Impacts of the California WaterFix Project Affecting Sacramento Regional County Sanitation District

SRCSD-31

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Prepared for

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November 30, 2017

1606538.000 - 6919

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Acronyms and Abbreviations

4A	the “preferred alternative,” scenarios H3 and H4 together
ADWF	average dry weather flow
B1	Boundary 1 scenario
B2	Boundary 2 scenario
CDEC	California Data Exchange Center
Delta	Sacramento-San Joaquin River Delta
DSM2	Delta Simulation Model 2
DWR	California Department of Water Resources
EC	electrical conductivity
ESB	emergency storage basin
FDM	Fischer Delta Model
Flow Science	Flow Science Incorporated
ICP-MS	inductively coupled plasma mass spectrometry
M&I	municipal and industrial
mgd	million gallons per day
mg/L	milligrams per liter
µS/cm	micro-Siemens per centimeter
NAA	no action alternative
NDD	north Delta diversion
NPDES	National Pollutant Discharge Elimination System
POTWs	publicly owned treatment works
Regional San	Sacramento Regional County Sanitation District
SRWTP	Sacramento Regional Wastewater Treatment Plant
TDS	total dissolved solids
WaterFix	California WaterFix Project
WY	water year

Limitations

This report summarizes work performed to date and presents the findings resulting from that work. The findings presented herein are made to a reasonable degree of engineering certainty. Exponent reserves the right to supplement this report and to expand or modify opinions based on review of additional material as it becomes available through any additional work or review of additional work performed by others.

1. Summary of findings

Sacramento Regional County Sanitation District (Regional San) is the primary wastewater treatment agency in the Sacramento area. Regional San operates the Sacramento Regional Wastewater Treatment Plant (SRWTP) near Elk Grove, California. SRWTP is one of the largest publicly owned treatment works (POTWs) in California.

SRWTP discharges treated effluent to the Sacramento River near Freeport through a 300-foot long, 74-port diffuser situated on the river bottom.[1] The diffuser is located in the northern end of the Delta, and thus it is subject to tidal influence. High tides reduce river flows past the diffuser under all but very high flow conditions, and tidal forcing sometimes causes the river to flow in an upstream direction ("reverse flow" events).

Regional San is allowed to discharge treated effluent only when the ratio of river flow to effluent flow is 14:1 or greater. When river flow rates fall in response to the tides such that a ratio of 14:1 or greater cannot be maintained, Regional San temporarily ceases discharging treated effluent to the river and diverts the treated effluent to emergency storage basins (ESBs) located adjacent to the treatment plant. Once the river flow returns above the 14:1 ratio, treated effluent discharges to the river resume, augmented by additional flows from the ESBs until the ESBs are empty again. In addition to the 14:1 discharge requirement, Regional San must meet several thermal discharge and receiving water requirements that sometimes necessitate diversion of treated effluent to ESBs. Thermal diversions are a regular occurrence at SRWTP, particularly during cold winter months.

Exponent evaluated whether the proposed WaterFix operations will have an impact on SRWTP operations and permitting conditions. The conclusions of this work are summarized below:

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[1] The diffuser was constructed with 99 ports. However, in 2005 it was discovered that effluent mixing near the eastern bank of the river was not occurring according to diffuser design criteria during low river flows. Therefore, 25 ports were blocked to restore intended mixing conditions under low-flow conditions. As a result, only 74 ports have been active on the diffuser since 2007.

1. **WaterFix will increase residence time in the Delta.** Exponent used DSM2 model input files obtained from the California Department of Water Resources (DWR) to evaluate residence time in the Delta. Results show that, in general, residence times are expected to increase markedly as a result of WaterFix in all water year (WY) types (i.e., critical, dry, below normal, above normal, and wet). The greatest increase in residence times relative to existing (EBC2) and no action alternative (NAA) scenarios is simulated to occur from July to December—a period that includes the summer months when water temperatures are highest. Increased residence times in the Delta are expected to result in the degradation of water quality in the Delta.

2. **Increased *Microcystis* growth may result from WaterFix.** *Microcystis* is a genus of cyanobacteria containing species known to produce toxic chemicals called microcystins, which are a risk to humans, livestock, and wildlife. Increased residence time in the Delta is expected to increase the likelihood of *Microcystis* blooms by decreasing the loss rate of *Microcystis* from the area by flushing, which in turn will lead to more opportunity for *Microcystis* growth and toxin production. Additionally, water temperatures within the Delta are expected to increase as a result of WaterFix (partly due to increased residence times), particularly during the already-warm summer months, likely leading to higher growth rates of *Microcystis* and longer periods of time when water temperatures exceed the threshold for *Microcystis* bloom formation.

