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# Report on Effects of the Proposed California WaterFix Project on Water Quality at the City of Brentwood

**Exhibit Brentwood-102**

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## Exhibit Brentwood-102

Prepared for

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# Acronyms and Abbreviations

| | |
|---|---|
| AMMP | Adaptive Management and Monitoring Program |
| BA | biological assessment |
| BDCP | Bay Delta Conservation Plan |
| BiOp | biological opinion |
| cfs | cubic feet per second |
| City | City of Brentwood |
| CVP | Central Valley Project |
| D-1641 | SWRCB Water Rights Decision 1641 |
| Delta | Sacramento-San Joaquin Bay-Delta |
| DSM | Delta Simulation Model |
| DWR | California Department of Water Resources |
| E/I | Exports to inflows ratio |
| EBC | Existing Biological Condition |
| EC | electrical conductivity |
| ECCID | East Contra Costa Irrigation District |
| EIR | environmental impact report |
| EIS | environmental impact statement |
| FEIR | final environmental impact report |
| M&I | municipal and industrial |
| maf | million acre feet |
| NAA | No Action Alternative |
| NDD | North Delta Diversion |
| NMFS | National Marine Fisheries Service |
| OMR | Old and Middle Rivers |
| POD | point of diversion |
| PP#1 | Contra Costa Canal at Pumping Plant #1 |
| RDEIR | recirculated draft environmental impact report |
| Reclamation | U.S. Bureau of Reclamation |
| SDEIS | supplemental draft environmental impact statement |
| SWP | State Water Project |
| SWRCB | California State Water Resources Control Board |
| TDS | total dissolved solids |
| TUCP | Temporary Urgency Change Petition |
| USFWS | U.S. Fish and Wildlife Service |
| WaterFix | California WaterFix Project |
| WQO | water quality objective |
| WY | water year |

# 1. Introduction

My name is Susan Paulsen and I am a Registered Professional Civil Engineer in the State of California (License # 66554). My educational background includes a Bachelor of Science in Civil Engineering with Honors from Stanford University (1991), a Master of Science in Civil Engineering from the California Institute of Technology ("Caltech") (1993), and a Doctor of Philosophy (Ph.D.) in Environmental Engineering Science, also from Caltech (1997). My education included coursework at both undergraduate and graduate levels on fluid mechanics, aquatic chemistry, surface and groundwater flows, and hydrology, and I served as a teaching assistant for courses in fluid mechanics and hydrologic transport processes. A copy of my *curriculum vitae* is included as Exhibit Brentwood-101.

My Ph.D. thesis was entitled, "A Study of the Mixing of Natural Flows Using ICP-MS and the Elemental Composition of Waters," and the major part of my Ph.D. research involved a study of the mixing of waters in the Sacramento-San Joaquin Bay-Delta (the Delta). I collected composite water samples at multiple locations within the Delta and used the elemental "fingerprints" of the three primary inflow sources (the Sacramento River, the San Joaquin River, and the Bay at Martinez), together with the elemental "fingerprints" of water collected at two interior Delta locations (Clifton Court Forebay and Franks Tract) and a simple mathematical model, to establish the patterns of mixing and distribution of source flows within the Delta during the 1996–1997 time period. I also directed model studies to use the chemical source fingerprinting to validate the volumetric fingerprinting simulations using Delta models (including the Fischer Delta Model and the Delta Simulation Model [DSM]).

I currently am a Principal and Director of the Environmental and Earth Sciences practice of Exponent, Inc. ("Exponent"). Prior to that, I was the President of Flow Science Incorporated in Pasadena, California, where I worked for 20 years, first as a consultant (1994–1997) and then as an employee in various positions, including President (1997–2014). I have 25 years of experience with projects involving hydrology, hydrogeology, hydrodynamics, aquatic chemistry, and the environmental fate of a range of constituents. I have knowledge of California water supply issues, including expertise in California's Bay-Delta estuary. My expertise includes designing and implementing field and modeling studies to evaluate groundwater and surface water flows and contaminant fate and transport. I have designed studies using one-dimensional hydrodynamic models, three-dimensional computational fluid dynamics models, longitudinal dispersion models, and Monte Carlo stochastic models, and I have directed modeling studies and utilized the results of numerical modeling to evaluate surface and groundwater flows.

I have designed and implemented field studies in reservoir, river, estuarine, and ocean environments using dye and elemental tracers to evaluate the impact of pollutant releases and treated wastewater, thermal, and agricultural discharges on receiving waters and drinking-water intakes. I have also designed and managed modeling studies to evaluate transport and mixing, including the siting and design of diffusers, the water quality impacts of stormwater runoff, irrigation, wastewater and industrial process water treatment facilities, desalination brines and cooling water discharges, and groundwater flows. I have designed and directed numerous field studies within the Delta using both elemental and dye tracers, and I have designed and directed numerous surface water modeling studies within the Delta.

My testimony provides comments on the California Department of Water Resources' (DWR) and U.S. Bureau of Reclamation's (Reclamation) joint petition to the California State Water Resources Control Board (SWRCB) to amend their existing water rights permits to allow new water diversions under the State Water Project (SWP) and Central Valley Project (CVP) (collectively, the Projects). Specifically, I evaluated whether the proposed diversions, which will operate under the California WaterFix Project (WaterFix), will have an impact on the supply and quality of water available to Brentwood, which uses fresh water from the Delta for potable municipal supply. This testimony presents my analysis and technical comments on the impact of the WaterFix project on the supply of fresh water available to Brentwood. Specifically, the proposed WaterFix operations under various diversion Scenarios were evaluated to determine if the quality of water diverted by Brentwood will be negatively impacted. I reviewed DWR's assessment of the proposed project to determine if their evaluation sufficiently characterizes the range of expected water quality impacts on the City.

This testimony presents three Opinions in response to the SWRCB's Notice of Petition: DWR's evaluation of the proposed WaterFix project is inadequate (Opinion 1); WaterFix will result in substantial changes in Delta hydrodynamics and degradation of Delta water quality (Opinion 2); compliance with water quality standards is likely to become more challenging in the future and WaterFix will degrade the water quality the City's water supply (Opinion 3). The bases for these opinions and supporting documentation are provided herein.

## 2. Background

In October 2015, the SWRCB issued a Notice of Petition that the DWR and Reclamation were seeking to add three new points of water diversion/rediversion (POD and PORD, respectively) to their water rights permits as part of WaterFix implementation (Exhibit Brentwood-103). The WaterFix Project, as described in the Recirculated Draft Environmental Impact Report (RDEIR)/Supplemental Draft Environmental Impact Statement (SDEIS), is identified as Alternative 4A, the California Environmental Quality Act preferred alternative.[1] The WaterFix Project includes water conveyance facilities consisting of three new water diversion intakes along the Sacramento River between Clarksburg and Courtland and the construction of two twin concrete tunnels (30 miles long, 40 ft in diameter) to convey water from the new points of diversion to the existing pumping facilities near Tracy (Exhibit Brentwood-103).

The DWR and Bureau of Reclamation filed a petition with the SWRCB on August 26, 2015 (with an addendum and errata submitted on September 16, 2015) to change their water rights by adding three PODs in the Sacramento River to allow conveyance of water through the tunnels (labeled “CWF [California WaterFix] Intake 2,” “CWF Intake 3,” and “CWF Intake 5” in Enclosure C of the SWRCB Notice of Petition; Exhibit Brentwood-103). CWF Intakes 2 and 3 will be located between Clarksburg and Hood on the east bank of the Sacramento River, while CWF Intake 5 will be located further south on the east bank between Hood and Courtland. Each intake is designed to have a withdrawal capacity of 3,000 cubic feet per second (cfs), which yields a maximum diversion capacity of 9,000 cfs from the Sacramento River under the WaterFix Project. Currently, the DWR and Bureau of Reclamation divert water from the Delta only at the Banks Pumping Station, Clifton Court Forebay Intake, and the Jones Pumping Plant. The petition seeks to change DWR permits 16478, 16479, 16481, 16482 for the SWP and Reclamation permits 11315, 11316, 12721, 12722, 12723, 11967, 11968, 11969, 11971, 11973, and 12364 for the CVP (Exhibit SWRCB-1; Exhibit Brentwood-103). The SWRCB must evaluate the potential effects on legal users of water and on the environment associated with the

[1] The RDEIR/SDEIS can also be identified as Exhibit SWRCB-3.

proposed new diversion points in the Sacramento River before taking any action on the proposed new points of diversion (Exhibit Brentwood-103).

The DWR and Bureau of Reclamation have stated in their petition and WaterFix project documents that diversions from the Sacramento River will be "greatest" during wetter periods and "lowest" during drier periods (Exhibit SWRCB-1). Although the magnitude of the seasonal diversions has not been precisely specified in the petition and a wide range of values was assumed in modeling conducted by DWR, the petition indicates that approximately half of the total Delta diversions will occur at the new Sacramento River diversion points, while the other half will remain at the existing pumping stations in the South Delta (i.e., Banks Pumping Plant and Jones Pumping Plant) (Exhibit SWRCB-1; Exhibit Brentwood-103). The DWR and Bureau of Reclamation generally state that the construction of the water conveyance tunnels and new points of diversion will afford the agencies greater flexibility in managing and transporting water to various pumping stations and users through varying hydrologic cycles, user demands, and environmental conditions (Exhibit SWRCB-1; Exhibit Brentwood-103). While the DWR submitted an environmental impact report (EIR) for the Bay Delta Conservation Program (BDCP, the predecessor to the California WaterFix) and issued a RDEIR/SDEIS for the WaterFix Project, the agency has not submitted a final EIR for WaterFix (Exhibit SWRCB-3). The RDEIR/SDEIS was available for public review and comment from July 10, 2015 to October 30, 2015, and the City of Brentwood submitted comments on the RDEIR/SDEIS, which we attach and incorporate by reference (Exhibit Brentwood-104).

Exponent was retained by the City of Brentwood to assist in its evaluation of the California WaterFix Project. Our analysis of the impacts of the WaterFix Project relies in part on our analysis of the modeling of Alternative 4A, which was modeled in 2015 and 2016; model runs provided to protestants by DWR in May 2016; and modeling of "existing conditions" (without project scenario) conducted in 2013.

# 3. Methods

Our analysis of the impacts of the WaterFix project relied in part on our analysis of modeling performed in support of the Petition (i.e., the No Action Alternative [NAA] and project operations Scenarios Boundary 1, Boundary 2, H3, and H4) and existing condition model runs EBC1 and EBC2, which were performed in 2013. DWR used the Delta Simulation Model II (DSM2) to simulate hydrodynamics and water quality throughout the Delta for a range of model conditions and operational scenarios; these model results were released in May 2016 via download from DWR.

## a. DSM2 Modeling and Volumetric Fingerprinting

Throughout the development of the BDCP, and now the California WaterFix (WaterFix), DWR used the DSM2 model to analyze and describe conditions within the Delta for the proposed project. DSM2 is a one-dimensional (with branched-channels) tidal hydrodynamic model used to simulate stage and tidal flows, water quality, and particle tracking in the Delta. The model was developed by DWR (Exhibit Brentwood-105). The model domain extends to the Sacramento River at I Street to the north and to the San Joaquin River at Vernalis to the south, and the model includes inflows from east-side streams (the Cosumnes, Mokelumne, and Calaveras Rivers). The downstream (western) boundary is located at Martinez.

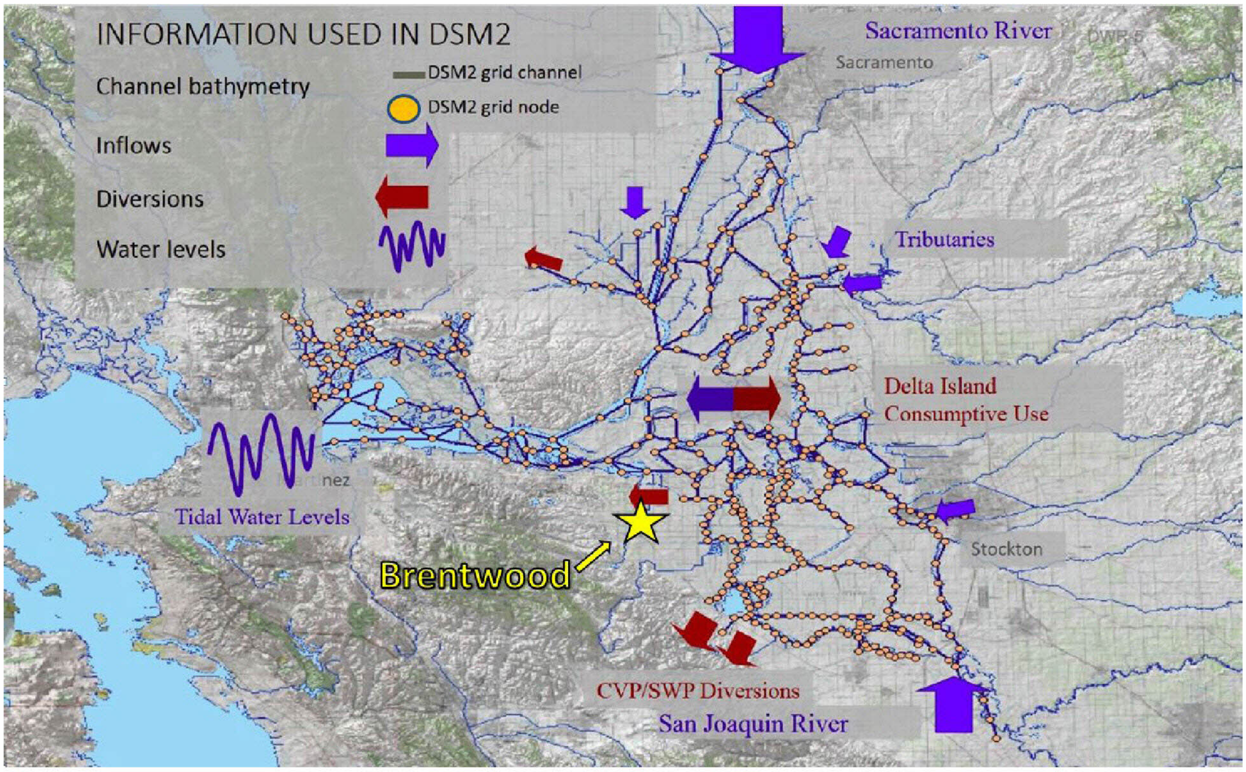


Figure 1. DSM2 model domain showing the grid nodes and channels. The City of Brentwood is shown in addition to primary inflows and diversions. (Source: Exhibit DWR-4 page 10, modified to show the general location of the City of Brentwood).

The DSM2 model has three separate components: HYDRO, QUAL, and PTM. HYDRO simulates flows in the channels defined in the DSM2 grid stage (water surface elevation) and tidal forcing at the downstream model boundary (Martinez). QUAL simulates the concentrations of conservative (i.e., no decay or growth) variables, such as EC (electrical conductivity, a measure of salinity), and non-conservative (decay or growth) variables, such as temperature and turbidity, given the inflows and tidal flows in the Delta channels simulated by HYDRO. The particle tracking model (PTM) simulates mixing and transport of neutrally buoyant (suspended) particles based on the channel geometry and tidal flows simulated by HYDRO. The model results (model output) provided by DWR in May 2016 included hydrodynamic and water quality information.

In addition to hydrodynamics and water quality modules, the DSM2 model can be used to perform “volumetric fingerprinting” to track inflows to the Delta throughout the model domain. Volumetric fingerprinting can be used to “tag” inflows to the Delta and determine the source of water within the interior of the estuary. Because the model input and output files provided to the public by DWR did not include volumetric fingerprinting results, Exponent used the model input files provided by DWR and the DSM2 model to perform volumetric fingerprinting to determine the location and time that flows from various sources entered the Delta; this analysis was performed for EBC2, NAA, and B1 Scenarios. The DSM2 modules used for the analyses and fingerprinting presented in this report include HYDRO and QUAL. Exponent's fingerprinting results are described in Opinion 2.

As noted above, DWR released new modeling for the WaterFix Project in May 2016. DWR had previously released DSM2 modeling analyses and results for the existing (no project) condition and for the Project (or prior iterations of the project) in association with the 2013 Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS), the 2015 RDEIR/SDEIS, the 2016 Draft Biological Assessment (BA), and model runs that were intended to represent the WaterFix Project for the 2016 final EIR (FEIR). The modeling files were obtained from:

- 2013 EIR/EIS: Received (date unknown) from DWR (the EBC2 model run was included in these model results)
- 2015 RDEIR/SDEIS (updates and sensitivity files): Received September 9, 2015 from DWR (B.G. Heiland)
- EBC1 model run: Downloaded September 30, 2015 from DWR (B.G. Heiland)
- 2016 Draft BA: Downloaded February 2, 2016 from Reclamation (Michelle Banonis)
- 2016 FEIR model runs: Downloaded March 4, 2016 from DWR (B.G. Heiland) (note that the FEIR itself is not yet available)

The DSM2 model produces data on 15-minute intervals that can be exported easily to various formats for post-processing. The time period modeled in DSM2 for most WaterFix and BDCP analyses spans from water year (WY) 1975–WY 1991; however, the model results from WY 1975 are considered model "spin-up" time and are excluded from analyses. The analyses in this report are based on the 16-year record from WY 1976–WY 1991. The scenarios evaluated in the

May 2016 modeling performed in support of the WaterFix petition include operational Scenarios H3 and H4, Boundary 1, Boundary 2, and the NAA. Descriptions of these various scenarios are presented by DWR in Exhibit DWR-5.

### b. Residence Time in the Delta

Residence time is a measure of the amount of time that water spends within a system; residence time is a function of the amount of water present in the system and the flow rate of water into or out of the system. The residence time can be estimated as follows:

$$Residence\ time = \frac{Volume\ of\ water}{Flow\ rate\ into\ system} = \frac{Volume\ of\ water}{Flow\ rate\ out\ of\ system}$$

During high flow conditions, residence times are shorter, while during low flow (drought) conditions, residence times are longer. Exponent's analysis of residence time is included in Opinion 2.

### c. Water Year Type Classification

Hydrology in the Delta varies from year to year. Water years in the Delta, defined as October through September of the following year, are classified as wet, above normal, below normal, dry, or critical. DWR determines the water year type by calculating a water year index number, which accounts for both the hydrology of the current year and the previous year's index[2]. By this classification system, the water years modeled in DSM2 by DWR fall into the following categories:

- Critical: 1976, 1977, 1988, 1990, 1991
- Dry: 1981, 1985, 1987, 1989
- Below Normal: 1979
- Above Normal: 1978, 1980

[2] Water year classifications from CDEC, accessed at http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST. Also, see Exhibit Brentwood-106.

- Wet: 1982, 1983, 1984, 1986

Because there is only one Below Normal water year in the modeled record, Exponent combined results for the Below Normal year with model results for Above Normal water years for the purposes of analyzing the WaterFix model runs; the water year type for water years 1978-1980 is referred to from here forward as “Normal.” In some analyses, data are averaged by month or by water year type. This is done by aggregating data from those specific months or water year types and calculating an average. For example, the daily average chloride concentration during March of dry water years was calculated by sorting the DSM2 model results into bins such that the simulated salinity values for each day in March from years 1981, 1985, 1987, and 1989 were grouped and could then be averaged.

In addition, we relied upon DWR’s water year classifications for the entire period of record, as summarized in Brentwood-106.

### d. D-1641 Water Quality Objectives for Municipal and Industrial Beneficial Uses

SWRCB Water Right Decision 1641 (D-1641) (Exhibit SWRCB-21) establishes water quality objectives (WQOs) in the Delta for various beneficial uses. As discussed in Opinion 3, DSM2 results were used to evaluate compliance of the different modeled scenarios and baseline conditions with the D-1641 WQOs for municipal and industrial (M&I) beneficial uses.

D-1641 uses two chloride thresholds to define WQOs for M&I beneficial uses at various locations as shown in Table 1. Compliance was evaluated for each modeled scenario at Contra Costa Canal at Pumping Plant #1 (PP#1) for both the 150 mg/L and 250 mg/L thresholds. Results are discussed in Opinion 3.

