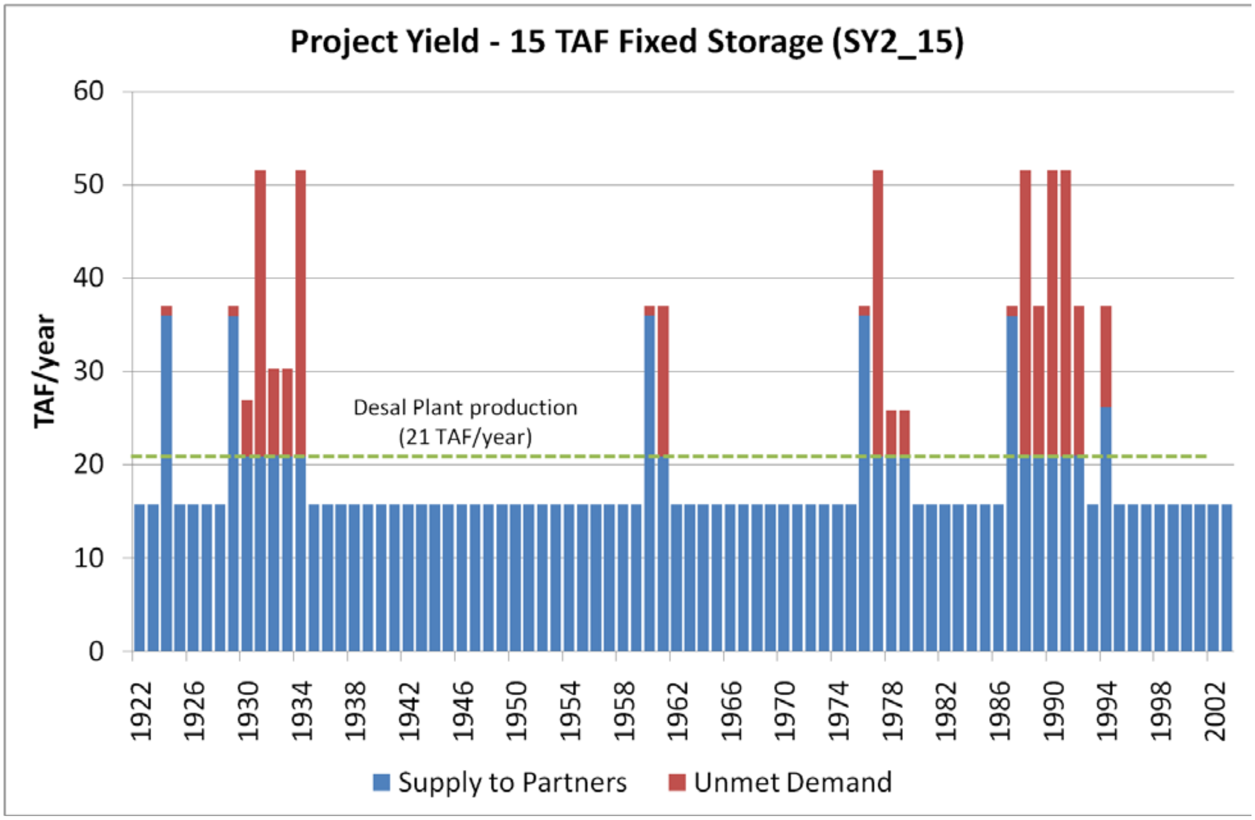
Delivery from Storage – Costs include delivery to the Mokelumne Aqueduct and do not include delivery to partners through EBMUD's system.

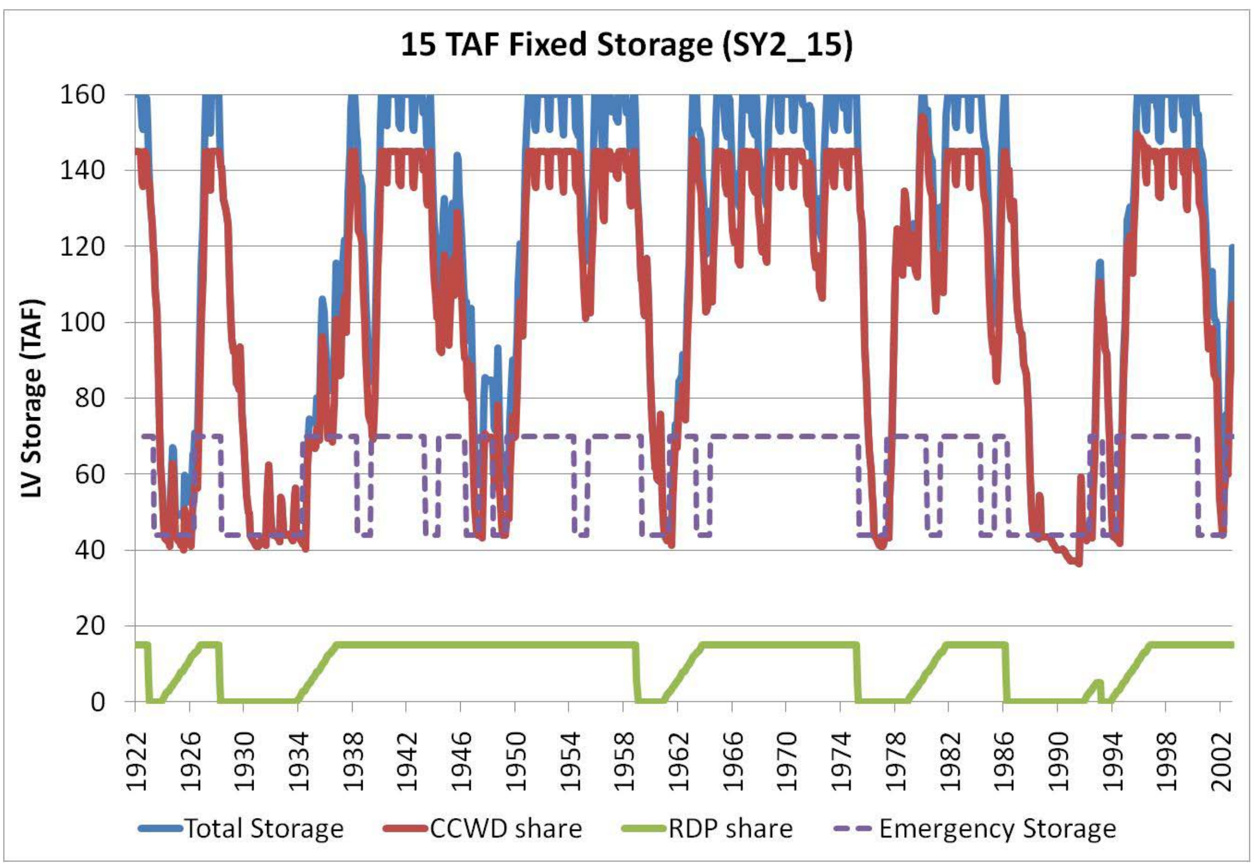
Capital Recovery. The approximate rental fee is $12/AF and the approximate wear and tear fee is $4/AF.