Table 1. WQOs for M&I beneficial uses as specified in D-1641.

| Compliance Location | Parameter | Description | Water Year Type | Time Period | Value |
|---|---|---|---|---|---|
| Contra Costa Canal at Pumping Plant #1 **or** San Joaquin River at Antioch Water Works Intake | Chloride (Cl-) | Maximum mean daily 150 mg/L Cl- for at least the number of days shown during the Calendar Year [in the "Value" column]. Must be provided in intervals of not less than two weeks duration. | W | | 240 days |
| | | | AN | | 190 days |
| | | | BN | | 175 days |
| | | | D | | 165 days |
| | | | C | | 155 days |
| Contra Costa Canal at Pumping Plant #1, **and** West Canal at Mouth of Clifton Court Forebay, **and** Delta-Mendota Canal at Tracy Pumping Plant, **and** Barker Slough at North Bay Aqueduct Intake, **and** Cache Slough at City of Vallejo Intake | Chloride (Cl-) | Maximum mean daily (mg/L) | All | Oct-Sep | 250 mg/L Cl- |

## e. D-1641 Water Quality Objectives Applicable to Total Exports

D-1641 includes a limitation on exports that is expressed in terms of the ratio of total exports out of the Delta (E) to total inflows to the Delta (I). The combined export rate (E) for this objective is defined in D-1641 as the Clifton Court Forebay inflow rate (minus Byron-Bethany Irrigation District diversions from Clifton Court Forebay) plus the export rate of the Tracy pumping plant and is calculated as a three-day running average.

The total inflow (I) to the Delta is defined in D-1641 as the sum of mean daily flows from the Sacramento River inflows at Freeport, the San Joaquin River inflows at Vernalis, the eastside streams (Mokelumne, Cosumnes, and Calaveras Rivers), the Sacramento Regional Treatment Plant average daily discharge from the previous week, the mean daily flow from the Yolo

Bypass for the previous day, and other miscellaneous flows (combined mean daily flow from Bear Creek, Dry Creek, Stockton Diverting Canal, French Camp Slough, March Creek, and Morrison Creek). Delta inflows are summed and evaluated as a 14-day running average.

Exponent calculated exports and inflows to the Delta for the purposes of this analysis from DSM2 model results with minor variations from the method specified in D-1641. Sacramento Regional Wastewater Treatment Plant flows and miscellaneous flows were omitted for our analysis, as these flows are small relative to the other flows specified in D-1641 and are not expected to change the analysis results significantly. Delta inflows were calculated as 14-day running averages, while Delta exports were calculated as three-day running averages. Criteria specified in D-1641 limit Delta exports to 35% of Delta inflow between February and June (i.e., export-to-inflow [E/I] ratio < 0.35 from February-June) and to 65% of Delta inflow between July and January (i.e., E/I < 0.65 from July-January). There are some exceptions to these general rules[3] that were not considered in this analysis.

Because some WaterFix project scenarios will increase the total amount of water exported from the Delta, the E/I ratio will change for these scenarios. Consistent with D-1641's definition of "E" as total exports and "I" as total inflows, Exponent evaluated the E/I ratio for the WaterFix scenarios as:

$$\left[\frac{E}{I}\right]_{D-1641} = \frac{Banks+\ Jones+NDD\ Exports}{Sacramento+San\ Joaquin+Cosumnes+Calaveras+Mokelumne+Yolo\ inflows} \qquad \text{Eqn. 1}$$

However, it appears DWR and Reclamation are proposing this method of calculation be modified in light of exports from the North Delta Diversion (NDD). Specifically, the Draft BA (Exhibit SVWU-1) states,

> *"The D-1641 export/inflow (E/I) ratio calculation was largely designed to protect fish from south Delta entrainment. For the PA [Preferred Alternative], Reclamation and DWR propose that the NDD be excluded from the E/I ratio calculation. In other words,*

[3] See Exhibit SWRCB-21, pp. 186–187.

*Sacramento River inflow is defined as flows downstream of the NDD and only south Delta exports are included for the export component of the criteria."*4

By this proposed method of calculation, both total inflows and total exports would be reduced by the volume of water exported from the NDD:

$$\left[\frac{E}{I}\right]_{CWF,modified} = \frac{Banks + Jones\ Exports}{(Sacramento - NDD\ Exports) + San\ Joaquin + Cosumnes + Calaveras + Mokelumne + Yolo\ inflows} \qquad \text{Eqn. 2}$$

From a mathematical perspective, subtracting the NDD exports from both the numerator and denominator of equation (1) to produce equation (2) reduces the calculated E/I ratio such that the E/I ratio is less restrictive under the new proposed calculation method. Exponent is not aware of whether this modified calculation method would constitute a change in water quality standards or whether the SWRCB would approve of such a calculation method. Thus, Exponent calculated the E/I ratio using both calculation methods and using the DSM2 model output provided by DWR. The results of Exponent's E/I calculations are included in Opinion 3.

### f. Salinity Conversions

The salinity of water in the Delta has historically been expressed as electrical conductivity (EC), total dissolved solids (TDS), or chloride. Many salinity measurements in the Delta are made using EC because the analysis is more cost-effective and quicker than measuring TDS or chloride, and an EC measurement can be taken *in situ,* making it useful for grab sampling or continuous monitoring. EC is thus widely used as a surrogate for salinity (Brentwood-117). Guivetchi (1986) also derived linear relationships between EC, TDS, and chloride, generating mathematical equations for various locations in the Delta that can be used to convert one type of salinity measurement to another. The DSM2 model provides salinity as EC, which is converted to chloride using these relationships.[5]

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[4] See Exhibit SVWU-1 (Draft BA), pp. 3–80.

[5] See http://www.water.ca.gov/suisun/facts/salin/index.cfm for additional details. Location ROLD21 was used for salinity conversions based on proximity to Brentwood's intake.

In general, the salinity of the Sacramento River is low, about 100 mg/L TDS; the salinity of water in the eastside streams is also low, typically less than 100 mg/L TDS. The EC (salinity) of freshwater inflows to the Delta is lower than that of sea water or water from San Francisco Bay. For example, in 2015, averaged measured EC in the Sacramento River at Freeport was 168 µS/cm (equivalent to TDS of 103 mg/L using the method of Guivetchi 1986) and ranged from approximately 109 to 281 µS/cm (TDS from 72 to 163 mg/L). Average EC in the San Joaquin River at Vernalis was 595 µS/cm (343 mg/L TDS), ranging from 99 to 1323 µS/cm (48 to 776 mg/L TDS), and average EC at Martinez (downstream boundary of Delta) was 26,384 µS/cm (17,882 mg/L TDS), ranging from 11,501 to 47,204 µS/cm (7440 to 32,490 mg/L TDS) (CDEC, data accessed online 1-6-15, Figure 4-8). By contrast, the salinity of seawater is approximately 50,000 µS/cm (35,000 mg/L TDS).

# 4. Delta Hydrodynamics

The Delta is the transition zone between the San Francisco Bay and its watershed, which is a 16.3-million-hectare (62,900-square-mile) basin that occupies roughly 40% of California's land area (Exhibit Brentwood-107). The Delta is fed by fresh water from the Sacramento River and San Joaquin River basins and east-side streams and is connected to the San Francisco Bay through Suisun and San Pablo Bays (Figure 2). The Sacramento River (and Yolo Bypass) provide approximately 60% to 80% of total inflow to the Delta (depending on hydrologic (water) year type), the San Joaquin River provides about 13% to 17% of total inflow, and the east-side streams, including the Calaveras, Cosumnes, and Mokelumne Rivers, constitute approximately 3% to 4% of total inflow (Exhibits Brentwood-108, Brentwood-109). The total annual inflow to the Delta during an average precipitation year is approximately 25 million acre-ft (maf) (Exhibit Brentwood-109), but inflows vary significantly during wet or dry years.

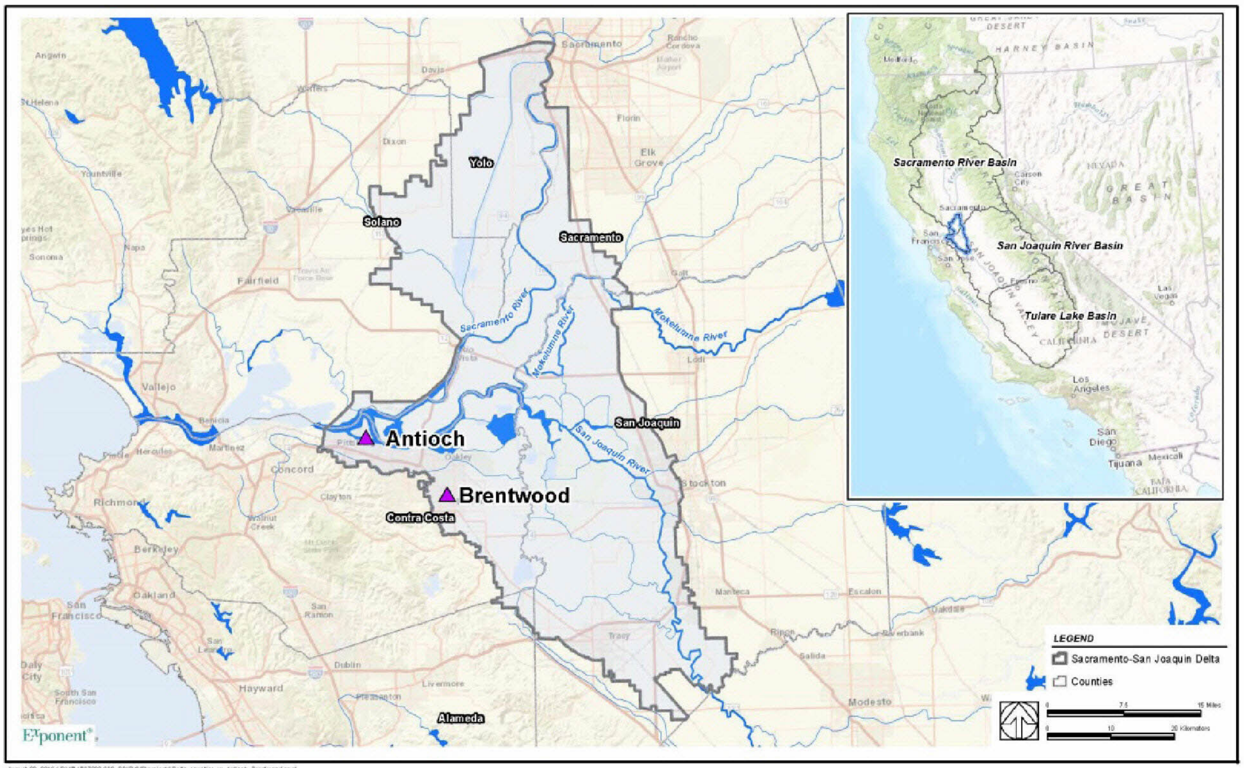


Figure 2. Overview of the Sacramento-San Joaquin Delta showing the approximate location of the City of Brentwood. The City of Antioch is also shown.

The salinity of water within the Delta results from the balance of freshwater flows into the Delta and higher salinity water that enters the Delta from the west as a result of tidal action. At the western boundary of the Delta, water typically has salinity levels that are intermediate between freshwater and ocean water. The salinity at the western Delta boundary results from the mixing of saltwater that enters San Francisco Bay through the Golden Gate from the Pacific Ocean and freshwater flows from both the Delta and stream and river flows that enter San Francisco Bay west of the Delta. Freshwater outflow from the Delta typically meets higher salinity water at an interface near Suisun Marsh; however, the location of this transitional zone is not fixed but rather fluctuates depending on freshwater flows and tidal action.

Salinity in the western Delta is also a function of both season and water year type. Salinity levels in the western Delta are typically low in the winter and spring months, when river outflows are higher as a result of winter rains and spring snowmelt, and higher in summer and fall months. During wet years, the Delta is dominated by fresh water flows, and in very wet years the saltwater-freshwater interface may be pushed into San Francisco Bay to the west of the Delta. During dry years, river flows are lower than in wet years, and the saltwater-freshwater interface may extend into the Delta.

It is important to note that even if there was no freshwater inflow into the Delta, water would be present in the Delta, as the bottom elevation of most Delta channels is below sea level—i.e., even if there were no freshwater flows into the system, water from San Francisco Bay would flow into the system, and water would be present. As noted by DWR,

> *"Because the Delta is open to the San Francisco Bay complex and the Pacific Ocean and its channels are below sea level, it never has a shortage of water. If the inflow from the Central Valley is insufficient to meet the consumptive needs of the Delta, saline water from the bay fills the Delta from the west. Thus, the local water supply problem in the Delta becomes one of poor water quality, not insufficient quantity."*[6]

Variations in hydrology also have a significant impact on the salinity and water quality of the Delta. Multiple drought periods have occurred over the last century and have served to decrease fresh water outflows and increase salinity intrusion farther east into the Delta.

### a. Residence Time

As mentioned in Section 3b, residence time is a measure of the amount of time that water spends within a system and is a function of the amount of water present in the system and the flow rate of water into or out of the system. Residence time is a function of many different factors and processes, and changes in residence time as a result of changes in Delta flow management are one determinant of water quality in the Delta. Jassby and Cloern (2000) (Exhibit Brentwood-107) estimated that the waterways within the Delta have a surface area of approximately 230 million $m^2$ (57,000 acres, or 2.5 billion $ft^2$) and a water depth ranging from less than 1 m (3.3 ft) to greater than 15 m (49 ft). Assuming an average depth of 6 m (20 ft), the volume of water in the Delta at any point in time would be about 1.4 billion $m^3$ (1.2 million

[6] Exhibit Brentwood-110

acre-feet). Assuming a mean inflow of 1700 $m^3/s$ (1.37 acre-feet/s or 60,000 cfs) during the winter and 540 $m^3/s$ (0.44 acre-feet/s, or 19,000 cfs) during the summer (Brentwood-108, 1968-1995), the average residence time of water in the Delta would be approximately 10 days during the winter and 30 days during the summer.

DWR has used modeling to perform more detailed estimates of residence time. Specifically, DWR calculated the residence time of fresh water in the Delta between 1990 and 2004 using DSM2 PTM simulations to track water that entered the system at Freeport (on the Sacramento River) and at Vernalis (on the San Joaquin River) (Exhibits Brentwood-111, Brentwood-112, Brentwood-113). The residence time was defined as the number of days required for 75% of the particles injected over a 24-hour period at a specific location (e.g., Freeport) to leave or be removed from Delta channels. The particles were assumed to have left Delta channels when they passed (i.e., were detected) at the following locations: SWP and CVP pumps, Contra Costa Water District and North Bay Aqueduct intakes, Delta island diversions, and the Sacramento River at Chipps Island. Mierzwa et al. (Exhibits Brentwood-111 and Brentwood-112) determined the average 75% particle residence time for each month (e.g., every February, every October) between 1990 and 2004 and then calculated a long-term mean for each month with those averages. The monthly average residence times of Sacramento River inflows ranged from an average of 16 days during February (minimum of 3 days and maximum of 38 days) to 51 days during October (minimum of 37 days and maximum of 74 days). Monthly average residence times for San Joaquin River flows ranged from an average of 16 days during January (minimum of 6 days and maximum of 38 days) to 33 days during April (minimum of 8 days and maximum of 54 days). As expected, residence times were longer during dry years than during wet years; minimum residence times during the study period for Sacramento inflows occurred during 1997 and 1998, which were wet years, while maximum residence times occurred during 1992, a critically dry year.

# 5. Opinion 1: DWR's evaluation of the proposed project is inadequate.

## a. The evaluation uses a flawed and inappropriate baseline.

Prior documents and model runs released by DWR utilized two model scenarios, EBC1 and EBC2, to simulate existing conditions; however, DWR's petition to the SWRCB did not include or evaluate water quality for an existing condition scenario. Rather, DWR presents only the NAA to represent "baseline conditions." The NAA scenario represents a future condition and includes about 15 cm of sea level rise but no new facilities.

The appropriate baseline condition for evaluating the impacts of the proposed WaterFix Project is the existing condition. As detailed in Exhibit Brentwood-104, Exponent, on behalf of the City, previously evaluated both the EBC1 and EBC2 existing condition model scenarios and found the EBC2 scenario to capture salinity within the Delta most accurately. I am unaware of any additional model runs conducted by DWR to evaluate hydrodynamics and water quality within the Delta for current conditions; since the existing condition does not involve project operations, the EBC2 model scenario is, to my knowledge, the best available model run to simulate the existing condition. In my experience, there is no precedent for using a future condition, such as the NAA, in isolation as a baseline for evaluating the impacts of a proposed project on other legal users of water. Furthermore, and as described below, the NAA scenario generally exhibits higher salinity at the City's water source than EBC2 under some conditions. If the NAA is used as a "baseline" scenario, the effect is to make some of the water quality impacts of the WaterFix project appear to be less significant than they actually are.

To assess the impact of using the NAA instead of the EBC2 scenario as the baseline in general terms, the daily average chloride concentrations were calculated for these two model runs and for the 16-year simulation period. The average chloride concentration at Contra Costa Pumping

Plant #1 (PP#1) [7] in the EBC2 and NAA scenarios was 105 mg/L. A statistical analysis comparing the simulated daily average chloride for each day in the 16-year simulation period confirmed however that the difference between EBC2 and NAA data sets is statistically significant. [8] Furthermore, the maximum daily average chloride concentrations simulated for the EBC2 and NAA scenarios are 395 mg/L and 462 mg/L, respectively. In addition, the standard deviation of the NAA scenario is 8% higher than EBC2, showing that simulated salinity is more variable in the NAA scenario than in the EBC2 scenario.

The percentage difference in monthly average chloride concentration was evaluated for the 16-year model period. Although some months show lower salinity for the NAA than the EBC2 scenario, in general, the NAA scenario shows that chloride concentrations are higher during dry, below normal, and critical years, as well as during the fall and winter months, as compared to the EBC2 scenario. During individual months, impacts can be significantly higher.

### b. Project operations are poorly defined.

The WaterFix project as proposed and as analyzed in the RDEIR/SDEIS and May 2016 modeling is not clearly defined, and future operating scenarios are not clearly described. As a result, it is difficult for the City to assess the potential impacts of the Project on its water rights and water supply. The incomplete and unclear description of the WaterFix project and operations also makes it problematic to assess or determine harm to downstream beneficial uses.

DWR's May 2016 modeling effort evaluated five scenarios: the NAA plus four model scenarios intended to describe the potential operations of the project: Boundary 1 (B1), Boundary 2 (B2), H3, and H4. These scenarios describe a broad range of potential operations, and little information is given regarding the criteria by which the project would be operated or the criteria for changes in operations over time. For example, DWR states,

[7] As detailed in Brentwood-1, most of the City of Brentwood's surface water supply is diverted from Contra Costa Pumping Plant #1 (also known as Rock Slough).

[8] The Single Factor Anova test (Microsoft Excel Version 14.0.7166.5000)

> *"Alternative 4A is described by initial operational criteria that provides for a range of outflow. This range is described as initial operational scenarios H3 and H4. However, prior to operation of the project, there will be specific initial operating criteria set forth in the CWF BiOp. These criteria may change based on adaptive management. Since the BiOp has not be issued, and DWR and Reclamation do not know the initial operational criteria the analysis framework presented for Part 1 is a boundary analysis. The boundary analysis will provide a broad range of operational criteria and the initial operating criteria will fall within this range. These boundaries are sufficiently broad as to assure the State Water Board that any operations considered within this change petition proceeding have been evaluated with regard to effects on legal users of water."*[9]

Scenarios B1 and B2 are intended to represent the wide range of potential operational states that may be implemented under the Adaptive Management and Monitoring Program (AMMP), which is a project management strategy that allows for wide flexibility in determining the rate, volume, and timing of water diversion from the Sacramento River. Operational scenarios H3 and H4 fall within the range of outflows produced by B1 and B2 and are bounded by those conditions.

As noted in DWR's testimony, operation of the WaterFix Project under Scenario B1 parameters "reflects a condition of less regulatory restriction on operations than the NAA. In this scenario, Delta outflow objectives are set per the D-1641 requirements. The Fall X2 and San Joaquin River inflow-export components from the Biological Opinions are not included in this scenario."[10] More specifically, scenario B1 does not include "additional spring Delta outflow, additional OMR [Old and Middle River] flows, existing I/E ratio, and the existing Fall X2 flow requirement imposed in the existing BiOp for Delta Smelt."[11]

[9] See Exhibit DWR-51, pp. 10:4–14.
[10] See Exhibit DWR-71, pp. 15:11–14.
[11] See Exhibit DWR-51, pp. 13:20–22.

In contrast,

> *"Boundary 2 reflects a condition of significantly increased delta outflow targets and increased restrictions on south delta exports as compared to the NAA... Delta outflow targets are significantly increased throughout the year, but particularly during winter and spring. More restrictive requirements were set for Old and Middle River (OMR) flows throughout the year that limit south Delta pumping substantially during January through June, and also impose further restrictions during July through December. In addition, modeling for Boundary 2 includes a fully-closed Head of Old River Gate during spring months which further reduces the amount of San Joaquin River water entering Old and Middle Rivers."*[12]

Scenario B2, which results in significant increases in Delta outflows, is not considered to be a realistic operational scenario. In its testimony, DWR states that the high outflow conditions were evaluated to "consider increases in outflow, without consideration of water supply benefits, and as such, an alternative that included this operational scenario would likely not meet the project objectives or purpose and need statement..."[13] DWR also stated that "the purpose of [boundary 2] is to demonstrate a scenario that has more restrictive Delta biological regulatory requirements."[14] It is therefore unlikely that the WaterFix project would be operated under parameters described by Scenario B2.

These Project model runs represent a wide range of operational scenarios; specifically, and compared to the NAA model results, Scenario B1 would result in about 1,200,000 acre-feet per year of *additional* exports, Scenarios H3 and H4 would result in about 500,000 acre-feet per year of *additional* exports, and Scenario B2 would result in 1,100,000 acre-feet per year *less* exports.[15] As detailed throughout this testimony, water quality impacts to the City are greatest under the B1 scenario, and most of the analyses presented in this testimony focus on model

[12] See Exhibit DWR-71, pp. 15:15–24.

[13] See Exhibit DWR-51, pp. 11.

[14] See Exhibit DWR-51, pp. 14:7–9.

[15] See Exhibit DWR-71, pp. 18:17–23.

scenarios describing the existing condition (EBC2), the NAA, and scenario B1. A summary of analysis results for additional scenarios (including Boundary 2 (B2), H3, and H4) is included in Appendix A.

In addition to the broad range of model scenarios, some information in DWR's testimony about project operations appears to be contradictory; specifically, and despite apparent statements to the contrary, one of the WaterFix model scenarios (Scenario B1) appears to be *inconsistent* with existing regulatory requirements.[16] Additionally, the criteria for some operational parameters, such as winter and summer outflow, are worded vaguely in the RDEIR/SDEIS: "Flow constraints established under D-1641 will be followed if not superseded by criteria listed above."[17] In this case, the "criteria listed above" comprises multiple pages of tables, and it is unclear which criteria are being referred to.

The limited discussion of operational flexibility in the RDEIR/SDEIS is particularly noteworthy for the City. It indicates that operations will be modified based on impacts to fish species, including critically important operations parameters for both spring outflow (to be managed for longfin smelt)[18] and Fall X2 (to be managed for delta smelt).[19] Although spring outflow and Fall

[16] For example, Exhibit DWR-51 (testimony of Jennifer Pierre) pp. 12–13 states that "existing regulatory requirements that will not change include: terms imposed through D-1641… water quality objectives… E/I ratio… Fall X2 flow." However, the Pierre testimony at pp. 13–14, in describing the Boundary 1 (B1) model scenario, states that "Boundary 1/Existing Outflow represents an operational scenario with most of the existing regulatory constraints… but does not include additional spring Delta outflow, additional OMR flows, existing I/E [*sic*] ratio, and the existing Fall X2 flow requirement… Fall X2 is an area of active investigation in a multi-agency collaborative group, and its future implementation might be adjusted based on the outcome of those investigations so this scenario excluded it from Boundary 1." It is further unclear why DWR refers to the B1 scenario as the "Boundary 1/Existing Outflow" scenario, since the operating assumptions in the B1 model run differ significantly from the operations and requirements currently in use; since Scenario B1 would export approximately 1.2 maf of water more than the NAA, and 0.9 maf more water than the EBC2, it should not be considered an existing outflow scenario.

[17] See Exhibit SWRCB-3 (RDEIR/SDEIS) at p. 4.1-10, Table 4.1-2. "New and Existing Water Operations Flow Criteria and Relationship to Assumptions in CALSIM Modeling" regarding the operations parameter "winter and summer outflow."

[18] See p. 4.1-9 of SWRCB-3 (the RDEIR/SDEIS), which indicates that, for spring outflow: "To ensure maintenance of longfin smelt abundance, initial operations will provide a March-May average outflow bounded by the requirements of Scenario H3, which are consistent with D-1641 standards, and Scenario H4, which would be scaled to Table 3-24 in Chapter 3, Section 3.6.4.2 of the Draft EIR/EIS… Adjustments to the criteria above and these outflow targets may be made using the Adaptive Management Process and the best available scientific information available [*sic*] regarding all factors affecting longfin smelt abundance."

X2 are critical determinants of water quality in the western Delta, there is no indication in the RDEIR/SDEIS or in the WaterFix testimony that operations would be constrained to avoid increases in salinity in the western Delta or to avoid impacts to M&I beneficial uses.

Finally, Water Code § 85086(c)(2) requires that appropriate Delta flow criteria be established. However, Delta flow criteria have not been established to date and have not been incorporated into the WaterFix Project modeling, resulting in additional uncertainty regarding project operations and project impacts.

As a result of the uncertainty in the operation of the WaterFix Project, it is difficult to predict with any certainty the water quality impacts that will occur at the City's intake. As described below, Exponent's analysis of project impacts focused on Scenario B1.

### c. The Adaptive Management and Monitoring Program is undefined.

DWR has stated that the WaterFix project will operate initially to Scenarios H3 or H4 and that these operations will be modified using the AMMP, ultimately (presumably) operating within the broad boundaries defined by Scenarios B1 and B2. The AMMP is to be implemented to develop additional science during the course of project construction and operation and to inform and improve conveyance facilities operational limits and criteria; the AMMP is anticipated to result in modifications to operations of the north Delta bypass flows, south Delta export operations, head of the Old River barrier operations, spring Delta outflows, and the Rio Vista minimum flow standard in January through August.

The AMMP is included within the RDEIR/SDEIS as a means to accommodate flexibility in the proposed project that is required due to the "considerable scientific uncertainty… regarding the Delta ecosystem, including the effects of CVP and SWP operations and the related operational

[19] For example, p. 4.1-9 of SWRCB-3 (the RDEIR/SDEIS) indicates that "September, October, November implement the USFWS (2008) BiOp Fall X2 requirements. However, similar to spring Delta outflow and consistent with the existing RPA adaptive management process, adjustments to these outflow targets may be made using the Adaptive Management and Monitoring Program described below and the best available scientific information regarding all factors affecting delta smelt abundance."

criteria." It is well established that there is substantial uncertainty in the Delta ecosystem, and an adaptive management strategy is necessary; however, an adaptive management strategy should not be used as a means to circumvent project planning.

RDEIR/SDEIS proposed project Alternative 4A relies heavily on the AMMP to dictate changes in operation of water conveyance facilities, habitat restoration, and other factors during project construction and operation. The AMMP is a central component of the WaterFix Project yet remains almost wholly undefined. Beyond an introduction to basic principles of adaptive management, there is little discussion in the RDEIR/SDEIS of how the AMMP will be implemented, nor does it appear that there will be a review process for the considerable changes that may be recommended as a result of the AMMP. Although the AMMP is described as a means of making adjustments to operations criteria, there is no discussion of how this iterative process will occur. In addition, no operational boundaries are defined with regard to potential application of the AMMP that would operate to reduce increased salinity caused by WaterFix and the operations of the State and Federal Projects.[20] Presumably, the AMMP would allow operations consistent with the B1 operating scenario; as detailed in these comments, operating to Scenario B1 operations criteria would result in significant increases in salinity at the City.

The RDEIR/SDEIS indicates that "collaborative science and adaptive management will, as appropriate, develop and use new information and insight gained during the course of project construction and operation to inform and improve… the operation of the water conveyance facilities under the Section 7 biological opinion and 2081b permit…" As with the discussion of project operations, the RDEIR/SDEIS appears to indicate that the only factor that will be considered in modifying operations will be impacts to fish. The City is concerned that an AMMP focused solely on fish will fail to consider potential impacts to other beneficial uses, including the potentially substantial water quality impacts to municipal and industrial uses that could be induced by even modest changes to project operations.

[20] The Delta Independent Science Board also noted the lack of clarity regarding the adaptive management program. Specifically, SWRCB-49 states at p. 5, "The lack of a substantive treatment of adaptive management in the Current Draft indicates that it is not considered a high priority or the proposers have been unable to develop a substantive idea of how adaptive management would work for the project" and there were no "examples of how adaptive management would be applied to assessing—and finding ways to reduce—the environmental impacts of project construction and operations."

Considering the previous discussion and considering the water quality impacts that would occur at the City as a result of the implementation of scenario B1 parameters (see Opinion 2), it is unreasonable and without foundation for the RDEIR/SDEIS to state, "For the purposes of analysis, it is assumed that the Collaborative Science and Adaptive Management Program (AMMP) developed for Alternative 4A would not by itself, create nor contribute to any new significant environmental effects."[21]

### d. DWR's evaluation of compliance with Water Quality Objectives is inadequate.

Although DWR provided exhibits intended to illustrate compliance with D-1641, these exhibits do not confirm compliance. For example, DWR states that Exhibit DWR-513 is intended to show compliance with D-1641:

> *"Exhibit DWR-513, Figures CL1-CL3 show the simulated chloride concentrations at Contra Costa Canal, Old River near Clifton Court, and Barker Slough/North Bay Aqueduct. (Exhibit DWR-513, pp.4-5). At all these locations there is year round D-1641 chloride concentration objective to be at or below 250 mg/L. Model results show that the monthly average chloride concentrations for all alternatives at these locations stay below this threshold."*[22]

However, D-1641 objectives for M&I beneficial uses are to be evaluated as "maximum mean daily" chloride (see Table 1). DWR states that "[s]ince CalSim II is a model with a monthly time-step and a number of daily D-1641 objectives are active during only portions of a month (e.g. April 1 to June 20 and June 20 to August 15), D-1641 objectives are calculated as a monthly weighted average."[23]

Exhibit DWR-513 (Figure CL1) was recreated to include the EBC2 scenario as shown in Figure 3. Note the values shown are on the order of a few percent lower than those shown in DWR-513

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[21] See Exhibit SWRCB-3 (RDEIR/SDEIS) at p. 4.1-18.

[22] See Exhibit DWR-66, pp. 6:21–26

[23] See Exhibit DWR-71, pp. 5:16–18.

CL1, likely because we are unclear which EC to chloride conversion was used by DWR in the preparation of DWR-513, and we may have used a slightly different relationship to convert EC to chloride (for details regarding salinity conversions see Section 3f).

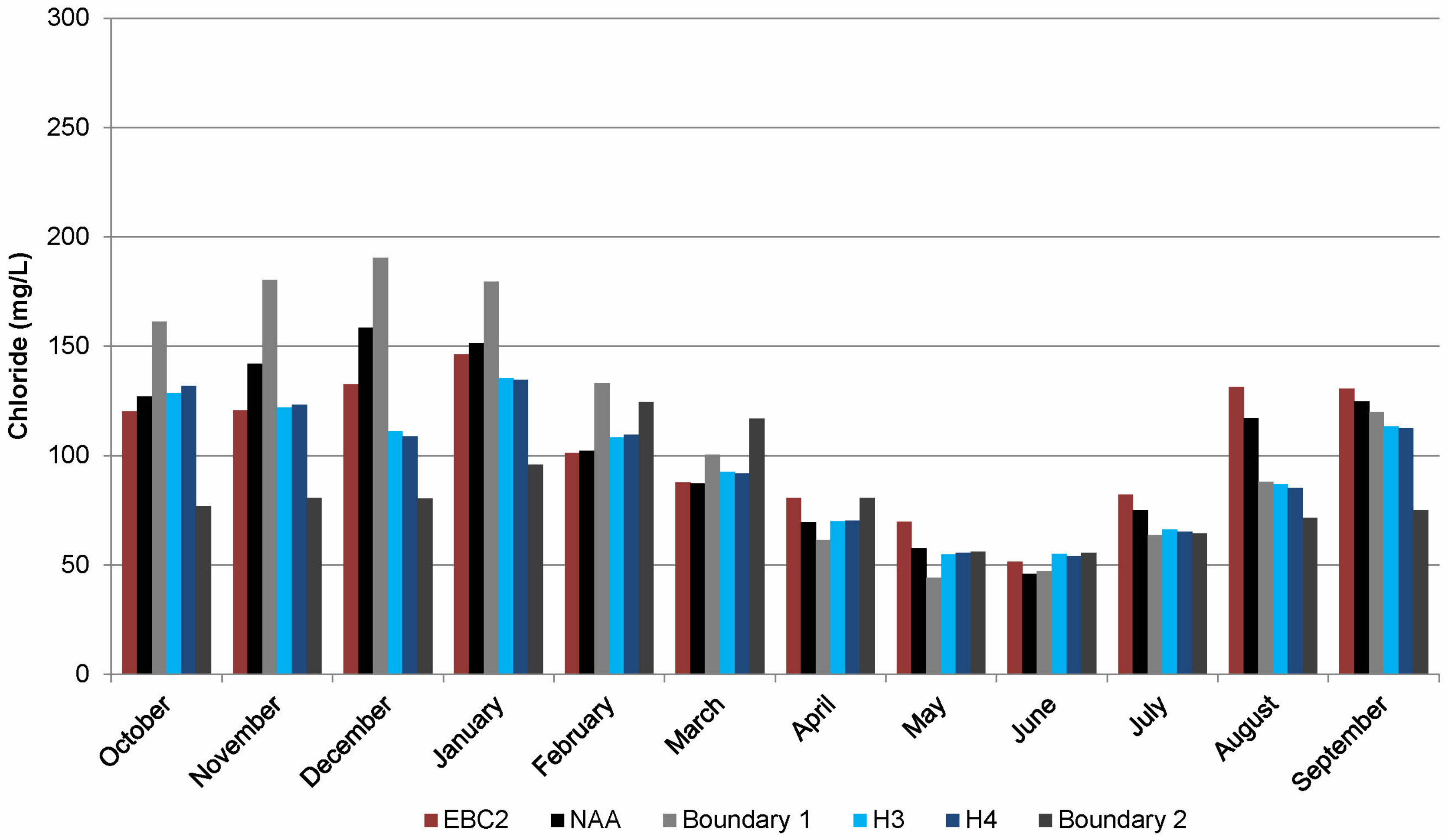


Figure 3. Monthly average chloride concentration at PP#1 from the 16-year modeled record. Note that the bars for the NAA, Boundary 1, H3, H4, and Boundary 2 scenarios were provided by DWR in DWR-513 (values may differ slightly due to different salinity conversions); Exponent has added the bar representing the existing condition (EBC2) scenario as modeled by DWR.

The model results presented in Figure 3 and those presented in DWR-513 do not provide model results or analysis to confirm that *daily* chloride concentrations are expected to meet D-1641 water quality standards. In fact, DWR has averaged the data in two ways: first, DWR calculated monthly average chloride concentrations from simulation results, and, second, DWR averaged the monthly average chloride concentrations for each month (e.g., each January) in the 16-year simulation period. Much of the variability from changes in natural hydrology or SWP/CVP operations is lost when DWR's 16-year simulation record of 15-minute interval data are averaged to monthly timesteps and when those monthly timesteps are then averaged over a 16-year simulation period.

As an example of how averaging to monthly timesteps and across multiple years results in a loss of information, Figure 4 shows daily average chloride concentrations simulated for WY 1978 and WY 1979. Figure 4 shows that the 250 mg/L threshold is exceeded from early October 1977 through early January 1978 for Scenarios NAA and B1 and again from late December through the end of February for the B1 scenario. The existing condition (EBC2) scenario exceeds the 250 mg/L chloride threshold for a few days in early January 1977 as well but not during the remainder of the time period shown in Figure 4. Figure 5 shows the daily average chloride concentrations from Figure 4 superimposed on the long-term monthly average concentrations presented by DWR, and reproduced here as Figure 3. Clearly, model results averaged both by month and over a 16-year period cannot be used to evaluate compliance with a water quality standard that is expressed in terms of *daily* chloride concentrations. Perhaps more importantly, M&I water purveyors, such as the City, operate intake facilities and manage water treatment operations to meet consumer demand on short timeframes (e.g., hourly); highly processed model results do not provide the information the City needs to assess the impacts of the WaterFix project on the City's drinking water operations.

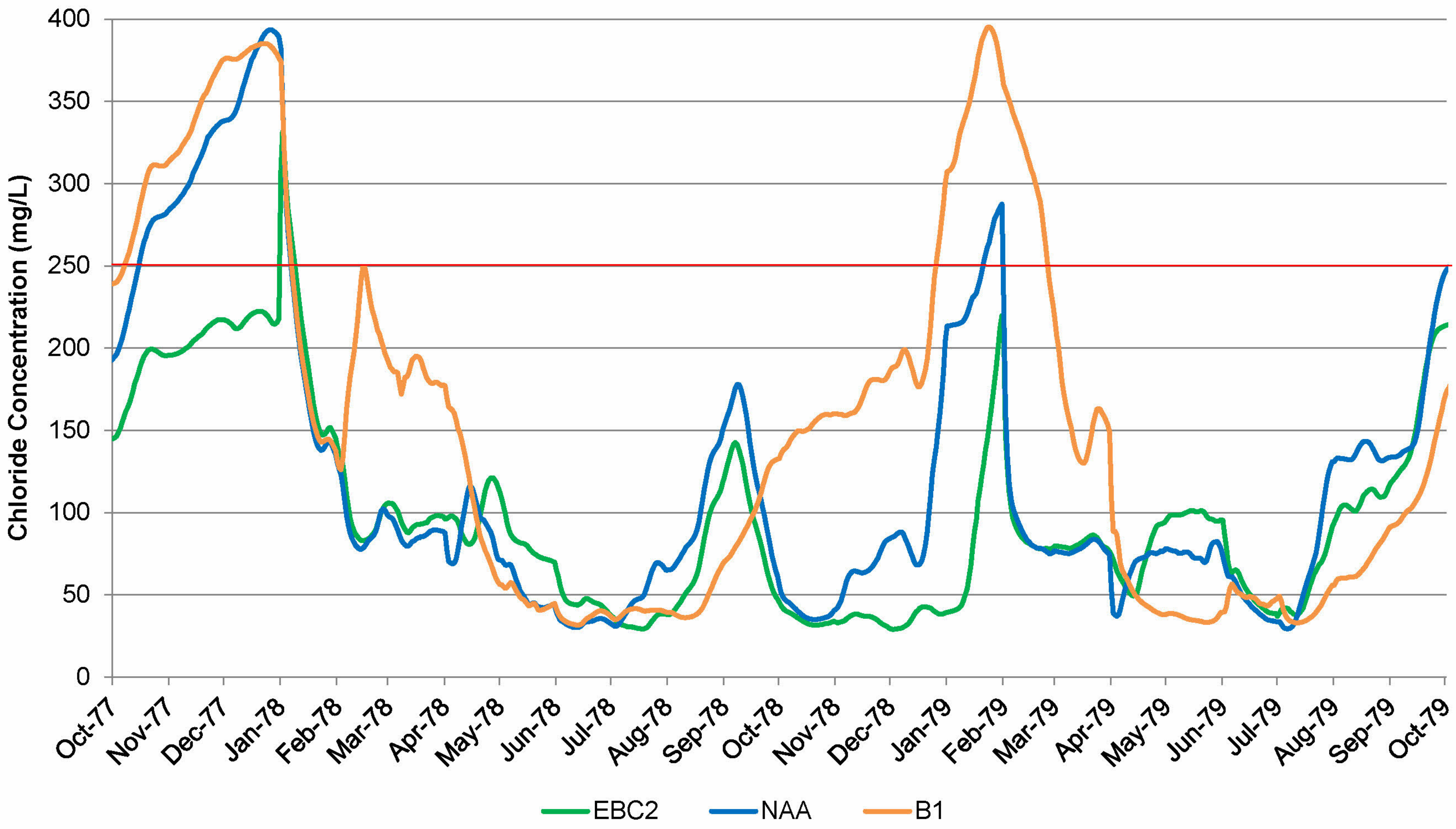


Figure 4. Daily average chloride concentrations at PP#1 for WY 1978–WY 1979, from DWR's model results. The red line indicates the 250 mg/L chloride threshold of D-1641.