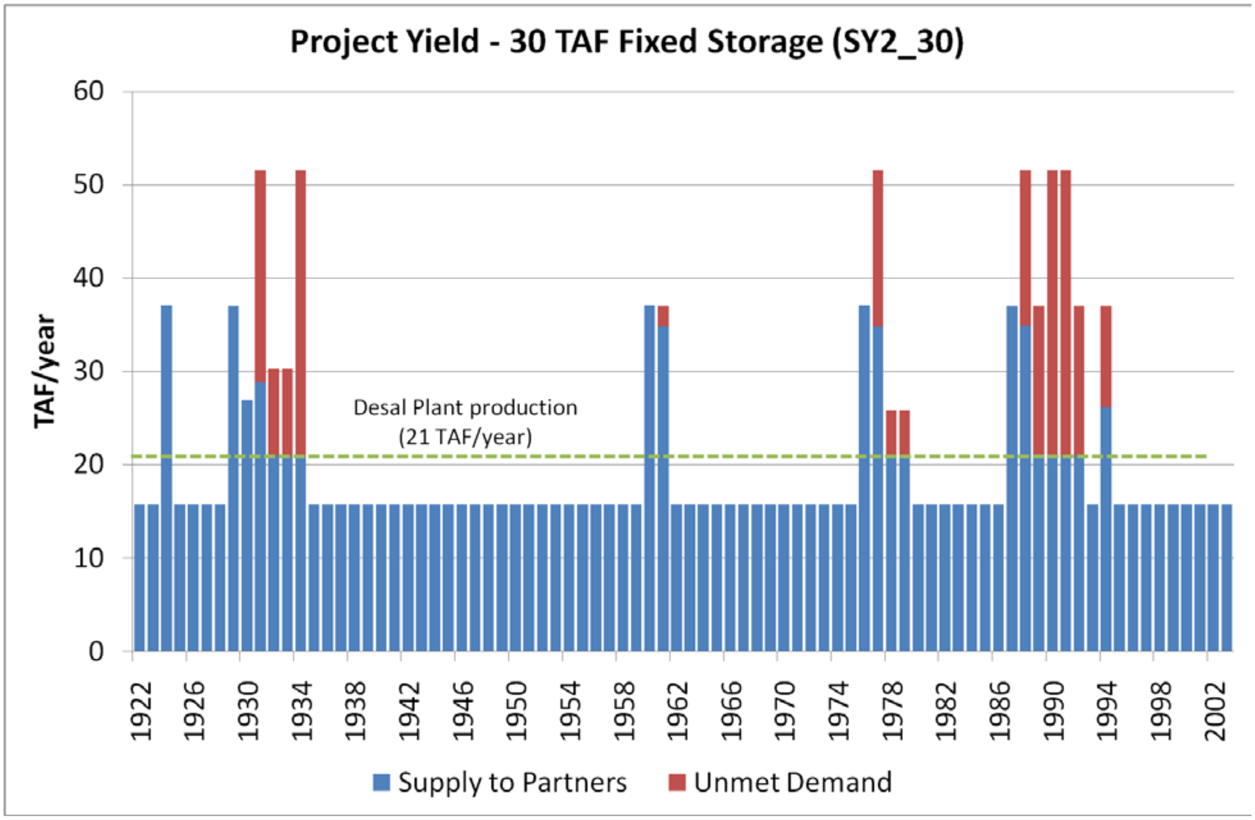
The preliminary cost estimate to deliver water from Los Vaqueros into the EBMUD system through the existing raw water intertie for final delivery to BARDP partners is approximately $16/AF.