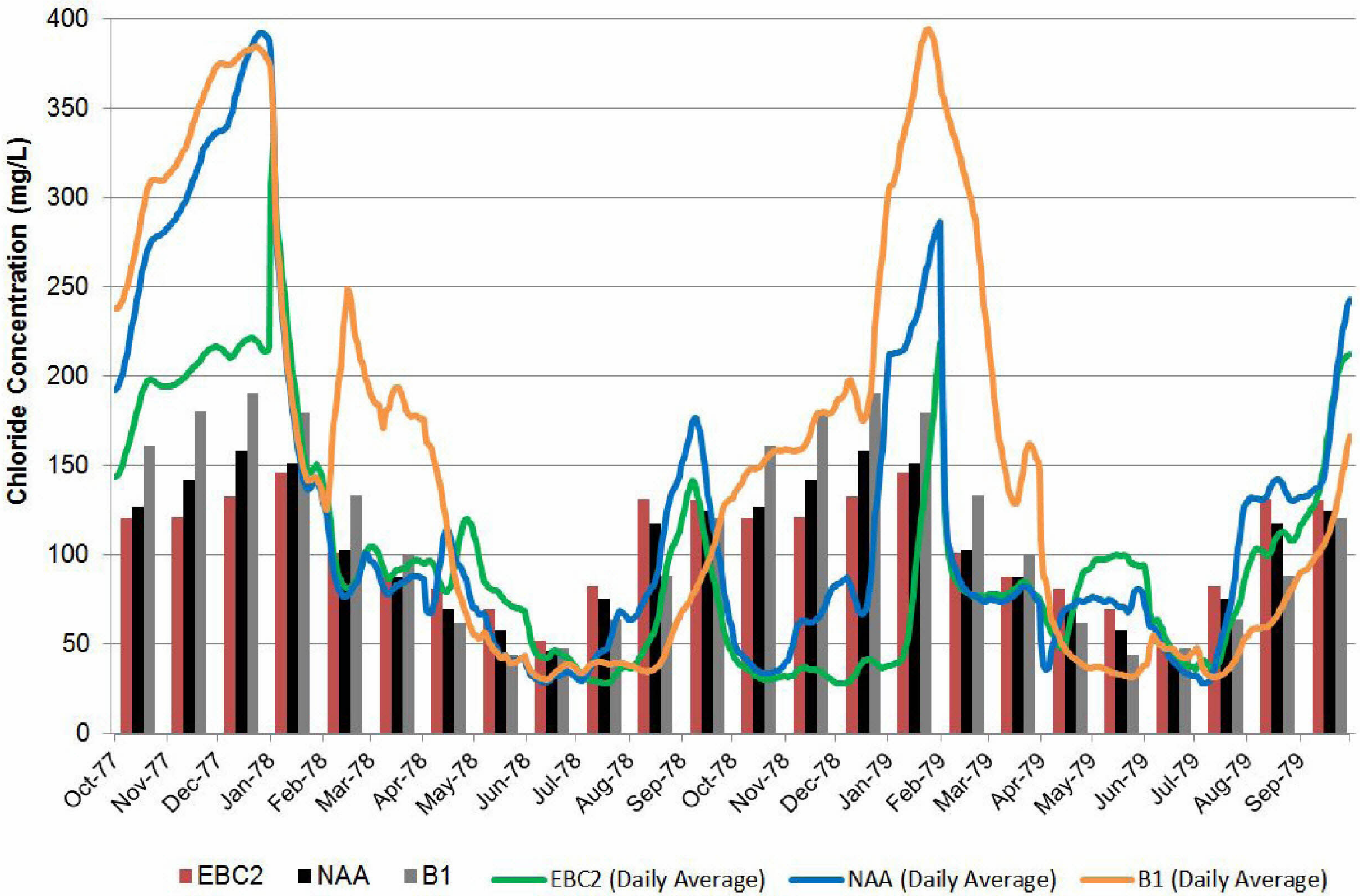


Figure 5. Daily average chloride concentrations at PP#1 for WY 1978-WY 1979 superimposed on the monthly averaged data presented in DWR-513 and recreated in Figure 3. The bars describing average salinity were repeated for each month in WY 1978 and 1979.

The problems with creating a long-term average of model results are also shown in Figures 6 through 9. Figures 6 through 9 show the same model results as Figure 3, averaged by water year classification (e.g., model results describing monthly average chloride concentrations for 1976, 1977, 1988, 1990, and 1991 were averaged to obtain the simulated monthly average chloride concentrations for critical years, as shown in Figure 6). As shown in Figure 7, the increase in the monthly average chloride concentrations in dry years is significantly higher for Scenario B1 than is indicated by the 16-year monthly average for Scenario B1 as shown in DWR-513 (see Figure 3). Monthly average chloride concentrations are simulated to exceed the 250 mg/L threshold of D-1641 in December and January of "normal" year types; for months with an average chloride concentrations between 200 and 250 mg/L (i.e., just below the 250 mg/L threshold of D-1641; see, e.g., November and December of critical and dry years), the 250 mg/L threshold is likely to be exceeded for some days during the month. Thus, not only is the D-1641 threshold for M&I beneficial uses likely to be exceeded, but it is clear that the WaterFix project can be expected to have significant impacts on the City's primary water supply.

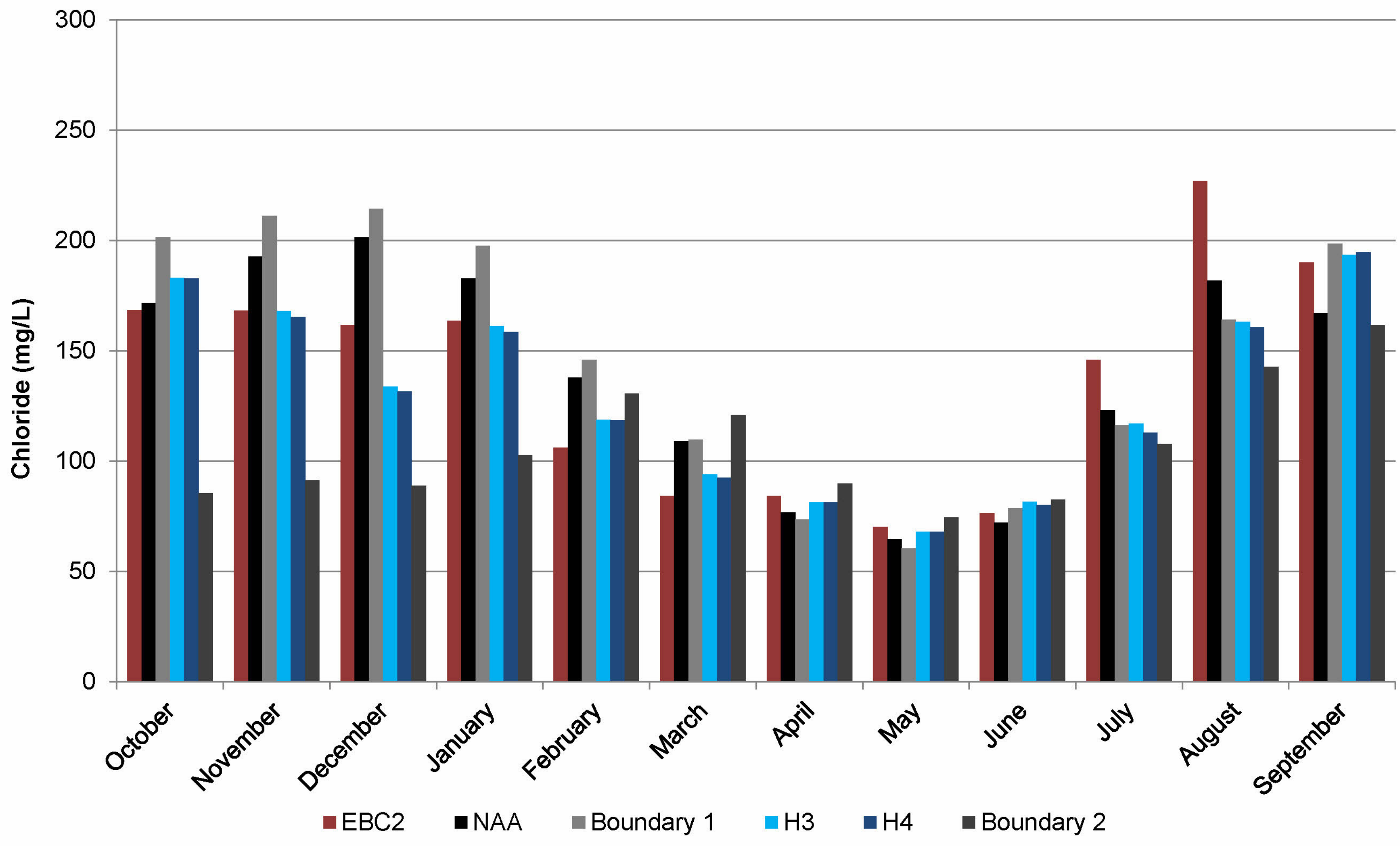


Figure 6. Modeled monthly average chloride concentrations at PP#1 in critical water years (1976, 1977, 1988, 1990, 1991). Calculated from DWR model results.

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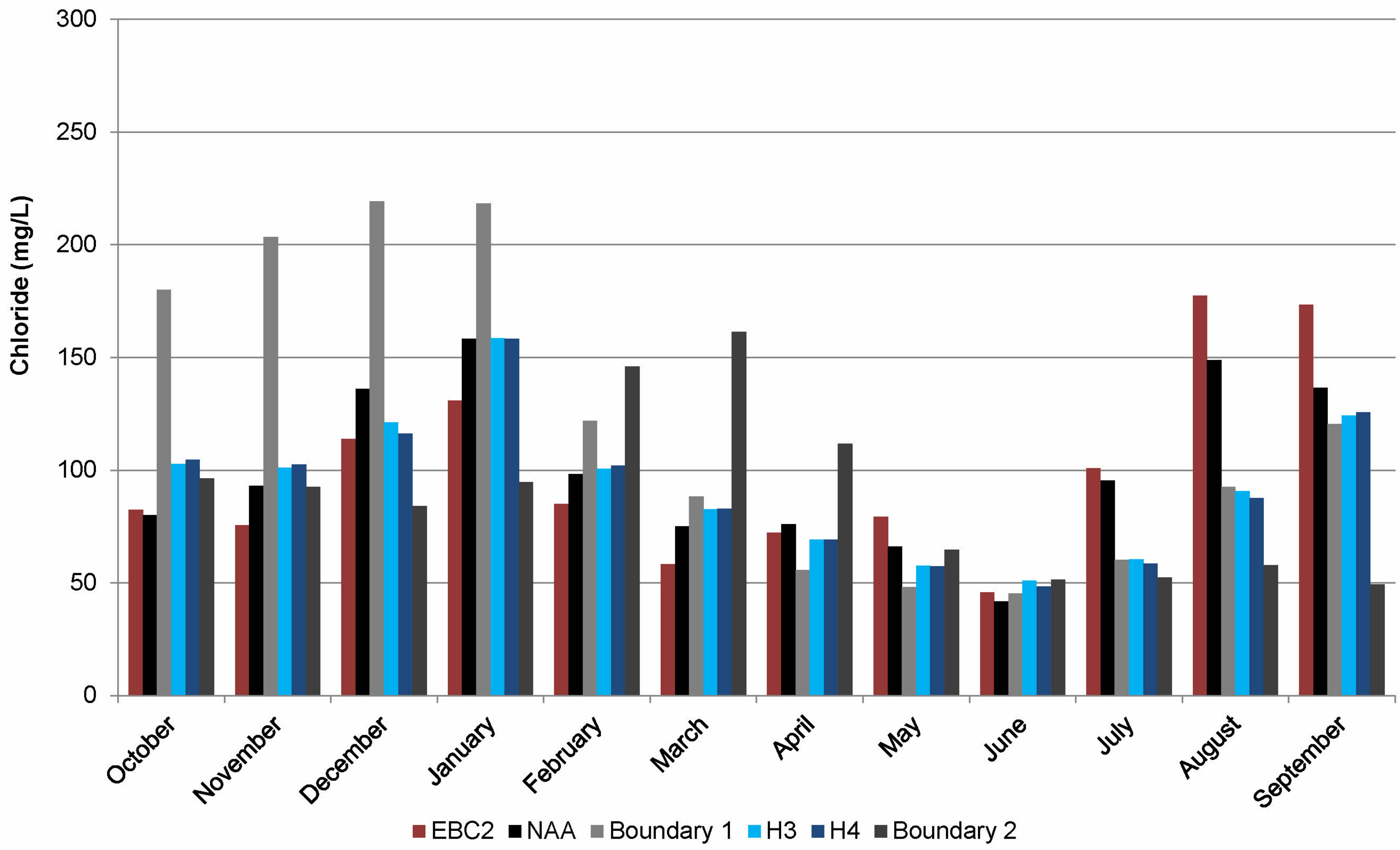


Figure 7. Modeled monthly average chloride concentrations at PP#1 in dry water years (1981, 1985, 1987, 1989). Calculated from DWR model results.

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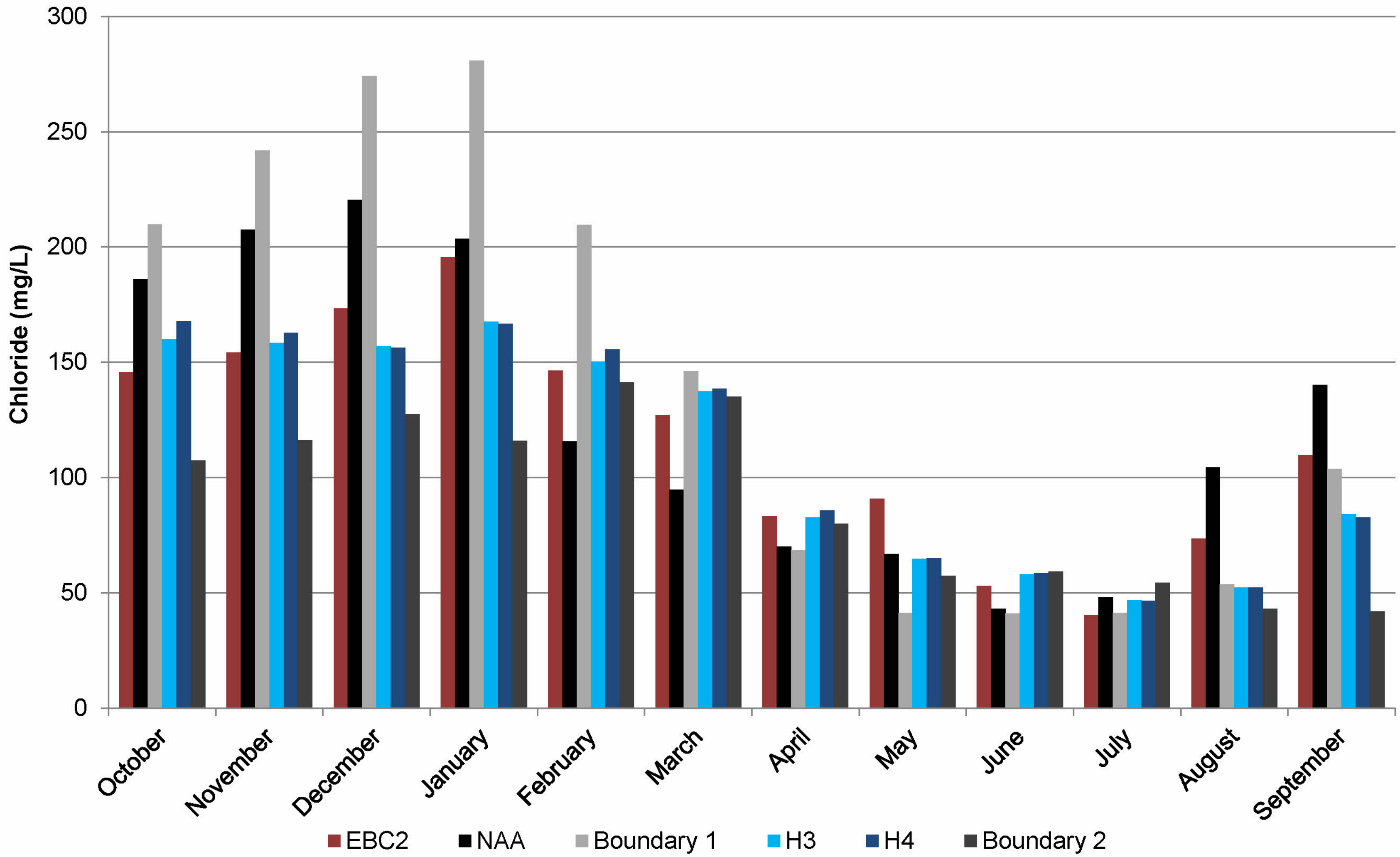


Figure 8. Modeled monthly average chloride concentrations at PP#1 in normal water years (1978, 1979, 1980). Calculated from DWR model results.

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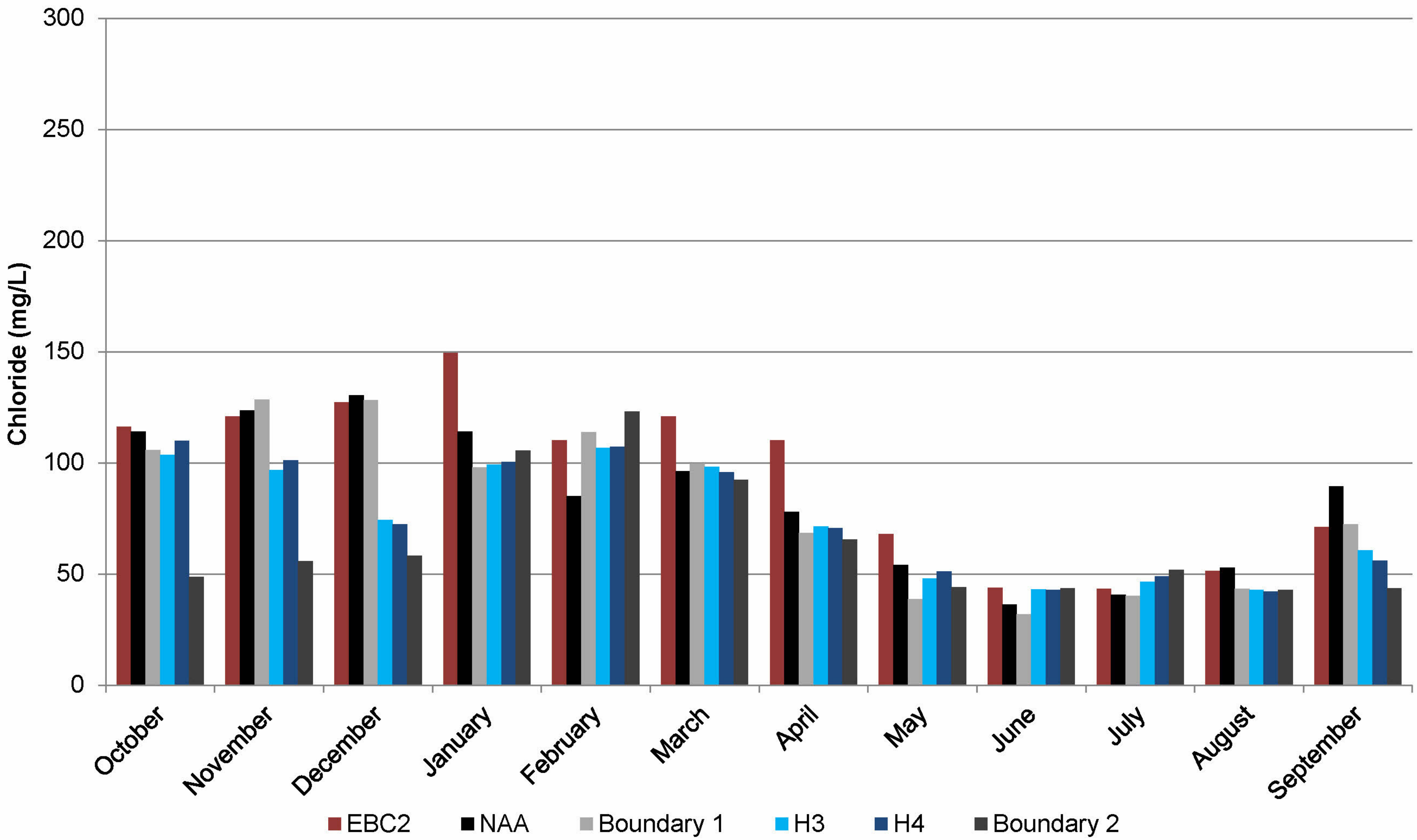


Figure 9. Modeled monthly average chloride concentrations at PP#1 in wet water years (1982, 1983, 1984, 1986). Calculated from DWR model results.

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Exponent also created figures to show the *difference* between the 16-year average monthly chloride concentrations (as shown in Figure 3) and the monthly average chloride concentrations for specific year types (as shown in Figure 6 through 9). Positive values indicate an increase in salinity for the month of that specific water year type relative to the 16-year average monthly concentration, and negative values indicate a decrease in salinity. These figures also illustrate how long-term averages can mask some of the variability in the model results. For example, Figure 11 shows that the difference between the 16-year average monthly chloride concentrations and the monthly average chloride concentrations for dry years for Scenario B1 is as much as 39 mg/L, or 20%. Similarly, Figure 12 shows that the salinity during October through March of normal water years will increase by as much as 101 mg/L (or 44%) in comparison to the 16-year average monthly data.

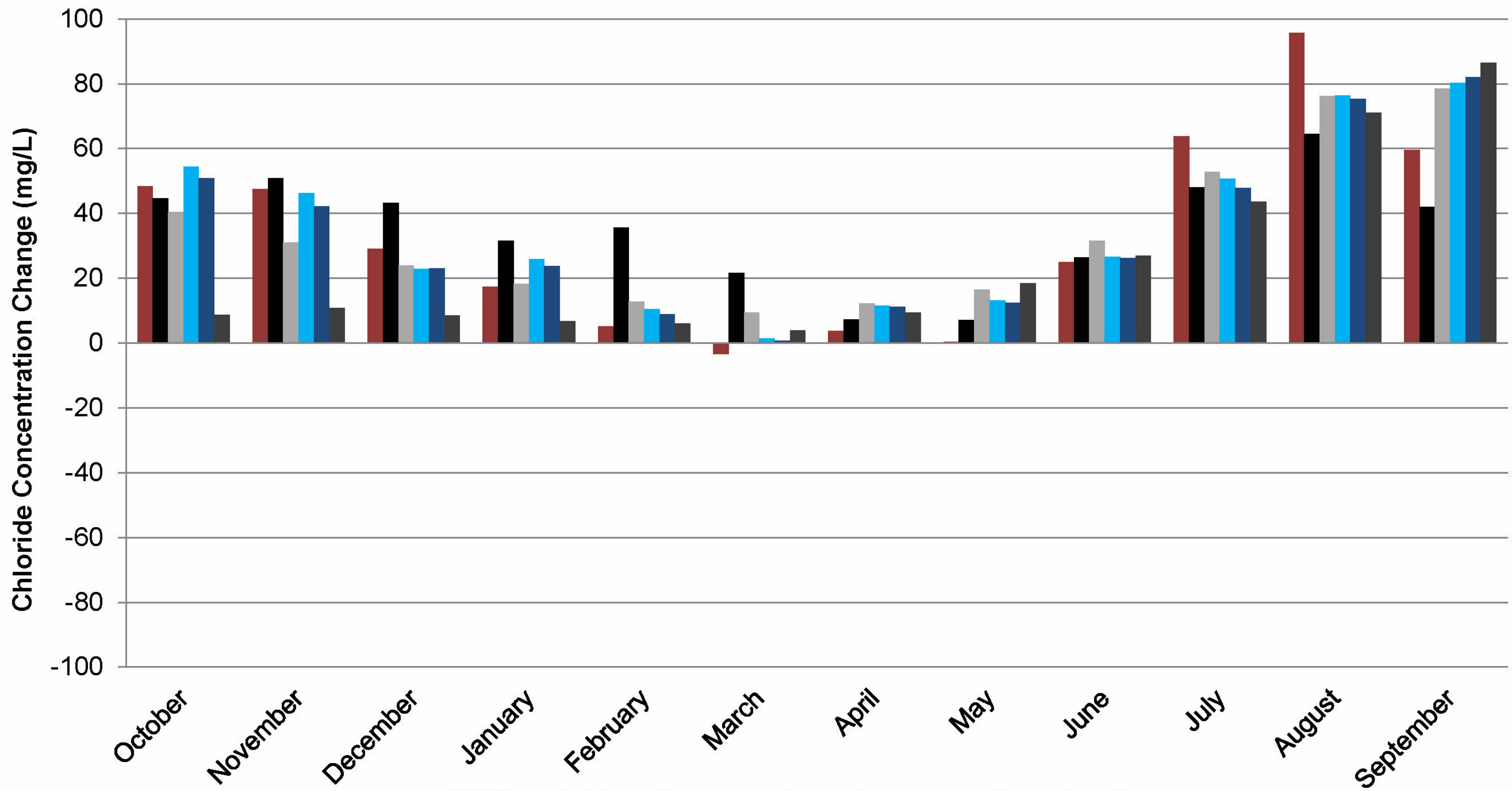


Figure 10. The difference between the 16-year average monthly chloride concentrations (as shown in Figure 3) and the monthly average chloride concentrations at PP#1 for critical water year types.

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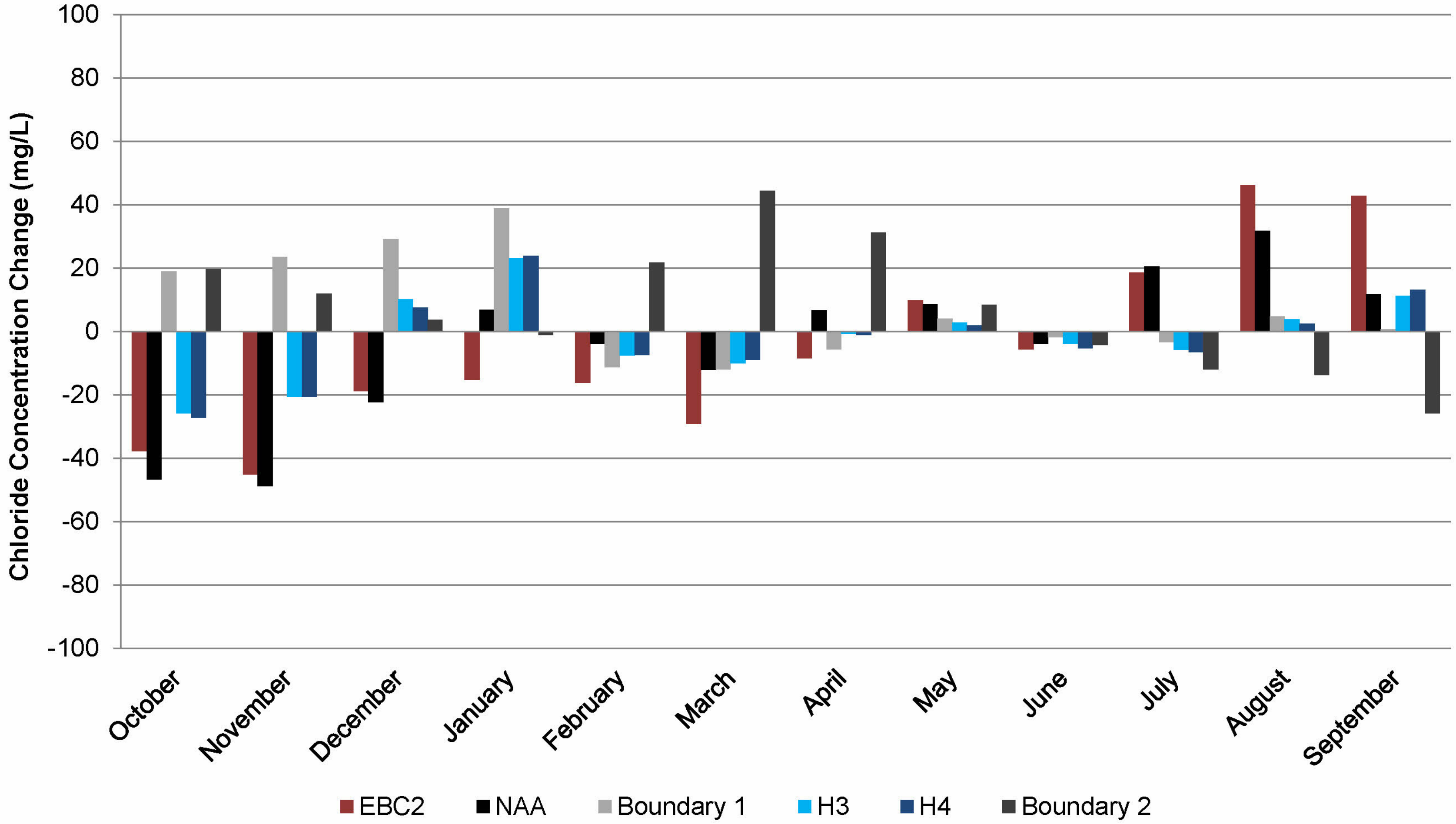


Figure 11. The difference between the 16-year average monthly chloride concentrations (as shown in Figure 3) and the monthly average chloride concentrations at PP#1 for dry water year types.

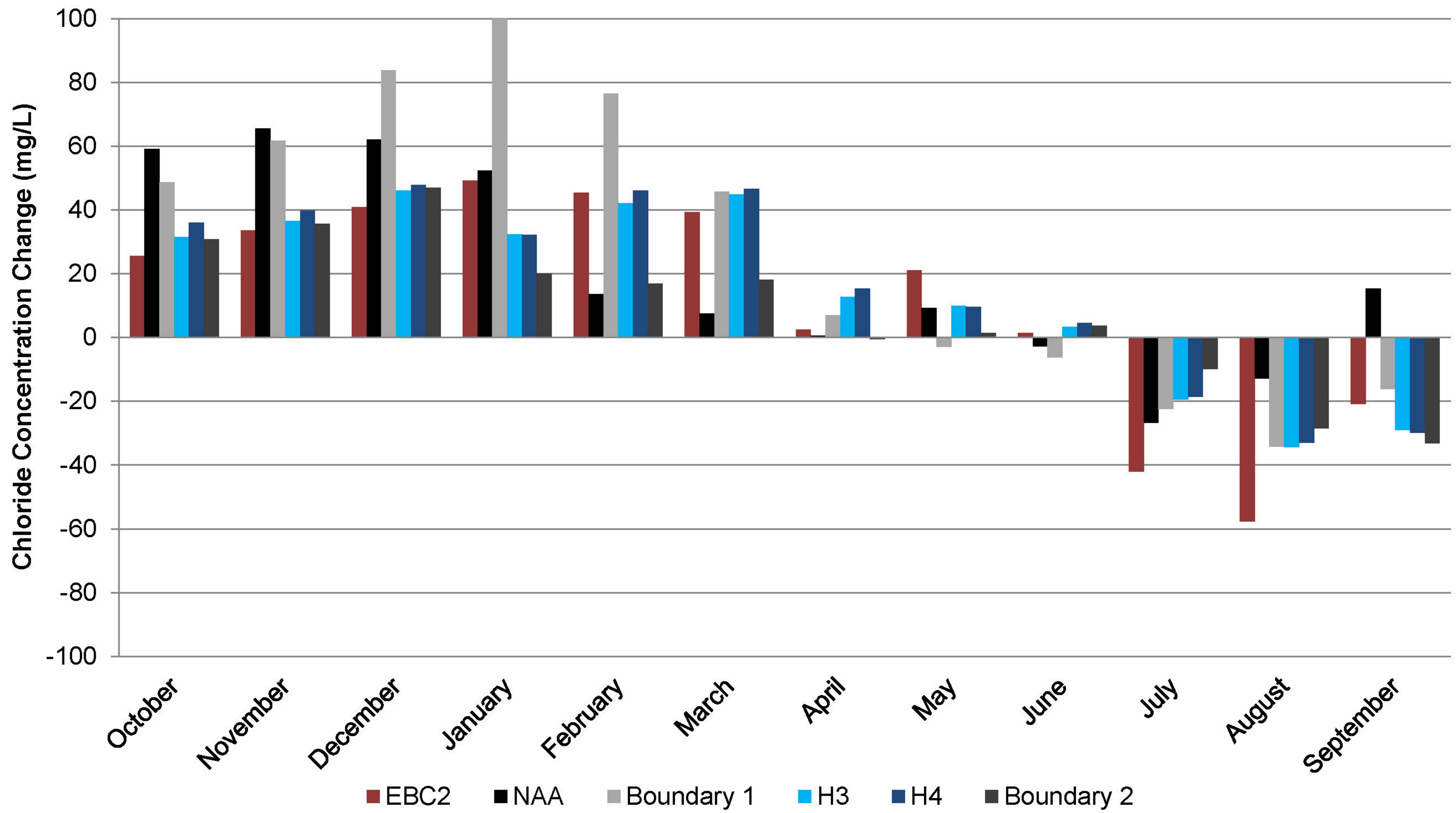


Figure 12. The difference between the 16-year average monthly chloride concentrations (as shown in Figure 3) and the monthly average chloride concentrations at PP#1 for normal water year types.

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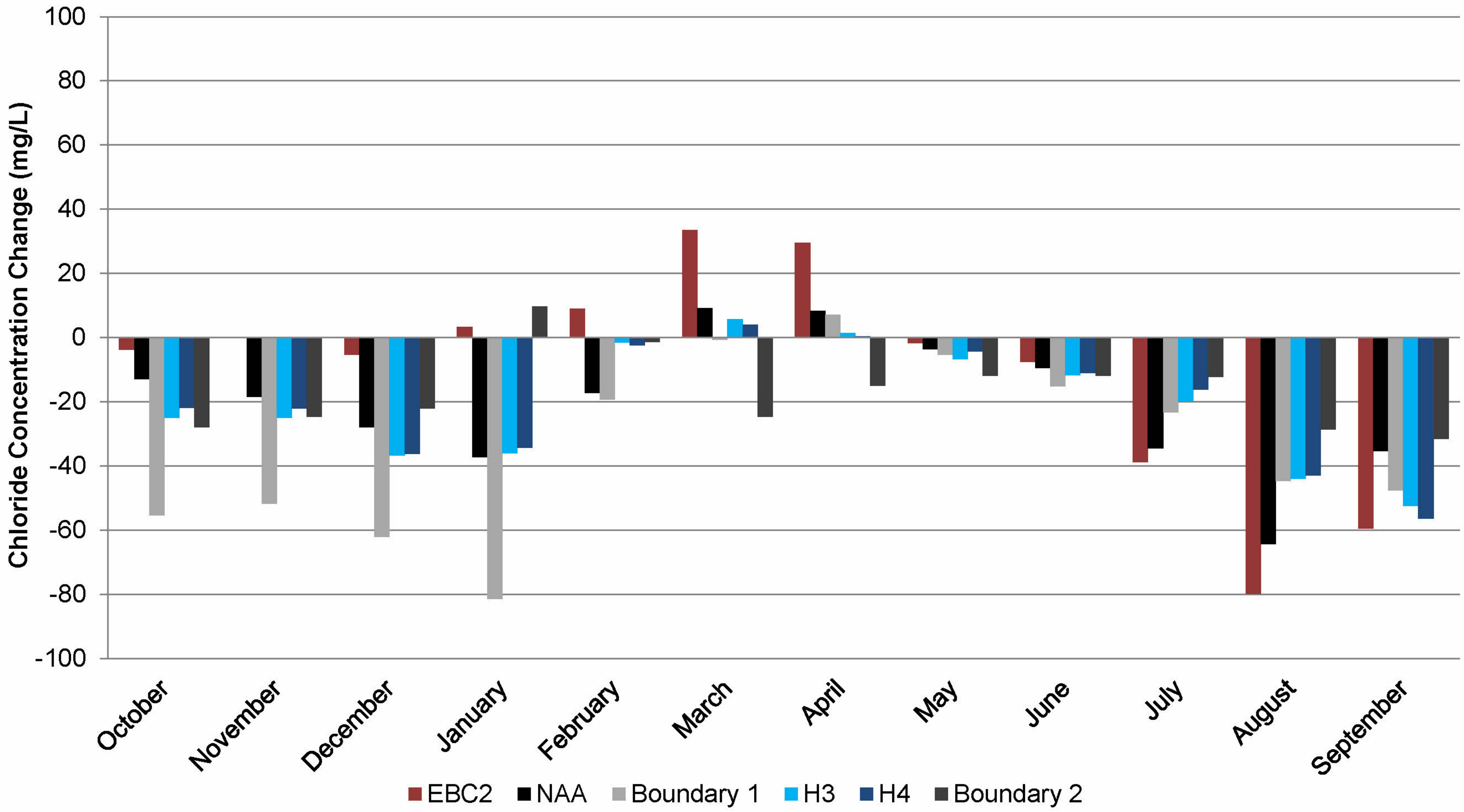


Figure 13. The difference between the 16-year average monthly chloride concentrations (as shown in Figure 3) and the monthly average chloride concentrations at PP#1 for wet water year types.

The D-1641 standards were written such that the 250 mg/L chloride standard was expressed as a "maximum mean daily" chloride concentration to be met on each day. The standard is not expressed as a monthly average, or as an average over many years, at least in part because long-term average chloride concentrations are not directly relevant to water users. As noted above, municipal and industrial water purveyors, such as Brentwood, operate intake facilities and manage water treatment operations to meet consumer demand on short timeframes (e.g., hourly); long-term average model results do not provide information suitable for determining the impacts of the WaterFix Project on the City's drinking water operations. DWR's analysis, when disaggregated to show daily and monthly variability, indicates that water quality in the Delta will be degraded and there will be reduced compliance with water quality objectives under Scenario B1.

# 6. Opinion 2: WaterFix will result in substantial changes in Delta hydrodynamics and degradation of Delta water quality.

## a. CWF will almost certainly export more water from the Delta in the future than is currently exported.

DWR's testimony indicates that operational scenario B1 would result in an average of about 1,200,000 acre-ft per year of additional exports, while scenarios H3 and H4 would result in about 500,000 acre-feet per year of additional exports. Although operational scenario B2 would result in less water exported from the Delta, it appears that this scenario is unlikely to be implemented, as it would not "meet the project objectives or purpose and need statement."[24] Because Delta channels are below sea level, they will always contain water, but the source of the water in the interior Delta will change as water is exported from the system. As a basic mass balance, if more fresh water is removed from the system, Delta outflow will decline, and higher salinity water from San Francisco Bay will flow into the Delta. Similarly, if more water is removed from the NDD and less water is removed from the South Delta, the residence time and composition of water in the South Delta will change over time.

A detailed review of the modeling conducted for the proposed WaterFix Project confirms that the amount of water that would be exported from the Delta would increase for most model scenarios: "Model simulations suggest significant changes in south of Delta deliveries to SWP and CVP service contractors. The boundary scenarios reflect a range of a 34 percent increase to a 33 percent decrease in deliveries to these contractors."[25]

Figure 14 shows the amount of water that would be exported from the Delta under the model scenarios EBC2 (existing condition), NAA (no action alternative), and B1 (high export scenario). Exports in the B1 scenario are divided to show the location from which water was exported from the Delta in the model simulations: either from the South Delta or from the NDD.

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[24] See Exhibit DWR-51, pp. 11:10–11.

[25] See Exhibit DWR-71, pp. 20:20–22.

(Of course, both the EBC2 and NAA scenarios would involve exports from the South Delta only.) The results in Figure 14 are averaged by water year type (i.e., export quantities were calculated for each month in the simulation period and averaged by month for each year type [wet, normal, dry, and critical]). The total amount of water exported from the Delta in the Boundary 1 scenario is generally greater than the amounts exported in the EBC2 and NAA scenarios during the spring in all year types. During May of normal water years, for example, modeled exports from Jones and Banks pumping plants are on the order of 2,000 cfs for EBC2 and NAA but are simulated to increase to approximately 8,500 cfs under B1 operations. During dry years, exports under scenario B1 increase for the months of October, November, and January through May by as much as 3,000 cfs (simulated mean increase in March of dry years). The annual average simulated Delta exports for Scenario B1 and for scenarios EBC2 and NAA for each water year type are shown to the right-hand side of each figure. With the exception of critical water years, the annual average volume of water exported under Scenario B1 is greater than that for the EBC2 and NAA scenarios. During wet and normal water years, an additional 1,000 cfs (approximately) is exported monthly for the B1 scenario compared to EBC2 and NAA.