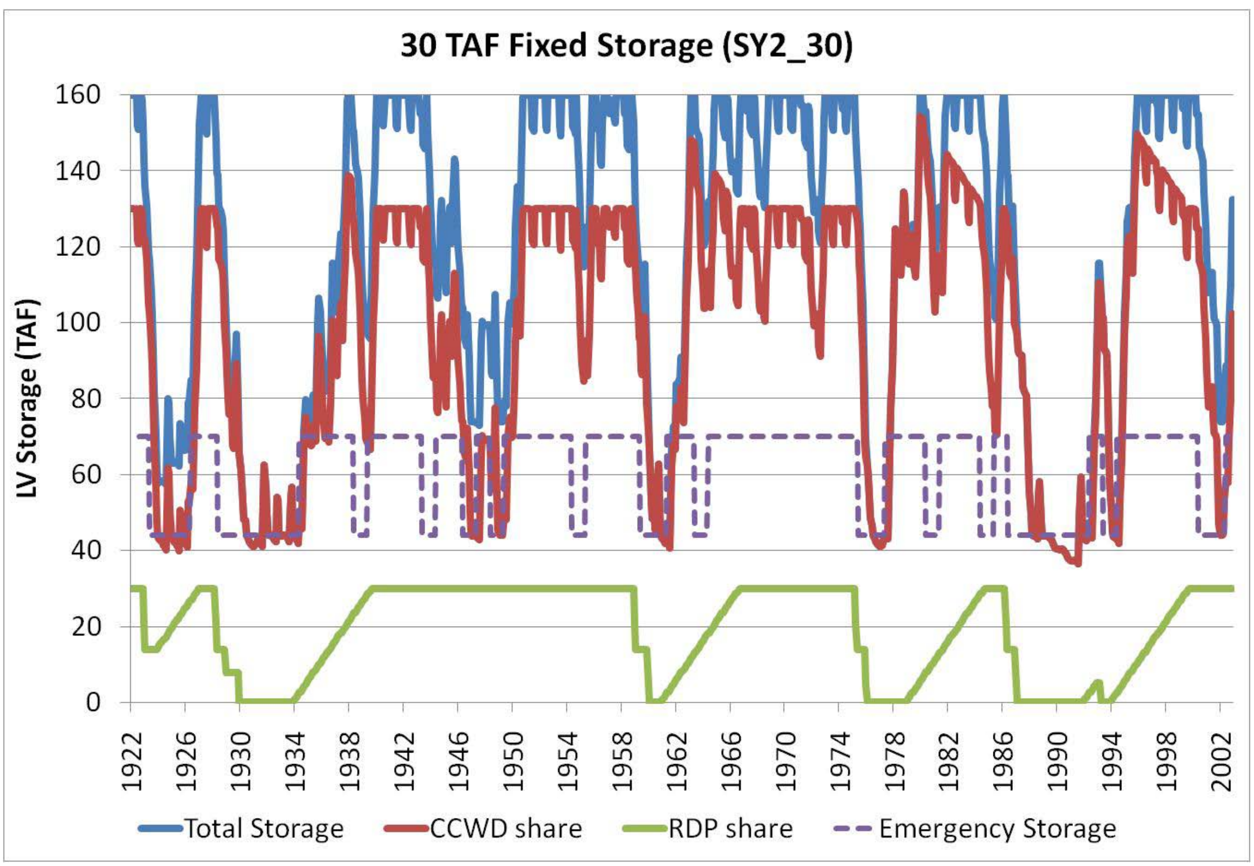
Appendix 3-A: Time Series of Storage Modeling Results

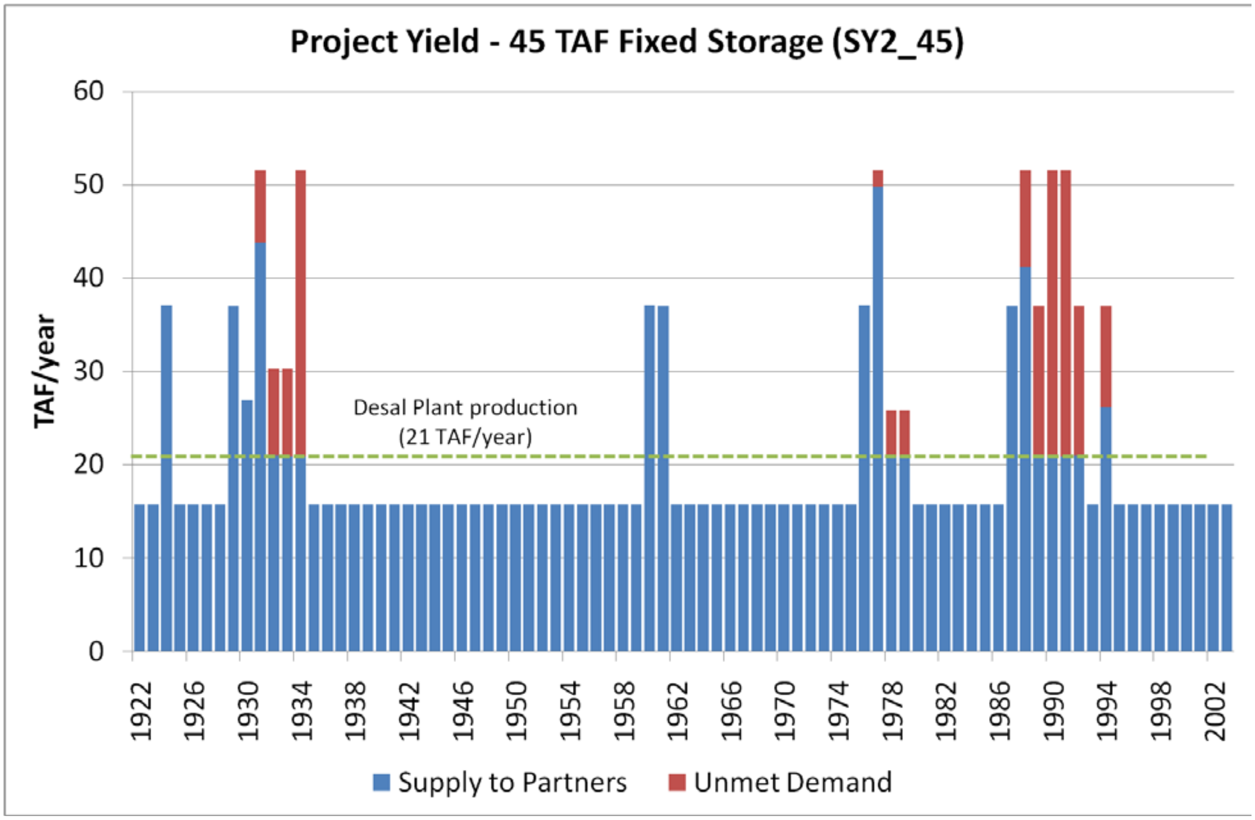

Project Yield - No Storage in LV (SY1)
TAF/year
Desal Plant production
(21 TAF/year)
Supply to Partners
Unmet Demand
60
50
40
30
20
10
0
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002

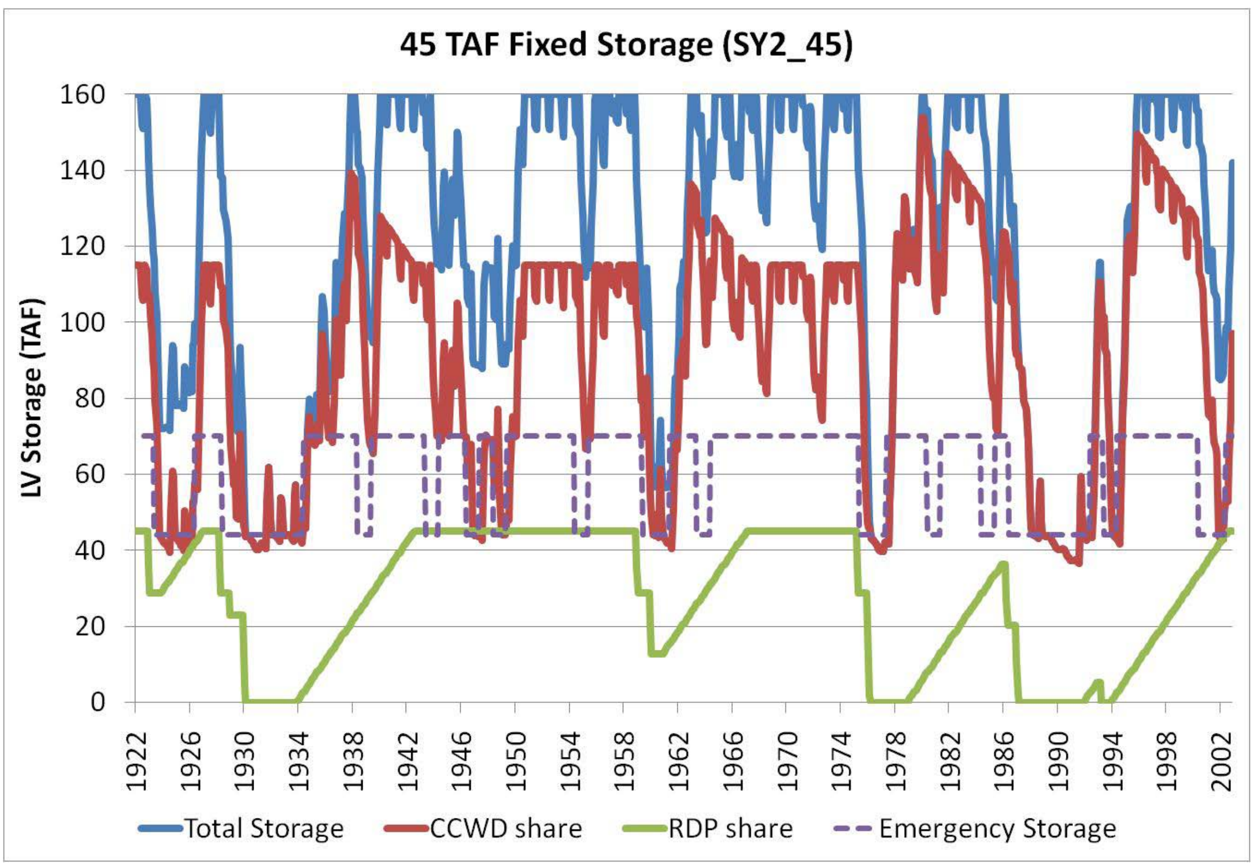

Project Yield - 15 TAF Fixed Storage (SY2_15)
TAF/year
Desal Plant production
(21 TAF/year)
Supply to Partners
Unmet Demand