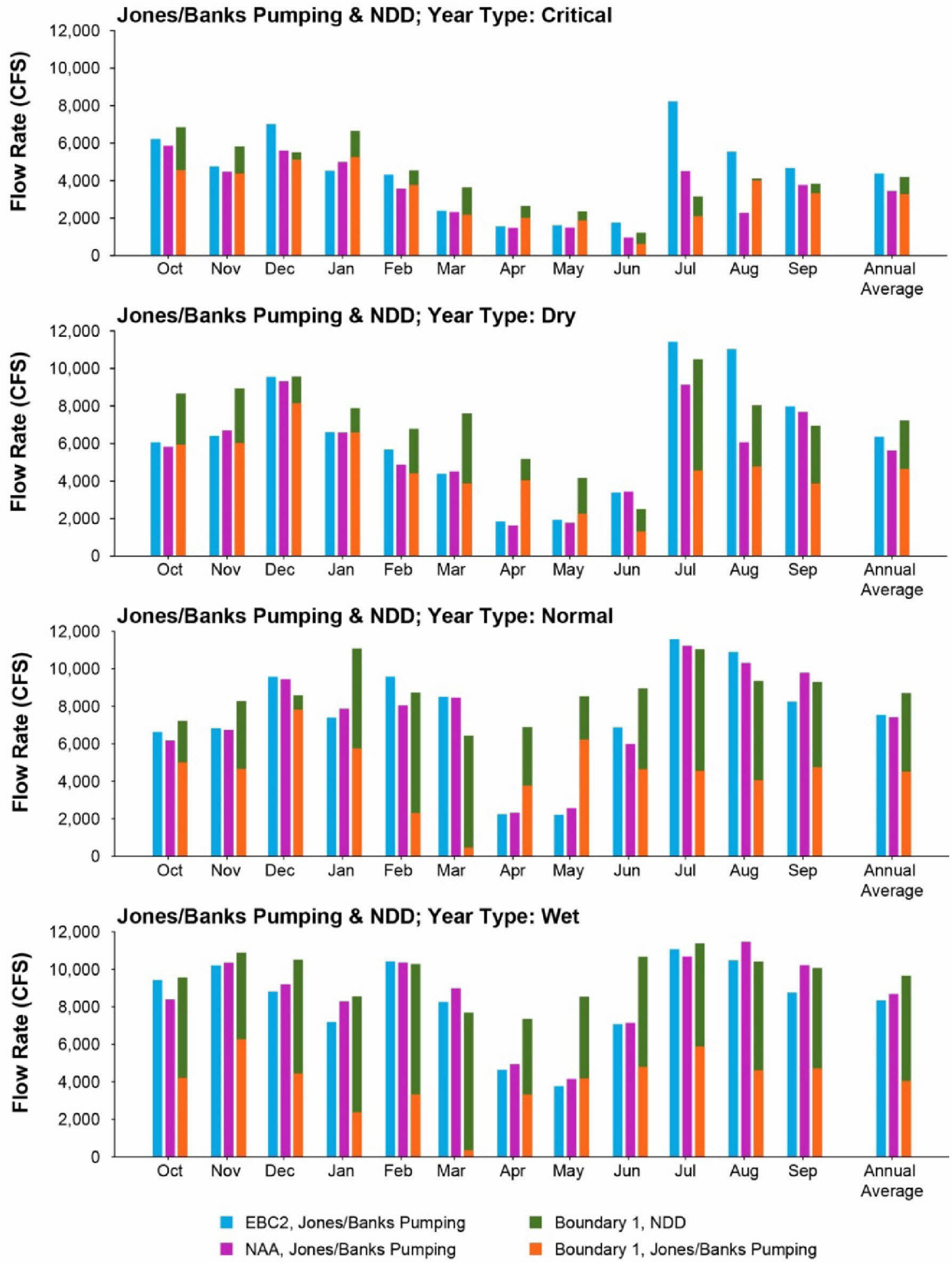


Figure 14. Quantity of water that would be exported from the Delta under the model Scenarios EBC2, NAA, and B1 as modeled by DSM2. Exports in the B1 scenario are divided to show the location from which water was exported from the Delta in the model simulations: either from the South Delta or from the NDD. Results are averaged by water year type.

### b. Not only will the CWF remove more water from the Delta, the CWF will remove a greater fraction of Sacramento River water than current project operations, resulting in changes in the composition and quality of water within the Delta.

Because the new NDD intakes are located on the Sacramento River in the northern part of the Delta, water exported from these locations will consist almost entirely of Sacramento River water. In contrast, water exported from the South Delta pumping locations consists of water from several sources, including the Sacramento River, the San Joaquin River, eastside streams, and agricultural return flows; the relative fractions of these sources varies from year to year and season to season. To evaluate the source of the water at PP#1 under the various model scenarios, we used DWR's model input files to conduct fingerprinting runs using the DSM2 model, as described in Section 3a.

The source of water in the Delta largely determines the water quality, including the salinity, of water within the Delta. In general, the salinity of the Sacramento River is low, about 100 mg/L TDS; the salinity of water in the eastside streams is also low, typically less than 100 mg/L TDS. In 2015, the salinity of the Sacramento River was 106 mg/L TDS on average and ranged from 75 to 166 mg/L TDS (see Section 3f). In contrast, the salinity of the San Joaquin River varied seasonally in 2015 from 48 to 776 mg/L TDS (average 343 mg/L TDS). San Joaquin River water is typically higher in salinity, bromide, and other chemicals than water from other freshwater sources to the Delta (Brentwood-114). Agricultural return flows are also a source of salinity (and other constituents) to the Delta. Agricultural return flows have elevated salinity levels as a result of the concentration of salts from soils, from fertilizers used within the Delta, and from evaporation of water applied for irrigation (Brentwood-115). Although there are many individual locations of agricultural return flows, few have been characterized with respect to salinity levels or flow rates. It has been estimated that, in the San Joaquin River at Vernalis, agricultural surface runoff occurring upstream of Vernalis accounts for up to 43% of total salt loading in the San Joaquin River at Vernalis (Brentwood-114), based on historical data 1977–1997). Bay water, as recorded at Martinez (the western boundary of the DSM2 model) varies from nearly fresh in times of high Delta outflow to 32,000 mg/L TDS during the fall months of dry years.

As shown in Figures 15 and 16, the fraction of Sacramento River water at the City's intake in most months of most year types for operational scenario B1 is less than both the existing condition (EBC2) and NAA scenarios (i.e., less Sacramento River water is expected to be present at the City's intake with implementation of the WaterFix project than is present now or than would be present in the future if the WaterFix project is not built). The fraction of Sacramento River water is generally higher for the EBC2 scenario than for the NAA scenario. As the Sacramento River water fraction declines, the San Joaquin River water fraction increases. For example, during February of normal water years, the fraction of Sacramento River water is 40% less for Scenario B1 than for existing conditions, while the fraction of San Joaquin River water is nearly 30% greater. During March of wet water years, the San Joaquin River fraction at the City's intake is nearly 80% in Scenario B1, while under existing conditions it comprises only 30%. During dry and critical years the differences are subtler.

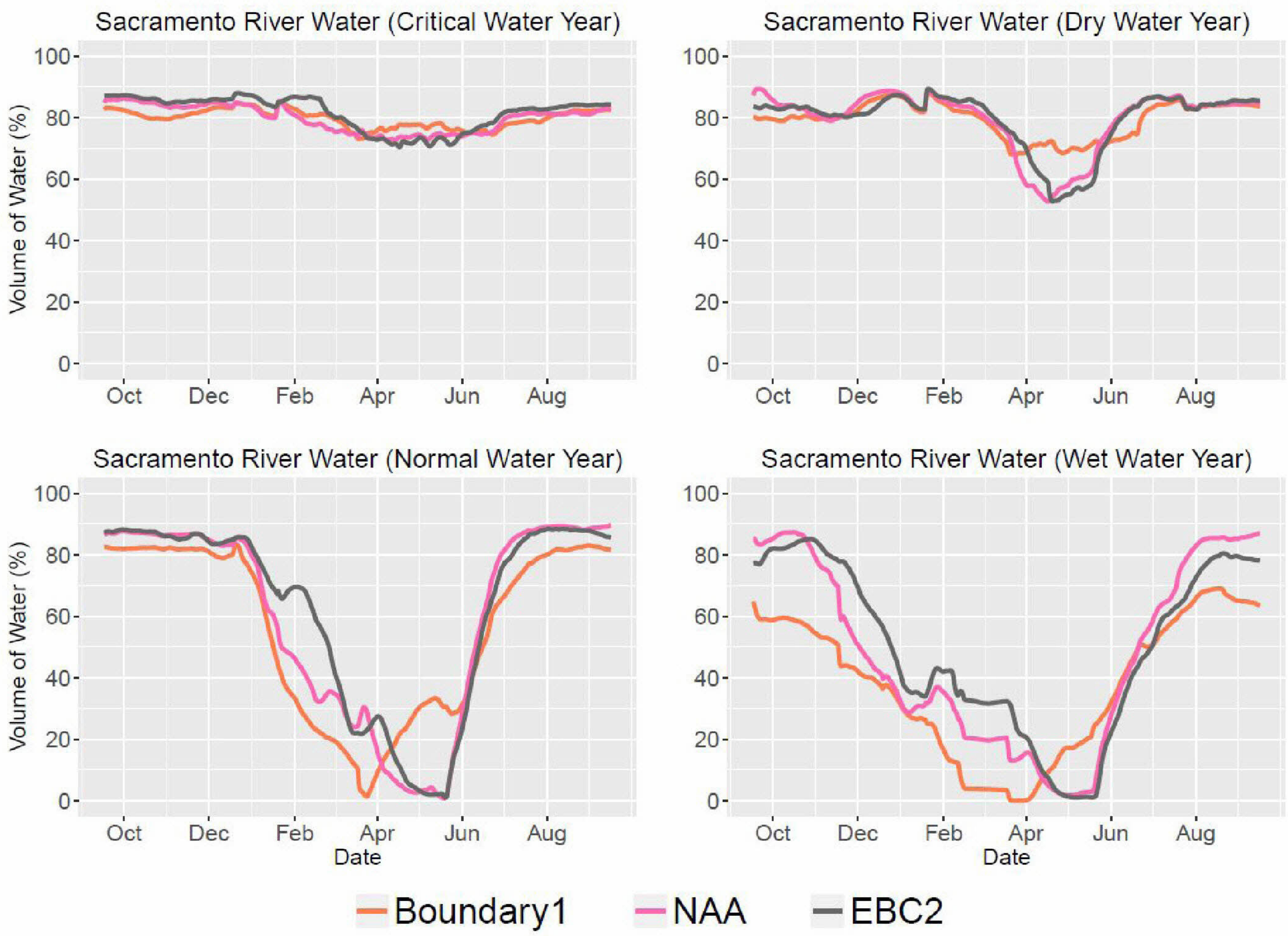


Figure 15. Source fractions of Sacramento River water at PP#1 as modeled by DSM2. Each figure represents the average daily source fraction of Sacramento River water averaged for a given water year type.

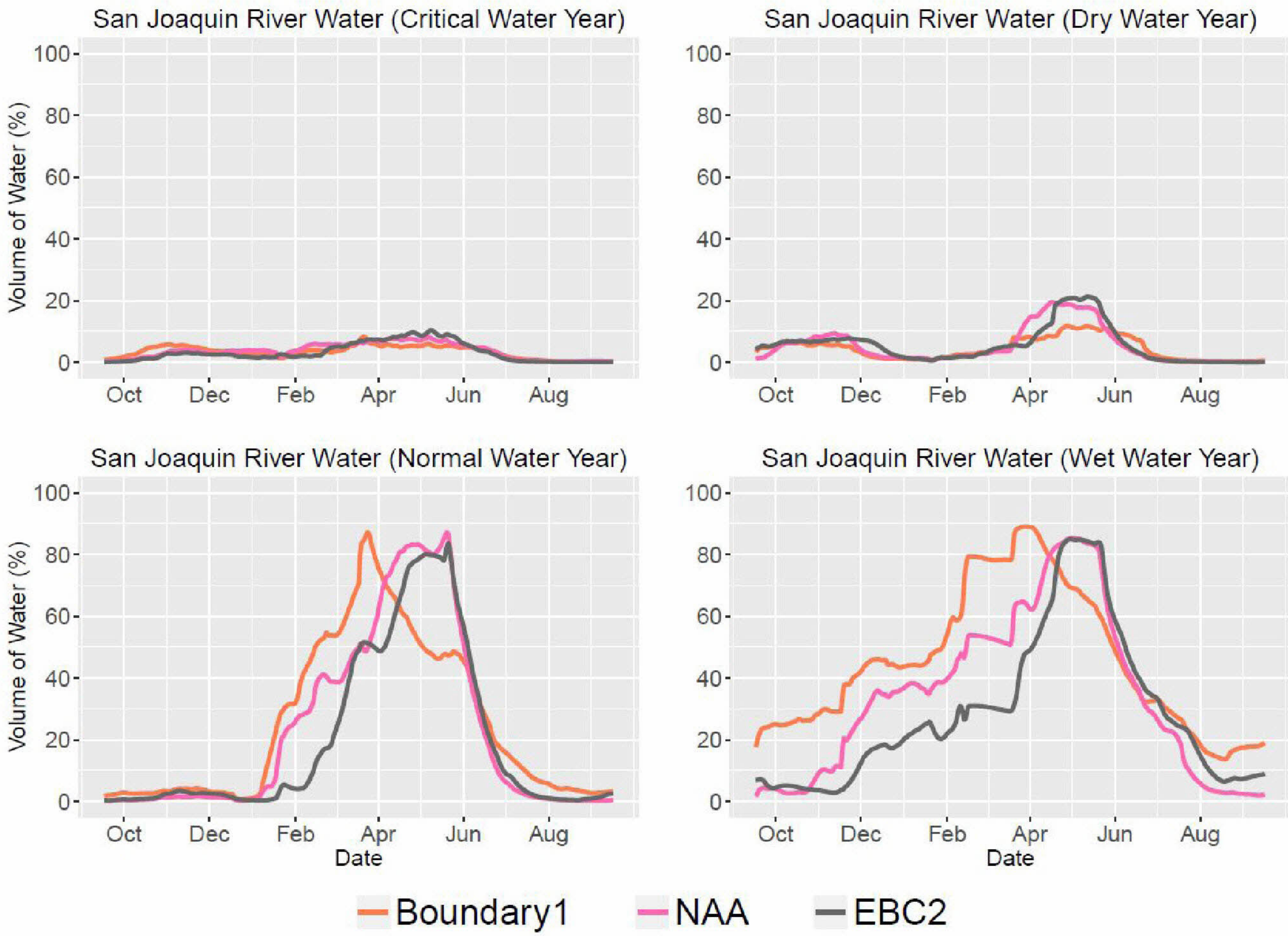


Figure 16. Source fractions of San Joaquin River water at PP#1 as modeled by DSM2. Each figure represents the average daily source fraction of San Joaquin River water averaged for a given water year type.

The decrease in the simulated amount of Sacramento River water at the City's intake for the B1 scenario is a result of the export of substantial volumes of Sacramento River water from the NDD. Source water fingerprints indicate that the total volume of water that is exported from the Delta over the 16-year simulation period is 74.9 million acre-feet (maf) for EBC2, 70.1 maf for the NAA, and 83.1 maf for Scenario B1; although the total volume of water exported from the Delta in Scenario B1 is approximately 11 % greater than under existing conditions, the volume of Sacramento River water exported increases by 56% relative to existing conditions. For normal and wet water years, the volume of Sacramento River water exported under the B1 scenario exceeds the EBC2 scenario by 73% and 182%, respectively.

### c. The California WaterFix Project will increase the residence time of water in the South and Western Delta, reducing flushing and resulting in degraded water quality.

The California WaterFix Project will affect residence times both by changing the point of diversion within the Delta and by increasing the amount of water diverted from the Delta. The WaterFix Project will allow diversions to occur directly from the Sacramento River via three new proposed NDD intakes. As shown above, this will result in the export of Sacramento River water directly from the Delta before it has the opportunity to flow into and through the Delta and mix with water from other sources; in effect, the NDD will reduce inflows to the Delta and will reduce the volume of exports from the South Delta pumps.[26] Reducing inflows to the Delta (and reducing exports from within the Delta) will result in increased residence times for water within the Delta. This effect will be most notable in the South Delta, where the NDD diversions will reduce the amount of Sacramento River water in the South Delta relative to existing conditions. Thus, relative to existing conditions, WaterFix Scenario B1 will reduce the amount of "flushing" that has occurred in the past when exports from the South Delta diversion locations acted to "pull" Sacramento River water into the South Delta. This is confirmed by Exponent's analysis of the source of water in the South Delta, as shown in Section 6b, which

[26] Note that DWR appears to agree that diversions from the NDD can be considered to reduce inflows to the Delta and to reduce exports from the Delta, as they have proposed the NDD exports would be subtracted from the exports and subtracted from Delta inflows for the purposes of calculating the E/I ratio of D-1641.

shows less Sacramento River water in the South Delta under Scenario B1 than under existing conditions.

### d. WaterFix operations will cause an increase in salinity and will reduce the quality of water, and the number of days useable water is available, at PP#1.

The WaterFix will have adverse effects on water quality at PP#1 under the Boundary 1 scenario. Model results show that salinity modeled at PP#1 for the Boundary 1 scenario will be higher than salinity for the existing condition (EBC2) model scenario.[27] The average and maximum simulated salinity (EC) levels at PP#1 for the existing condition (EBC2) scenario are 105 mg/L and 395 mg/L, respectively. For the NAA scenario, the average and maximum salinity levels are 105 mg/L and 462 mg/L, respectively. For WaterFix Scenario B1, the average and maximum simulated salinity levels are 114 mg/L and 681 mg/L, respectively, an increase of 8% and 47% relative to current conditions. Thus, the average salinity at PP#1 (the City's primary water source) will increase relative to existing conditions; however, long-term averages by definition average out shorter-term differences or differences in salinity levels between different year types. As shown below, changes in salinity will decrease the availability of water to the City in some years to a greater extent than in other years.

Exponent used the EBC2 scenario to characterize water quality at PP#1 under current conditions; simulated water quality under the EBC2 scenario was compared to simulated water quality under the B1 and NAA scenarios. Tables 2 and 3 provide the number of days, calculated from DWR's model results, that daily average water quality is predicted to be *above* the chloride thresholds of 150 mg/L and 250 mg/L.[28] Under the existing conditions scenario (EBC2), salinity is above the 150 and 250 mg/L chloride thresholds 33% and 7% of the time, respectively. The B1 scenario results in 27 and 39 additional days above the 250 mg/L chloride

[27] As Jennifer Pierre stated in her oral testimony before the SWRCB on July 29, 2016, the Boundary 1 model scenario can be used as a basis for assessment of harm.

[28] Although the D-1641 thresholds of 150 mg/L and 250 mg/L are not applied directly at the location of the City's intake, these thresholds are measures of the suitability of water for M&I uses.

threshold for dry and normal years compared to the EBC2 scenario, equivalent to a 59% and 55% increase, respectively.

Table 2. Number of days per year average daily chloride concentration is above 150 mg/L at PP#1 from DWR model results for the time period 1975–1991.

| Year Type | EBC2 | NAA | B1 |
|---|---|---|---|
| All | 120 | 108 | 132 |
| Critical | 172 | 159 | 184 |
| Dry | 104 | 84 | 128 |
| Normal | 112 | 118 | 162 |
| Wet | 77 | 63 | 50 |

Table 3. Number of days per year average daily chloride concentration is above 250 mg/L at PP#1 from DWR model results for the time period 1975–1991.

| Year Type | EBC2 | NAA | B1 |
|---|---|---|---|
| All | 25 | 33 | 36 |
| Critical | 32 | 44 | 34 |
| Dry | 19 | 27 | 46 |
| Normal | 32 | 54 | 71 |
| Wet | 15 | 10 | 4 |

Table 4 shows the change, relative to existing conditions, in the number of days per year that water quality would be below these salinity thresholds for the NAA and B1 scenarios. A positive value indicates that salinity is predicted to remain *below* the threshold for *more* days relative to the existing condition (EBC2) (i.e., model results predict an improvement in water quality relative to the baseline scenario). A negative value indicates that salinity will be *above* the threshold for that many more days (i.e., model results predict adverse impacts relative to the baseline scenario).

Table 4. The change, relative to existing conditions, in the average number of days per year chloride concentrations at PP#1 are below thresholds of 100 mg/L and 250 mg/L for scenarios NAA and B1. Bold values indicate an adverse water quality impact relative to existing conditions. Results computed from DWR model results for the time period 1975–1991.

| | 150 mg/L | | 250 mg/L | |
|---|---|---|---|---|
| Year Type and Percent Occurrence[a] | NAA | B1 | NAA | B1 |
| All | 12 | **-12** | **-8** | **-11** |
| Critical (16%) | 13 | **-12** | **-12** | **-2** |
| Dry (22%) | 20 | **-25** | **-7** | **-27** |
| Normal (BN 18%, AN 15%) | **-6** | **-50** | **-21** | **-39** |
| Wet (29%) | 15 | 28 | 6 | 11 |

Source: The frequency of occurrence was calculated from the 95-year record from 1921–2015 (see Brentwood-108). Above normal (AN) and Below Normal (BN) water years were combined for this analysis.

Table 4 shows that during critical, dry, and normal years operational Scenario B1 is predicted to result generally in degradation of water quality relative to the existing condition (EBC2) scenario. More specifically, when operating under the B1 scenario the threshold will be *exceeded* by the following number of additional days relative to the existing condition (EBC2) scenario:

- 12 days during critical years, 25 days during dry years, and 50 days during normal years at the 150 mg/L chloride threshold
- 2 days during critical years, 27 days during dry years, and 39 days during normal years at the 250 mg/L chloride threshold

Under Scenario B1 operations, the reliability of the City's primary water supply would be compromised. As shown in Table 4 and at the 150 mg/L threshold, Scenario B1 of the WaterFix project would result in the loss of 50 useable water days on average during normal (above normal and below normal) water years, and 25 useable water days on average during dry years, relative to existing conditions.