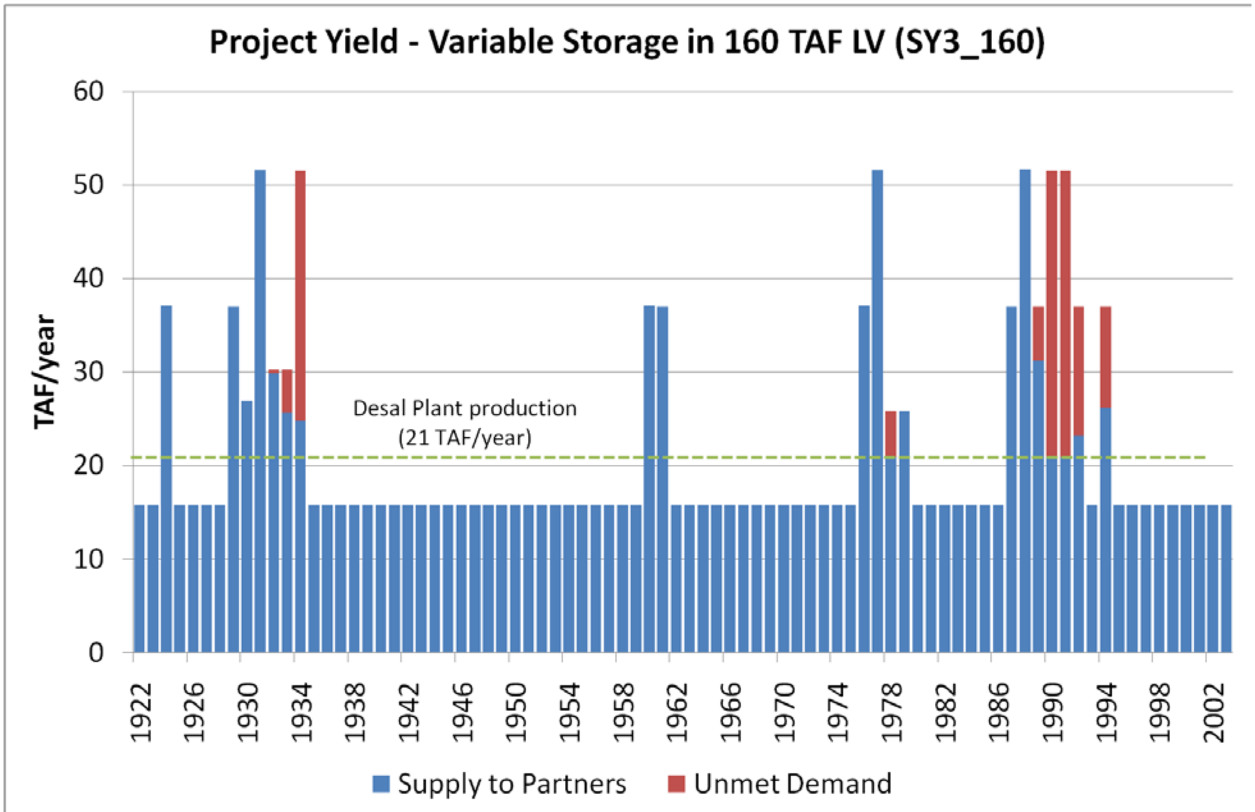

15 TAF Fixed Storage (SY2_15)
LV Storage (TAF)
Total Storage
CCWD share
RDP share
Emergency Storage

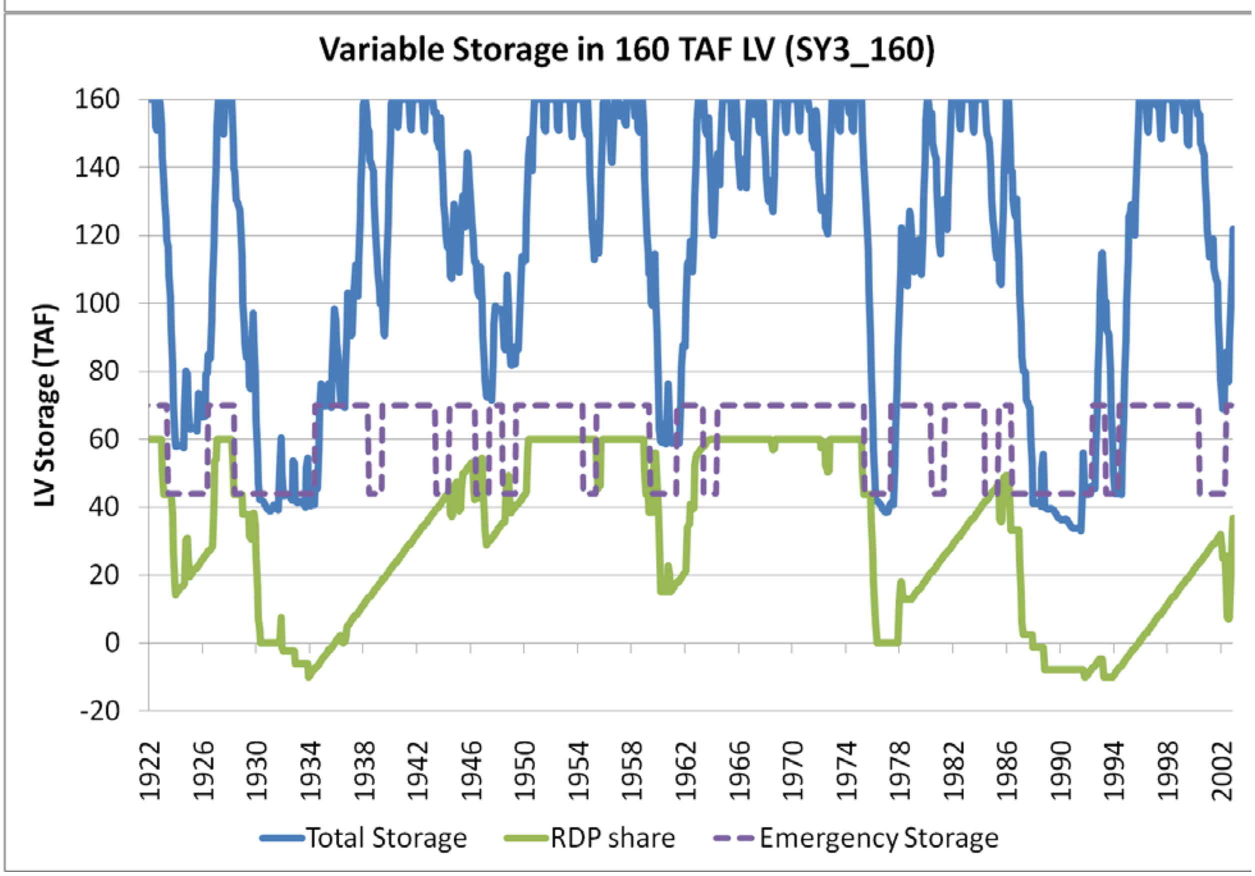

Project Yield - 30 TAF Fixed Storage (SY2_30)
TAF/year
Desal Plant production
(21 TAF/year)
Supply to Partners
Unmet Demand