Over a longer time period, the loss of useable water days will be cumulative and can be estimated using the distribution of year types in the historical record. Assuming the frequency of year types will be the same as in the past (a questionable assumption, given climate change), dry, critical, and normal years will constitute approximately 55% of the water years in the future (as these year types accounted for 55% of the years between 1921 and 2016). Using the average number of days that water will be above the 150 mg/L chloride threshold shown in Table 3, we calculate that the WaterFix Project could, over a 50-year project implementation period, result in the loss at PP#1 of as many as 946 days of useable water in critical, dry, and normal year types. This loss of water is equivalent to a total of more than 2.5 years of water during the 35 critical, dry, and normal water years that would be expected in a 50-year period (or 7% of the time during those year types), assuming that the distribution of year types in the future is similar to the distribution in the historical record. Although an increase in usability is predicted during wet years, it would not offset the loss of days in critical, dry, and normal years. Thus, we conclude that the degradation in water quality of the City's primary water supply is significant, and as detailed in Brentwood-1 would necessitate additional purchases of water from outside sources and/or significant changes in the City's water treatment facilities.

In addition to increases in chloride concentrations (i.e., salinity), the City is concerned about increases in bromide concentrations that will be caused by the proposed project. The RDEIR/SDEIS analyzed bromide concentrations near the location of PP#1's intake in Old River at Rock Slough and notes that

> *"multiple interior and western Delta assessment locations would have an increased frequency of exceedance of 50 µg/L [bromide], which is the CALFED Drinking Water Program goal for bromide as a long-term average applied to drinking water intakes… These locations [include] Old River at Rock Slough… Similarly, these locations would have an increased frequency of exceedance of 100 µg/L [bromide], which is the*

> *concentration believed to be sufficient to meet currently established drinking water criteria for disinfection byproducts."*[29]

Appendix B to the RDEIR/SDEIS presents the average bromide concentrations at PP#1 for all years of the modeled record and during a drought period specified as WY 1987–WY 1991. Appendix B to the RDEIR/SDEIS shows that the frequency of exceedance of the 100 µg/L bromide criterion at the PP#1 is 97% under the NAA scenario, 98% under EBC2, and 100% under the H3 scenario; the RDEIR/SDEIS further notes that bromide concentrations are generally correlated with chloride concentrations.[30] As noted above, chloride concentrations at PP#1 will increase significantly for WaterFix Scenario B1; accordingly, bromide concentrations at PP#1 intake are expected to increase significantly. Yet, the RDEIR/SDEIS concludes that impacts due to bromide are "less than significant."[31] Given the significant increase in chloride concentrations that is simulated to occur for WaterFix Scenario B1, and given the relationship between chloride and bromide concentrations in the Delta, this conclusion is not credible.

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[29] See Exhibit SWRCB-3 (RDEIR/SDEIS) pp. 4.4.4-8:9

[30] SWRCB-3 (RDEIR/SDEIS) pp. B-85.

[31] SWRCB-3 (RDEIR/SDEIS) pp. ES-43. The effects on chloride concentrations are listed as "LTS" or "less than significant" for Alternative 4 in the RDEIR/SDEIS Executive Summary, even though the same alternative was determined, using the same model runs, to have "significant and unavoidable" impacts to salinity in the western Delta in 2013; the basis for this change relative to the findings for Alternative 4 in the 2013 EIR/EIS is unclear.

# 7. Opinion 3: Compliance with water quality standards is likely to become more challenging in the future, and WaterFix will degrade the water quality of the City's water supply.

## a. Compliance with D-1641 water quality standards is likely to be more challenging in the future than under current conditions.

As noted above, the changes in hydrodynamics and water quality in the Delta resulting from WaterFix will degrade water quality PP#1, the primary source of surface water to the City. Model simulations performed by DWR illustrate that water quality will be degraded regardless of whether the Delta after WaterFix implementation is in compliance with water quality and flow criteria.[32]

DWR's evaluation of regulatory compliance for current conditions is not based upon modeling but rather upon a qualitative discussion of compliance in recent years. DWR's evaluation of compliance with water quality criteria in recent years excludes periods during which Temporary Urgency Change Petitions (TUCPs) were issued by the State Board. DWR asserts that "To the extent that recent drought conditions suggest future SWP/CVP operations may require relaxing water quality standards to avoid exceedances, my testimony shows that historical hydrology over the last several drought years are truly unprecedented"[33] and that drought periods like the recent years are "statistical outliers from what would be within the expected range of conditions."[34] Notably absent from DWR's testimony is any discussion or consideration of whether the drought conditions witnessed in recent years are part of a "new normal" instead "unprecedented" "statistical outliers." Indeed, it seems contradictory that DWR incorporates sea

[32] As noted above, flow criteria have not yet been established that will govern conditions within the Delta after implementation of the WaterFix project. Thus, it is not currently possible to determine which operational scenarios will result in compliance with the new (anticipated) flow criteria for the Delta or how the WaterFix project will be operated to comply with these criteria. The evaluations in this section focus on compliance with existing water quality and flow criteria.

[33] See Exhibit DWR-61, pp. 8:3–8.

[34] See Exhibit DWR-61, pp. 13:20–22.

level rise (one outcome of climate change) in their modeling and evaluation of the proposed WaterFix Project at the same time they appear to assume that recent drought conditions will not be repeated in the future.

Climate change, and in particular sea level rise, is expected to lead to increased salinity within the Delta in the future. As noted in DWR-4 (page 30), the recent drought years were among the warmest and driest years on record. In addition, DWR-4 (page 31) shows that snowfall patterns during 2012-2015 resulted in some of the lowest April 1 snowpack percent of average on the historic record. DWR's own research indicates that the loss of Sierra snowpack is expected to be significant by the end of the current century, and that climate change is expected to enhance variability of weather patterns throughout the state, which can in turn lead to longer and more severe droughts (Brentwood-116). In my opinion and given scientific literature regarding climate change, these trends are not likely to have occurred by chance alone but are likely to be exacerbated in the future.

In light of potential changes in hydroclimatic changes, compliance with existing water quality criteria is expected to be more difficult in the future than it is now, even without WaterFix implementation. The WaterFix project will exacerbate the degradation of water in the Delta by exporting more water from the Delta than occurs under existing conditions (exports would increase significantly under scenarios H3, H4, and B1), and increasing both the amount and proportion of high quality Sacramento River flows removed from the system.

### b. WaterFix Project operations will result in additional exceedances of objectives for municipal and industrial beneficial uses

DWR used modeling to evaluate compliance with salinity and flow objectives for the NAA and proposed project scenarios (H3, H4, B1, and B2); modeling was not used to evaluate compliance for existing conditions. DWR states that the "modeling provides information in support of how the CWF can be operated while continuing to meet DWR and Reclamation's responsibilities under the Water Rights Decision 1641 objectives (D-1641)."[35] However, DWR's position on whether the WaterFix project will comply with existing standards is contradictory. DWR states in portions of its petition that a series of existing regulatory requirements will not change, including terms imposed through D-1641 and terms in the BiOps and State CESA Permits[36]; however, DWR states in the same testimony that the B1 scenario does not include "additional spring Delta outflow, additional OMR flows, existing I/E [*sic*] ratio, and the existing Fall X2 flow requirement imposed in the existing BiOp for Delta Smelt."[37]

Exponent evaluated the proposed operational scenario B1, the existing condition (EBC2), and the future no action alternative (NAA) to assess the frequency of compliance with the water quality standards specified in D-1641 for M&I beneficial uses. Exponent used DSM2 model results provided by DWR to evaluate compliance with the D-1641 water quality standards for the 16-year simulation period, which included all water year types, from one of the wettest years on record (1983) to one of the driest (1977). Results are discussed below.

***Part 1: Evaluation of compliance with D-1641 Table 1 requirements for 250 mg/L chloride***

As detailed in Table 1 in Section 3d, D-1641 requires that the maximum mean daily chloride concentration remain below 250 mg/L at five locations within the Delta. Exponent used DSM2 model results provided by DWR to evaluate whether the maximum mean *daily* chloride objective of 250 mg/L is simulated to be met at PP #1. The number of days the WQOs are not met are shown for each year for the 16-year modeled record in Table 5. There exists significant variability from year to year between the different scenarios; however, Scenario B1 most frequently exceeds the threshold value for the most number of days. In the dry year of 1989, for

[35] See Exhibit DWR-66, pp. 2:20–22.

[36] Exhibit DWR-51, pp. 12:17–13:4 states that "Existing regulatory requirements that will not change include: Terms imposed through D-1641 (assigning responsibility for WQCP objectives); Water Quality Objectives, Outflow Objectives, Delta Cross Channel Gate Operations, E/I ratio, Rio Vista Minimum Flow Objectives. Terms in BiOps and State CESA Permits; San Joaquin River Inflow/Export (I/E) ratio, OMR flows, Fall X2 flow, Additional Delta Cross Channel Gate Operations, HORB and agricultural rock barriers operations."

[37] See Exhibit DWR-51, pp. 13:20–22.

example, Scenario B1 exceeds the threshold for 124 days that year, and during the critical water year of 1991 the threshold is exceeded 117 days by Scenario B1.

Table 5. Number of days in each water year that the 250 mg/L chloride threshold for municipal and industrial beneficial uses is not met at PP#1 based on DWR model results.

| Water Year | Year Type | Total Days | EBC2 | NAA | B1 |
|---|---|---|---|---|---|
| 1976 | Critical | 366 | 37 | 0 | 0 |
| 1977 | Critical | 365 | 8 | 50 | 16 |
| 1978 | Normal | 365 | 10 | 87 | 105 |
| 1979 | Normal | 365 | 0 | 17 | 64 |
| 1980 | Normal | 366 | 87 | 57 | 44 |
| 1981 | Dry | 365 | 0 | 0 | 0 |
| 1982 | Wet | 365 | 3 | 12 | 10 |
| 1983 | Wet | 365 | 34 | 0 | 0 |
| 1984 | Wet | 366 | 0 | 0 | 0 |
| 1985 | Dry | 365 | 0 | 0 | 15 |
| 1986 | Wet | 365 | 23 | 26 | 6 |
| 1987 | Dry | 365 | 0 | 0 | 46 |
| 1988 | Critical | 366 | 1 | 4 | 14 |
| 1989 | Dry | 365 | 77 | 106 | 124 |
| 1990 | Critical | 365 | 40 | 60 | 25 |
| 1991 | Critical | 365 | 76 | 107 | 117 |

The data from Table 5 are summarized in Table 6 by water year type, and an overall average number of days the 250 mg/L chloride threshold is exceeded for each scenario is calculated in the bottom row. While the year-to-year variability is muted somewhat by the aggregation, several general trends are clear. During dry and above and below normal water years and for Scenario B1, the 250 mg/L chloride threshold is exceeded 46 and 71 days per year on average, respectively (Table 6). For critical water years, NAA is in exceedance most often with an average of 44 days, and existing conditions (EBC2) exceed the threshold most often during wet years (Table 6).

Table 6. Average days per year by water year type that the 250 mg/L chloride threshold for municipal and industrial beneficial uses is not met at PP#1 calculated from DWR model results.

| | EBC2 | NAA | B1 |
|---|---|---|---|
| Critical | 32 | 44 | 34 |
| Dry | 19 | 27 | 46 |
| Normal | 32 | 54 | 71 |
| Wet | 15 | 10 | 4 |
| Average | 25 | 33 | 37 |

DWR's model results show complying with the D-1641 250 mg/L water quality objective at PP#1 is challenging under both the existing conditions (EBC2) and the future no project (NAA) scenarios. As summarized in Table 6, DWR's model results show that compliance will occur less frequently under Scenario B1. For example, the number of days of non-compliance with the 250 mg/L chloride threshold more than doubles in dry and normal year types for Scenario B1 relative to existing conditions. Relative to the NAA, the number of exceedances for the 250 mg/L chloride threshold increases under Scenario B1 by about 70% in dry years and about 30% in normal years. Thus, DWR's own model results do not appear to support DWR's testimony that increased operations flexibility will result in greater compliance with water quality objectives in the future.

***Part 2: Evaluation of compliance with D-1641 Table 1 requirements for 150 mg/L chloride***

D-1641 includes WQOs for M&I beneficial uses of 150 mg/L to be met at either PP#1 or at Antioch, which is located in the San Joaquin River channel. D-1641 specifies that the "maximum mean daily" chloride concentration of 150 mg/L must be met for a specific number of days during the calendar year to be provided in "intervals of not less than two weeks duration" (see Table 1 in Section 3d).

Exponent used DSM2 model output to calculate the number of days per calendar year that compliance is achieved at the PP#1, which is also the City's primary source of surface water. Table 7 presents the results of the 150 mg/L threshold analysis, and illustrates that water quality objectives are not met during two of the five critical water years in the 16-year model period for the Boundary 1 and NAA scenarios, or for one of the five critical water years under EBC2 scenario.

Table 7. Years of compliance from the 16-year modeled record with D-1641 WQOs for M&I Beneficial Uses WQOs at PP#1 for the 150 mg/L threshold averaged by water year type.

| Water Year Type | Total Years | EBC2 | NAA | B1 |
|---|---|---|---|---|
| Critical | 5 | 4 | 3 | 3 |
| Dry | 4 | 4 | 3 | 4 |
| Normal | 3 | 2 | 3 | 3 |
| Wet | 4 | 3 | 3 | 4 |

The impacts from the WaterFix Project on compliance at PP#1 appear subtle as shown in Table 7. Disaggregating the data yields more useful information. Although many years in the simulation period are technically in compliance with the D-1641 150 mg/L chloride threshold, the total number of days below the threshold, as counted in two-week consecutive intervals (as specified in D-1641) decreases significantly in certain years (Table 8). During WY 1979, a below normal year, Scenario B1 shows that salinity will be below the 150 mg/L threshold at PP#1 for 160 *fewer* days relative to existing conditions (EBC2), yet the objective of 175 days is still met for that year. Similarly, in WY 1981, a dry year, simulations indicate that salinity will be below the 150 mg/L threshold at PP#1 for 34 *fewer* days relative to existing conditions but the objective of 165 days will be met. During the normal water year of 1979, the B1 scenario reduces the number of days the chloride objective is met by as much as 160 days and 133 days compared to EBC2 and NAA, respectively, and yet still remains in compliance with D-1641.

Table 8. Number of days daily average salinity levels will be below 150 mg/L as indicated by DWR model results for the 16-year modeled record at PP#1. The D-1641 WQOs in terms of number of days for each year are indicated as "threshold criteria." Bold numbers indicated exceedance of threshold criteria.

| WY | WYT | Threshold Criteria (days) | EBC2 (days) | NAA (days) | B1 (days) | Difference of B1 and EBC2 (days, %) | | Difference of B1 and NAA (days, %) | |
|---|---|---|---|---|---|---|---|---|---|
| 1976 | Critical | 155 | 291 | 366 | 301 | 10 | 3% | -65 | -19% |
| 1977 | Critical | 155 | 156 | **145** | **112** | -44 | -33% | -33 | -26% |
| 1978 | Normal | 190 | 243 | 239 | **188** | -55 | -26% | -51 | -24% |
| 1979 | Normal | 175 | 338 | 311 | 178 | -160 | -62% | -133 | -54% |
| 1980 | Normal | 190 | **187** | 202 | 242 | 55 | 26% | 40 | 18% |
| 1981 | Dry | 165 | 289 | 281 | 255 | -34 | -13% | -26 | -10% |
| 1982 | Wet | 240 | 299 | 298 | 287 | -12 | -4% | -11 | -4% |
| 1983 | Wet | 240 | 298 | 337 | 365 | 67 | 20% | 28 | 8% |
| 1984 | Wet | 240 | 366 | 357 | 366 | 0 | 0% | 9 | 2% |
| 1985 | Dry | 165 | 310 | 361 | 298 | -12 | -4% | -63 | -19% |
| 1986 | Wet | 240 | **213** | **235** | 254 | 41 | 18% | 19 | 8% |
| 1987 | Dry | 165 | 300 | 365 | 257 | -43 | -15% | -108 | -35% |
| 1988 | Critical | 155 | 217 | 263 | 250 | 33 | 14% | -13 | -5% |
| 1989 | Dry | 165 | 186 | **159** | 209 | 23 | 12% | 50 | 27% |
| 1990 | Critical | 155 | 164 | 165 | 168 | 4 | 2% | 3 | 2% |
| 1991 | Critical | 155 | 159 | **132** | **138** | -21 | -14% | 6 | 4% |

## b. WaterFix Project operations will result in additional exports from the Delta and so degrade water quality.

D-1641 also includes a limitation on exports of water from the Delta. Specifically, D-1641 limits the amount of water that can be exported from the Delta to a fraction of the water that flows into the Delta. Currently, the export-to-inflow (E/I) ratio is defined to include all water exported from the Delta and all freshwater inflows to the Delta; however, as detailed in Section 3e, DWR and Reclamation propose to redefine the E/I ratio such that the water diverted from the NDD would not be included in either the exports (E) or the inflows (I) used to evaluate this objective. The proposed new method of determining the E/I ratio would reduce the value of (E/I), making it easier to export more water from the Delta. Indeed, if only the NDD were used to export water, the value of the proposed new E/I ratio would be zero—in effect, any limitation on the fraction of inflows to the Delta that could be exported from the Delta would be eliminated.

Table 9 summarizes the number of days that the E/I ratio would be exceeded for each modeled scenario in the 16-year model period (5,832 days). The results show that including the number of exceedances of the E/I ratio is larger when the NDD water exports are included in both total exports and total inflows. In contrast, redefining the E/I ratio to exclude the amount of water exported from the NDD reduces the frequency with which the E/I ratio would be exceeded. For example, the B1 scenario exceeds the E/I ratio 850 days when the ratio is calculated to D-1641 specifications (i.e., to include all exports and all inflows) but only 270 times when the NDD is removed from the equation.

Table 9. Number of days of E/I ratio exceedance for the 16-year modeled record and overall percentage of time in exceedance.

| Scenario | EBC2[a] | NAA[a] | B1 |
|---|---|---|---|
| Redefined (E/I) excluding NDD flows | 481 (8.2%) | 349 (6.0%) | 270 (4.6%) |
| D-1641 specifications | | | 850 (14.6%) |

[a] Note that the E/I ratio does not change for the NAA and EBC2 scenarios because the NDD points do not exist for these scenarios.

As shown in Table 9, exceedances of the (E/I) ratio occur even in the existing condition (EBC2) and no action alternative (NAA). If the E/I ratio is evaluated for Scenario B1 using the same measure (i.e., including the water diverted from the NDD in both the exports and inflows), compliance with the E/I ratio declines with WaterFix operations. Excluding NDD exports and imports from the E/I ratio calculation has the effect of removing an important control on the amount of water exported from the Delta; it also has the effect of making it appear that the WaterFix Project will improve compliance with one of the many water quality objectives that apply to the Delta.

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# Appendix A

## Additional Figures and Tables

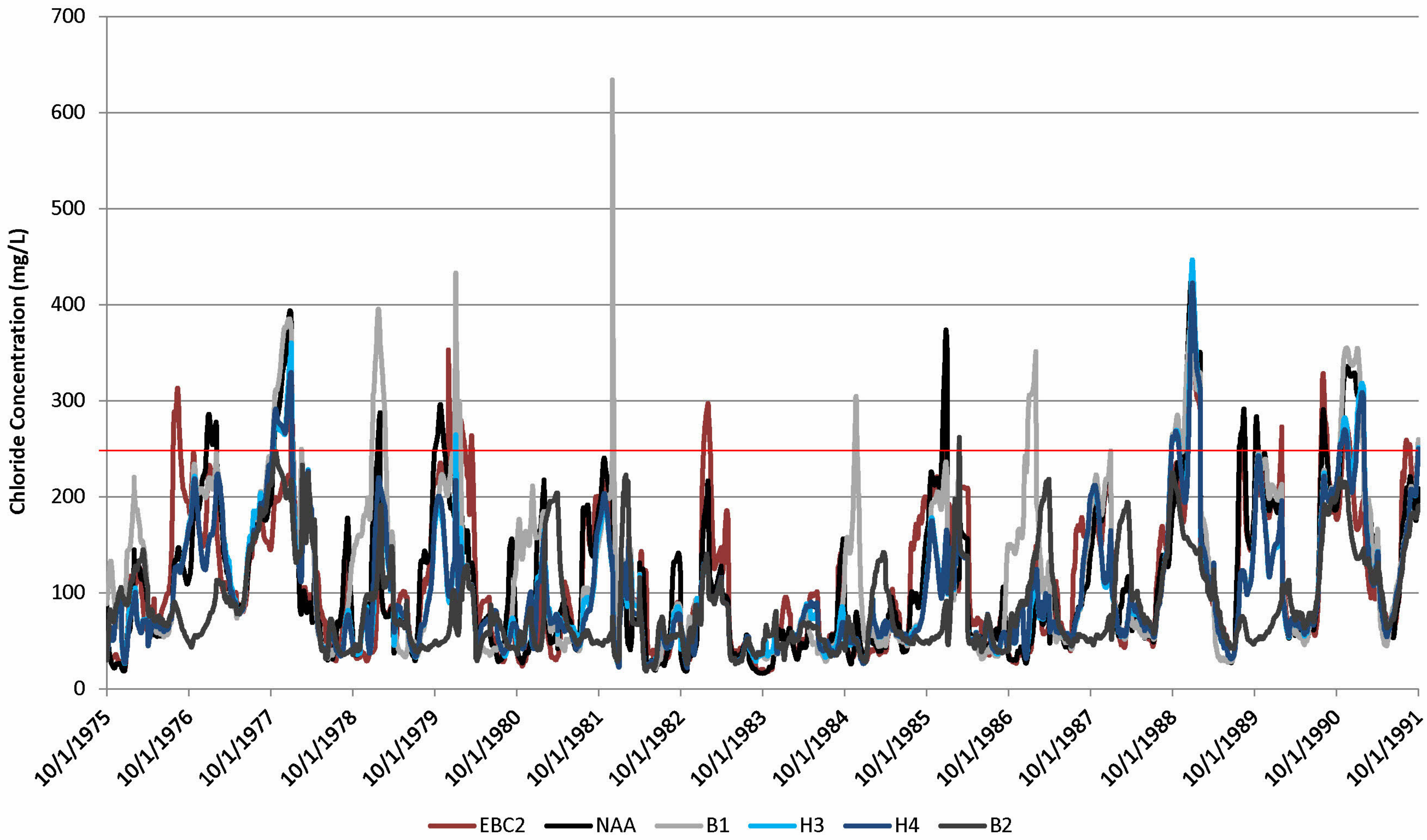


Figure A-4. Daily average chloride concentrations at PP#1 for WY 1975–WY 1991, from DWR's model results. The red line indicates the 250 mg/L chloride threshold of D-1641 (Note: colors may vary compared to Figure 4 in report, and entire modeled period included).

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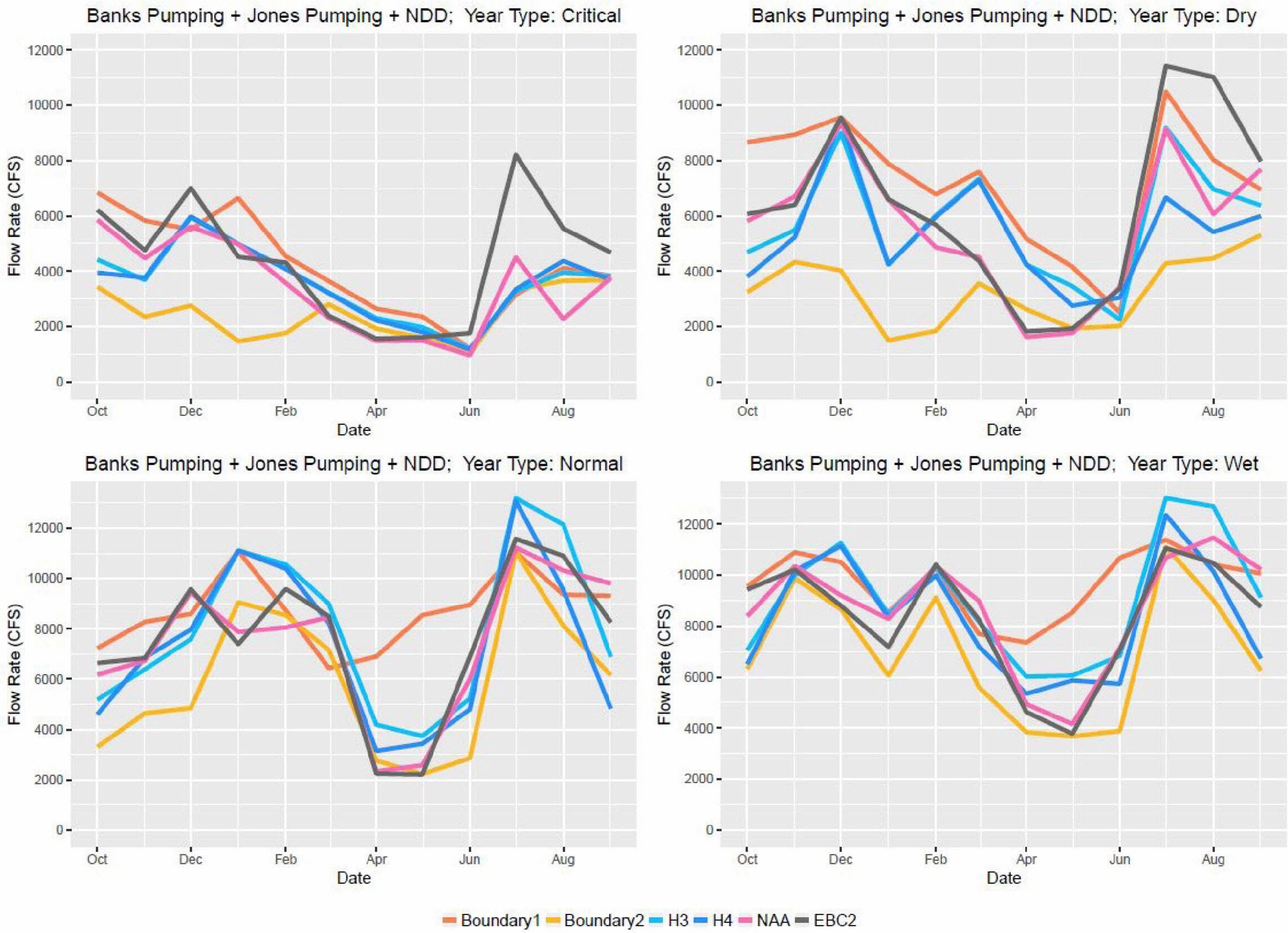


Figure A-1. Quantity of water that would be exported from the Delta under the model Scenarios EBC2, NAA, B1, H3, H4, and B2 as modeled by DSM2. Monthly average export flow rates are averaged by water year type (Note: The same data are included in Figure 14 of the report, but are presented differently).

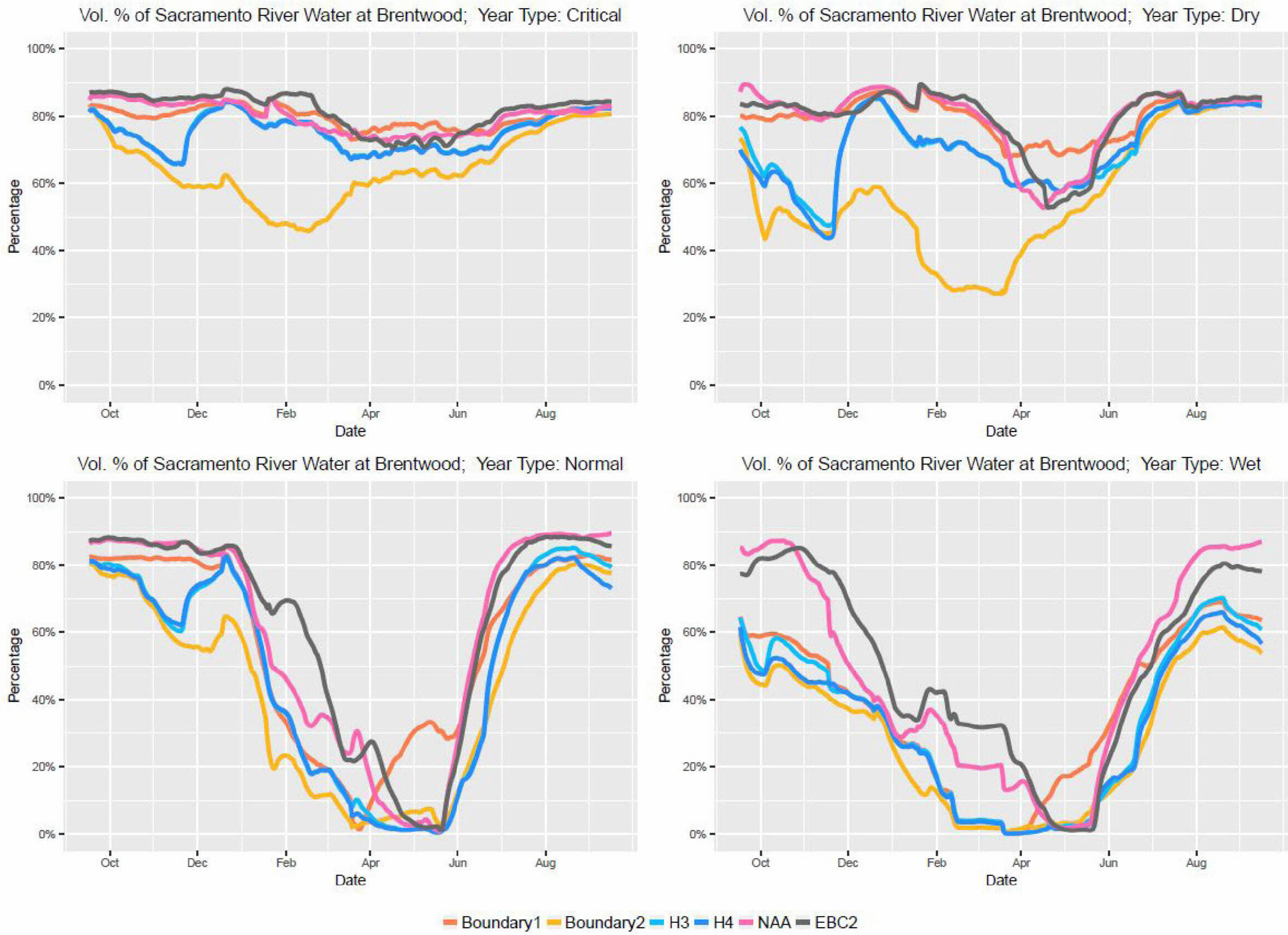


Figure A-2. Source fractions of Sacramento River water at the City's intake location as modeled by DSM2 using DWR's input files. Each figure represents the average daily source fraction of Sacramento River water averaged for a given water year type.

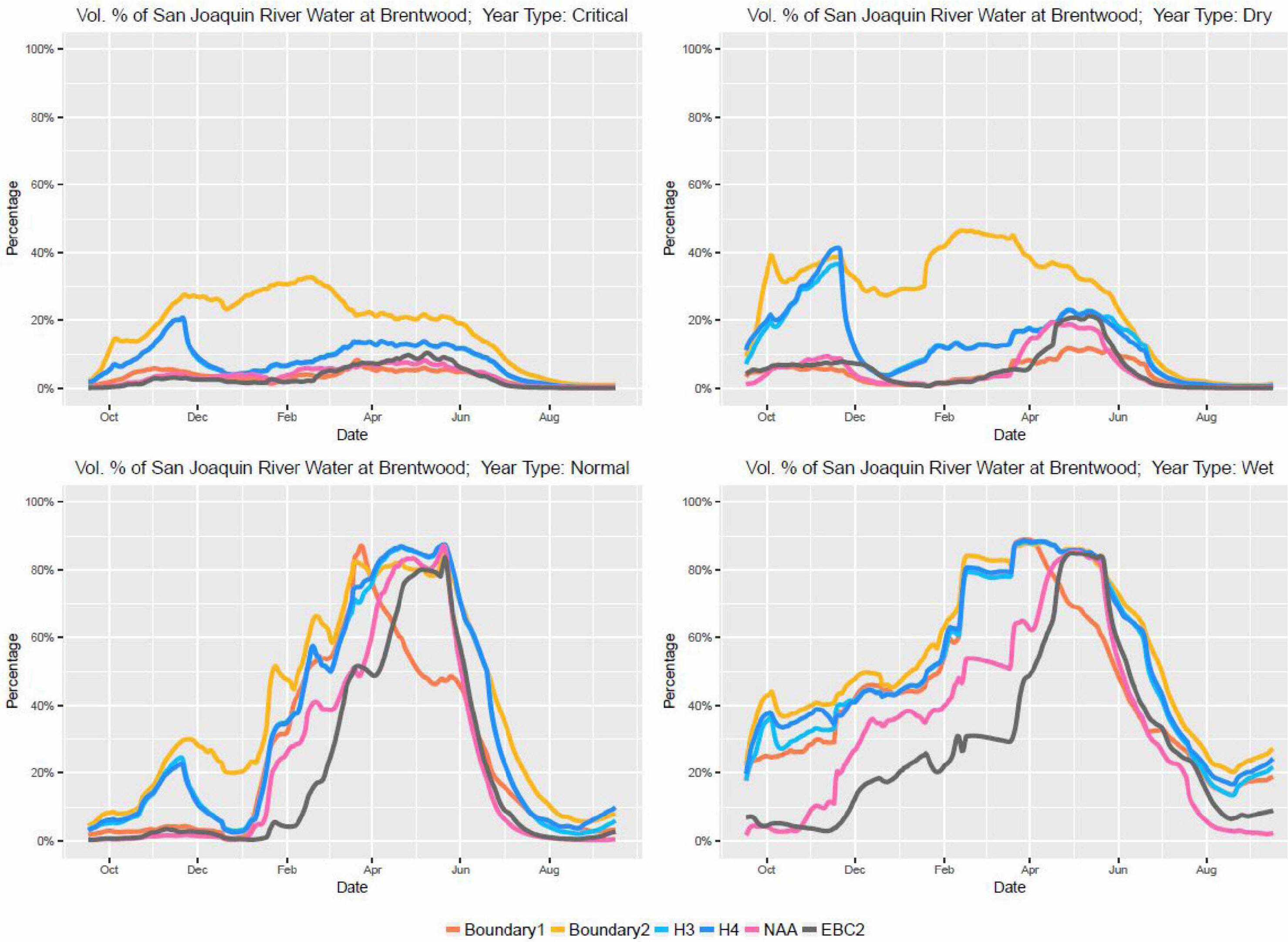


Figure A-3. Source fractions of San Joaquin River water at the City's intake location as modeled by DSM2 using DWR's input files. Each figure represents the average daily source fraction of San Joaquin River water averaged for a given water year type (Note: Font size changed).

Table A-1. Number of days per year average daily chloride concentration is above 150 mg/L from DWR model results for the time period 1975–1991.

| Year Type | EBC2 | NAA | B1 | H3 | H4 | B2 |
|---|---|---|---|---|---|---|
| All | 120 | 108 | 132 | 60 | 85 | 85 |
| Critical | 172 | 159 | 184 | 148 | 146 | 84 |
| Dry | 104 | 84 | 128 | 48 | 50 | 67 |
| Normal | 112 | 118 | 162 | 98 | 99 | 67 |
| Wet | 77 | 63 | 50 | 33 | 34 | 20 |

Table A-2. Number of days per year average daily chloride concentration is above 250 mg/L from DWR model results for the time period 1975–1991.

| Year Type | EBC2 | NAA | B1 | H3 | H4 | B2 |
|---|---|---|---|---|---|---|
| All | 25 | 33 | 39 | 20 | 19 | 2 |
| Critical | 32 | 44 | 34 | 23 | 21 | 0 |
| Dry | 19 | 27 | 46 | 23 | 22 | 0 |
| Normal | 32 | 54 | 71 | 32 | 31 | 6 |
| Wet | 15 | 10 | 4 | 1 | 1 | 1 |

Table A-3. Number of days in each water year that the 250 mg/L chloride threshold for municipal and industrial beneficial uses is not met at PP#1 based on DWR model results.

| Water Year | Year Type | Total Days | EBC2 | NAA | B1 | H3 | H4 | B2 |
|---|---|---|---|---|---|---|---|---|
| 1976 | Critical | 366 | 37 | 0 | 0 | 0 | 0 | 0 |
| 1977 | Critical | 365 | 8 | 50 | 16 | 0 | 0 | 0 |
| 1978 | Normal | 365 | 10 | 87 | 105 | 92 | 94 | 17 |
| 1979 | Normal | 365 | 0 | 17 | 64 | 0 | 0 | 0 |
| 1980 | Normal | 366 | 87 | 57 | 44 | 4 | 0 | 0 |
| 1981 | Dry | 365 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1982 | Wet | 365 | 3 | 12 | 10 | 0 | 0 | 0 |
| 1983 | Wet | 365 | 34 | 0 | 0 | 0 | 0 | 0 |
| 1984 | Wet | 366 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1985 | Dry | 365 | 0 | 0 | 15 | 0 | 0 | 0 |
| 1986 | Wet | 365 | 23 | 26 | 6 | 2 | 2 | 3 |
| 1987 | Dry | 365 | 0 | 0 | 46 | 0 | 0 | 0 |
| 1988 | Critical | 366 | 1 | 4 | 14 | 8 | 7 | 0 |
| 1989 | Dry | 365 | 77 | 106 | 124 | 92 | 89 | 0 |
| 1990 | Critical | 365 | 40 | 60 | 25 | 12 | 12 | 0 |
| 1991 | Critical | 365 | 76 | 107 | 117 | 96 | 86 | 0 |

Table A-4. Years of compliance from the 16-year modeled record with D-1641 WQOs for M&I Beneficial Uses WQOs at PP#1 for the 150 mg/L threshold averaged by water year type.

| | | Model Scenarios | | | | | |
|---|---|---|---|---|---|---|---|
| Water Year Type | Total Years | B1 | B2 | H3 | H4 | NAA | EBC2 |
| Critical | 5 | 3 | 5 | 4 | 5 | 3 | 4 |
| Dry | 4 | 4 | 4 | 4 | 4 | 3 | 4 |
| Normal | 3 | 3 | 3 | 3 | 3 | 3 | 2 |
| Wet | 4 | 4 | 4 | 4 | 4 | 3 | 3 |

Table A-5. Number of days with daily average salinity levels below 150 mg/L as indicated by DWR model results for the 16-year modeled record at PP#1. The D-1641 WQOs in terms of number of days for each year are indicated as “threshold criteria.” Bold numbers indicated exceedance of threshold criteria.

| WY | Criteria | EBC2 | NAA | B1 | H3 | H4 | B2 |
|---|---|---|---|---|---|---|---|
| 1976 | 155 | 291 | 366 | 301 | 356 | 357 | 366 |
| 1977 | 155 | 156 | **145** | **112** | **149** | 166 | 286 |
| 1978 | 190 | 243 | 239 | **188** | 197 | 200 | 194 |
| 1979 | 175 | 338 | 311 | 178 | 316 | 303 | 347 |
| 1980 | 190 | **187** | 202 | 242 | 291 | 308 | 366 |
| 1981 | 165 | 289 | 281 | 255 | 353 | 350 | 300 |
| 1982 | 240 | 299 | 298 | 287 | 316 | 313 | 330 |
| 1983 | 240 | 298 | 337 | 365 | 365 | 365 | 365 |
| 1984 | 240 | 366 | 357 | 366 | 366 | 366 | 366 |
| 1985 | 165 | 310 | 361 | 298 | 365 | 365 | 365 |
| 1986 | 240 | **213** | **235** | 254 | 304 | 304 | 338 |
| 1987 | 165 | 300 | 365 | 257 | 346 | 345 | 307 |
| 1988 | 155 | 217 | 263 | 250 | 296 | 293 | 291 |
| 1989 | 165 | 186 | **159** | 209 | 236 | 235 | 291 |
| 1990 | 155 | 164 | 165 | 168 | 222 | 217 | 301 |
| 1991 | 155 | 159 | **132** | **138** | 165 | 165 | 238 |

Table A-6. Number of days of E/I ratio exceedance for the 16-year modeled record (overall percentage of time in exceedance), based on DWR model results.

| Scenario | EBC2 | NAA | B1 | H3 | H4 | B2 |
|---|---|---|---|---|---|---|
| Redefined (E/I) excluding NDD flows | 481 (8.2%) | 349 (6.0%) | 270 (4.6%) | 144 (2.5%) | 119 (2.0%) | 32 (0.5%) |
| D-1641 specifications | | | 850 (14.6%) | 441 (7.6%) | 359 (6.2%) | 145 (2.5%) |

[a] Note that the E/I ratio does not change for the NAA and EBC2 scenarios because the NDD points do not exist for these scenarios.