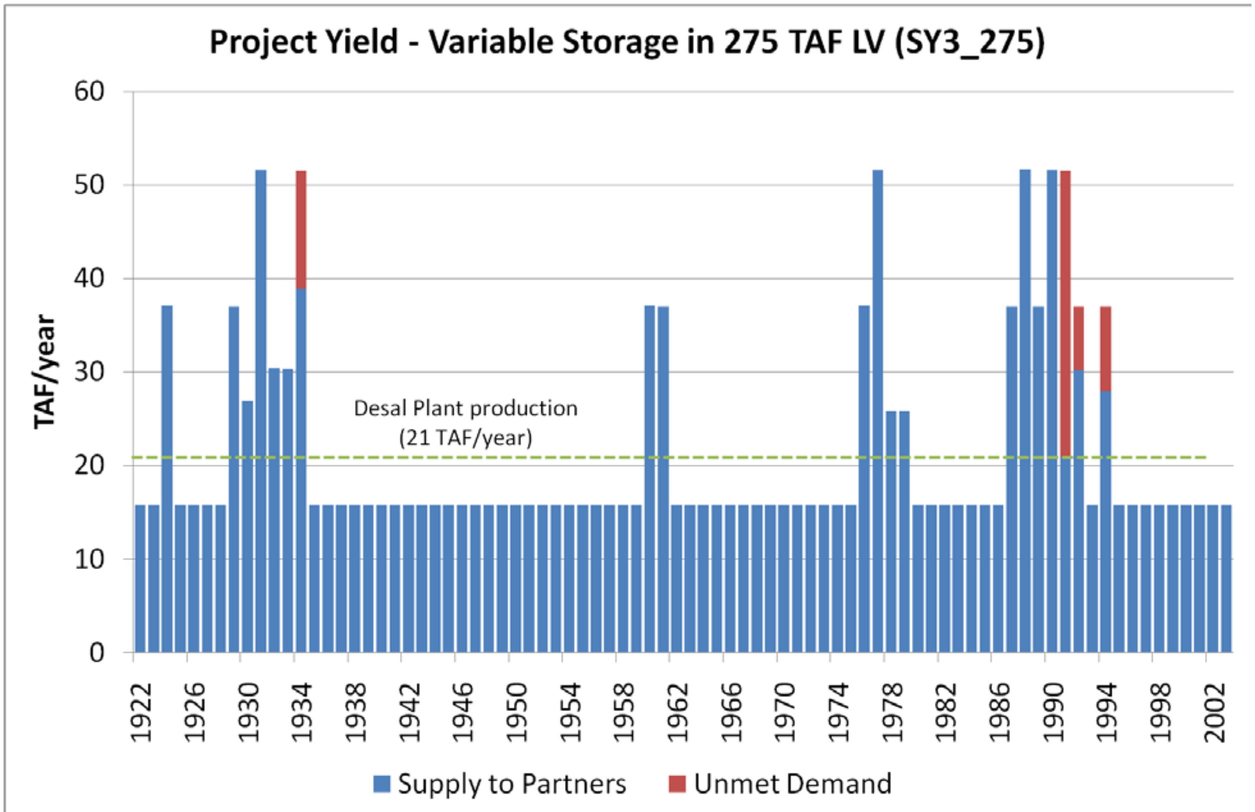

30 TAF Fixed Storage (SY2_30)
LV Storage (TAF)
Total Storage
CCWD share
RDP share
Emergency Storage

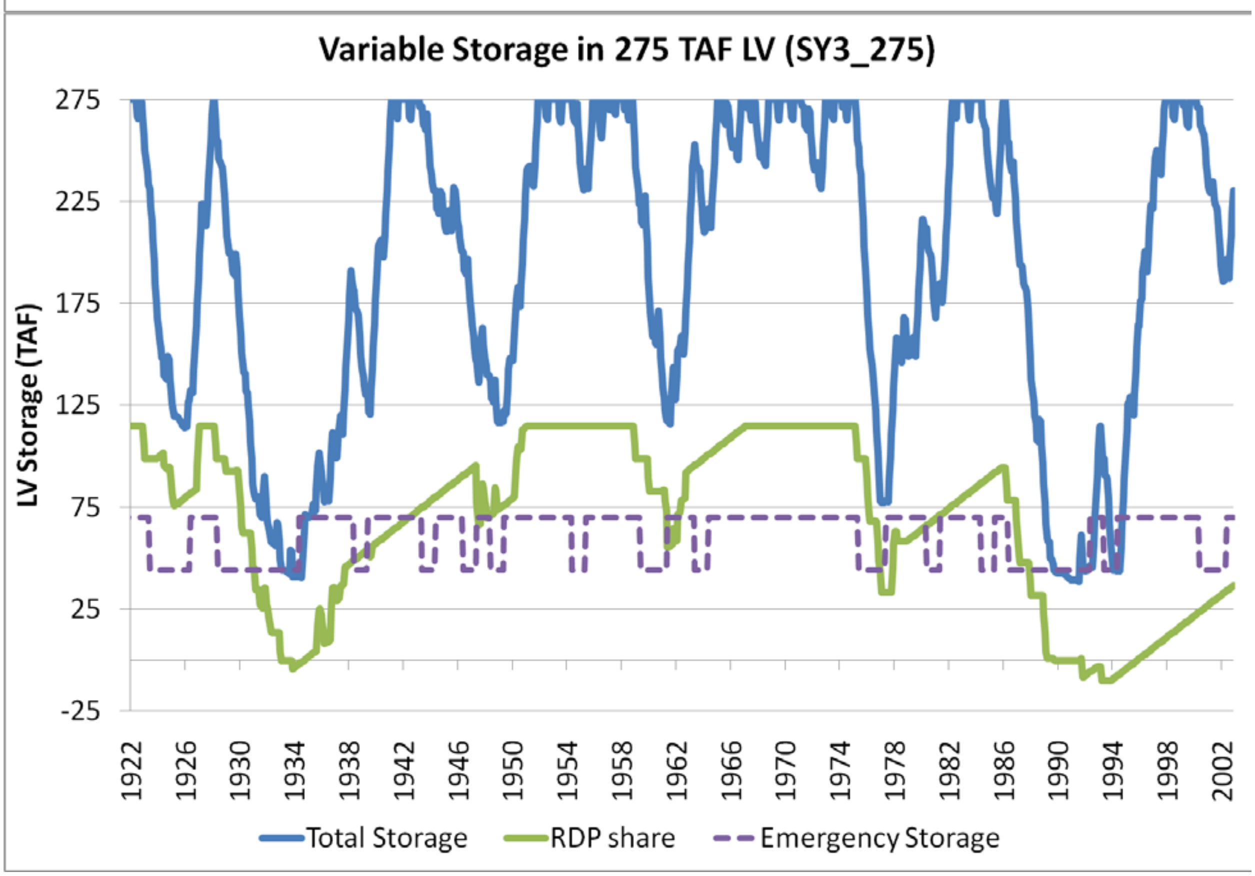

Project Yield - 45 TAF Fixed Storage (SY2_45)
TAF/year
Desal Plant production
(21 TAF/year)
Supply to Partners
Unmet Demand

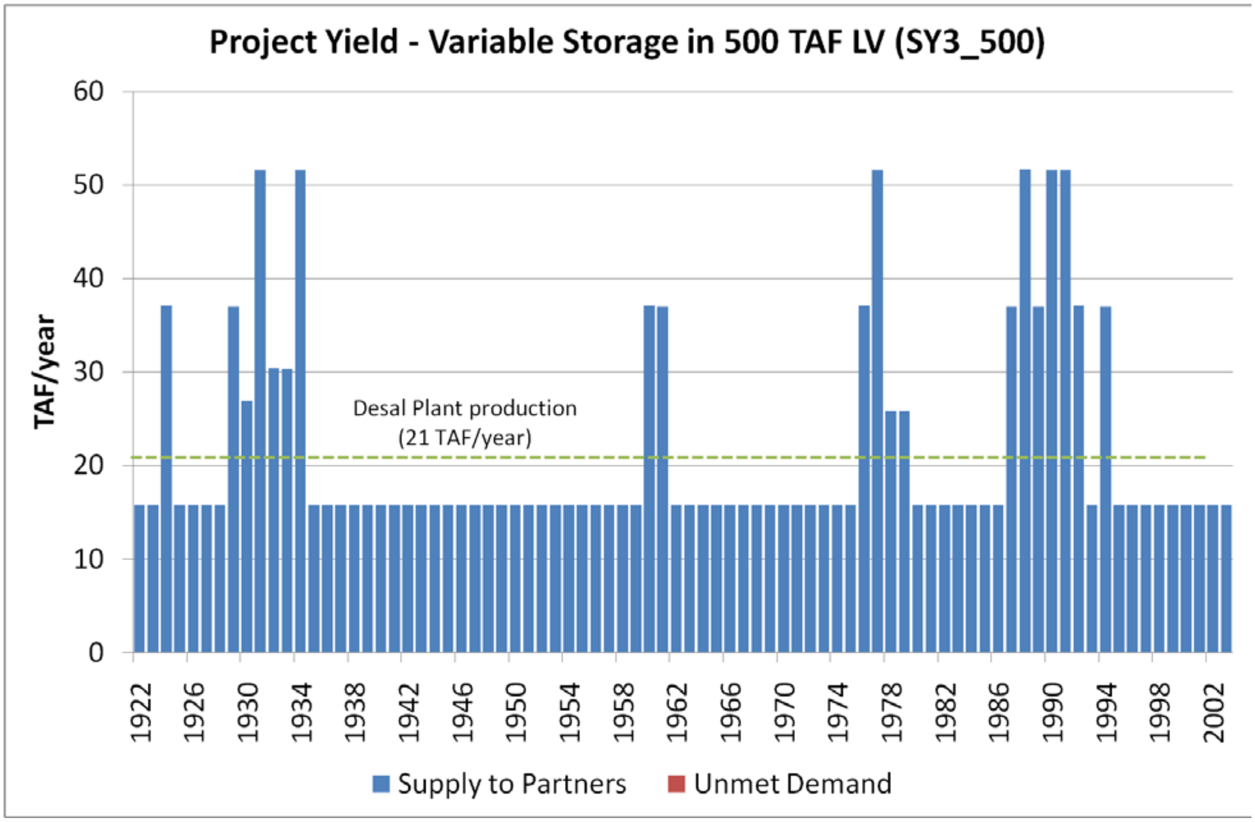

45 TAF Fixed Storage (SY2_45)
LV Storage (TAF)
Total Storage
CCWD share
RDP share
Emergency Storage

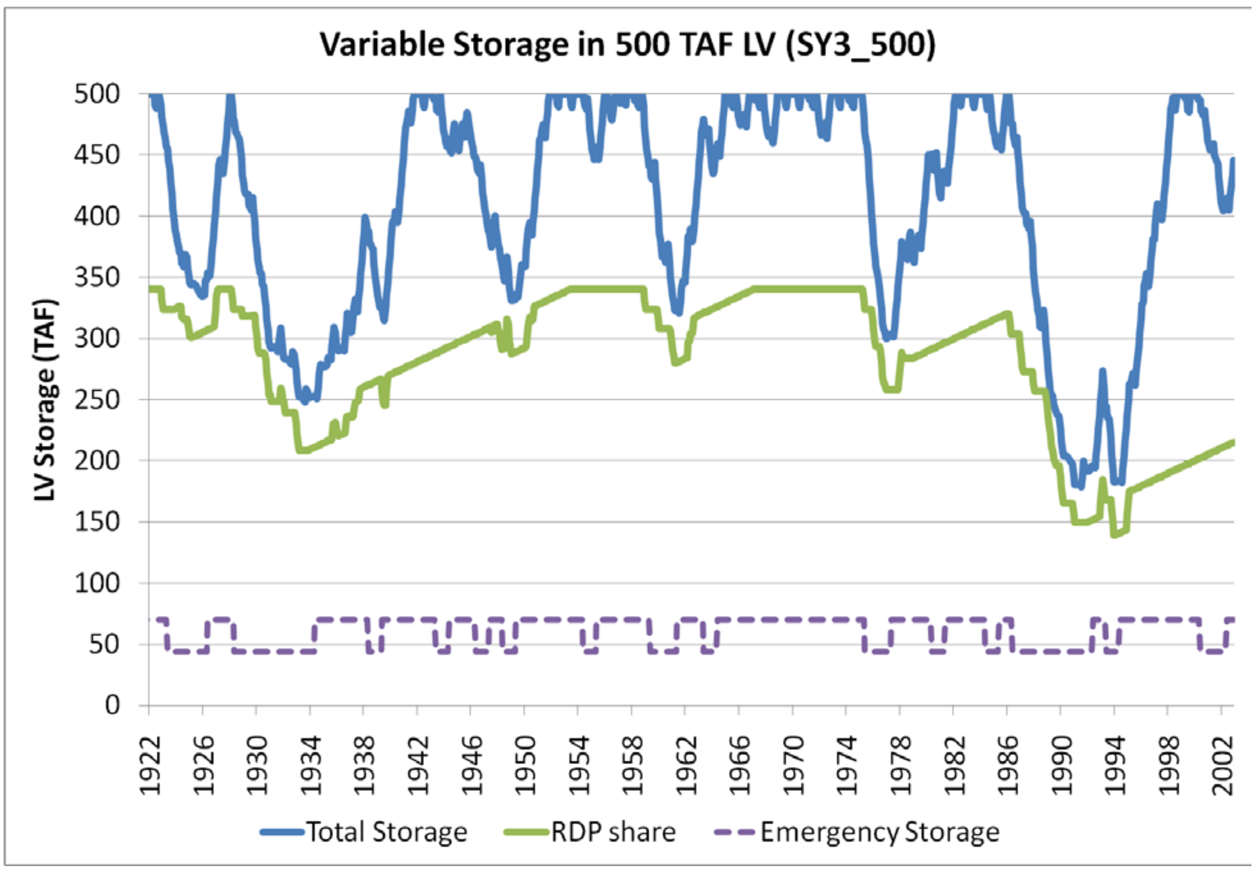

Project Yield - Variable Storage in 160 TAF LV (SY3_160)
TAF/year
Desal Plant production
(21 TAF/year)
Supply to Partners
Unmet Demand


Variable Storage in 160 TAF LV (SY3_160)
LV Storage (TAF)
Total Storage
RDP share
Emergency Storage


Project Yield - Variable Storage in 275 TAF LV (SY3_275)
TAF/year
Desal Plant production
(21 TAF/year)
60
50
40
30
20
10
0
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
Supply to Partners
Unmet Demand


Variable Storage in 275 TAF LV (SY3_275)
LV Storage (TAF)
275
225
175
125
75
25
-25
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
Total Storage
RDP share
Emergency Storage


Project Yield - Variable Storage in 500 TAF LV (SY3_500)
TAF/year
60
50
40
30
20
10
0
Desal Plant production
(21 TAF/year)
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
Supply to Partners
Unmet Demand


Variable Storage in 500 TAF LV (SY3_500)
LV Storage (TAF)
500
450
400
350
300
250
200
150
100
50
0
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
Total Storage
RDP share
Emergency Storage