3. **WaterFix will cause an increase in salinity in the Delta.** The WaterFix operations scenarios involve the export of water from new diversion structures on the Sacramento River, and some operational scenarios will lead to an increase in the amount of water exported from the Delta. WaterFix will lead to the export of more Sacramento River water than under existing conditions (i.e., the EBC2 scenario). Thus, WaterFix diversions from the north Delta will change the composition and quality of water within the Delta. The interior Delta will generally contain less high-quality Sacramento River water and more water from other, lower-quality sources, including San Joaquin River water, agricultural return flows, and saline inflow from Martinez. DSM2 modeling results for the Boundary 1 (B1) scenario show that chloride concentrations at Antioch

and Brentwood are expected to increase markedly relative to both the NAA and EBC2 (existing condition) scenarios. The increased salinity in the western Delta under B1 operations is expected to result in more frequent exceedances of the D-1641 chloride objectives for municipal and industrial (M&I) beneficial uses and lead to higher salinity in the western Delta even when D-1641 objectives are satisfied. Impacts to water quality are expected to occur in the interior Delta as well. Declining water quality in the Delta—including increasing temperatures, increased *Microcystis* growth, and increased salinity—has the potential to result in more stringent future permit conditions on existing discharges to the Delta, including discharges from the SRWTP.

4. **WaterFix will affect SRWTP operations by increasing the frequency and duration of diversion events relative to baseline conditions (i.e., EBC2 and NAA).** To evaluate the extent to which WaterFix operations would change flow rates in the Sacramento River at Freeport and thereby affect SRWTP operations, Flow Science, working based on instructions from Exponent, used output from DWR's DSM2 model to simulate Regional San's discharge and diversion operations. Flow Science's analysis shows that increases relative to baseline conditions (i.e., EBC2 and NAA scenarios) are expected in a number of relevant parameters, including (1) the number of diversion events, (2) the percentage of time that diversion would be required, (3) the percentage of time that effluent would be stored in ESBs, and (4) the cumulative volume of water that would be pumped from ESBs over the 16-year modeling period (1976–1991). Increasing the frequency and magnitude of diversion events will result in higher operational and maintenance costs and the potential for additional odor impacts. Additionally, the expected increase in the number of diversion events effectively amounts to an encroachment on Regional San's available ESB capacity.[2]

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[2] Exponent did not evaluate temperature-driven impacts to SRWTP diversion operations since DWR did not provide sufficient information to describe Sacramento River temperatures at Freeport under WaterFix operations scenarios.

2. Background

Regional San is the primary wastewater treatment agency in the Sacramento area. Regional San operates the SRWTP near Elk Grove, California. SRWTP is one of the largest POTWs in California. The permitted average dry weather flow (ADWF)[3] of the plant is 181 million gallons per day (mgd). Instantaneous flow rates at the plant may exceed 181 mgd (e.g., during wet weather). SRWTP serves more than 1.4 million residential, industrial, and commercial customers throughout the Sacramento area.

After treatment at the SRWTP, effluent is conveyed through a two-mile-long, 120-inch-diameter outfall pipe to the Sacramento River near Freeport. Treated effluent is discharged to the river just downstream of the Freeport Bridge through a 300-foot long, 74-port diffuser situated on the river bottom.[4] The diffuser has a discharge capacity of 410 mgd. The ten-inch diffuser ports discharge in the downstream direction, parallel with the direction of flow. The diffuser is located in the northern end of the Delta and is subject to tidal influence. High tides frequently reduce river flows past the diffuser significantly, and tidal forcing sometimes causes the river to flow in an upstream direction (“reverse flow” events). Reverse flow events are common, especially during the dry fall season when flows from upstream are relatively low.

The National Pollutant Discharge Elimination System (NPDES) permit for the SRWTP prohibits discharge of wastewater when the river-to-effluent flow ratio is less than 14:1. When river flow rates fall in response to the tides such that a 14:1 ratio cannot be maintained, Regional San temporarily ceases discharging treated effluent to the river and diverts the treated effluent to ESBs located adjacent to the treatment plant. Once the river flow returns above the 14:1 ratio, treated effluent discharges to the river resume, including flows from the ESBs until the ESBs are empty again.

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[3] ADWF is the average flow in the three consecutive months with the lowest average monthly flow rates.

[4] See footnote 1 for details regarding the configuration of the diffuser.

In addition to the 14:1 flow discharge requirement, Regional San must meet several thermal discharge and receiving water requirements that sometimes necessitate diversion of treated effluent to ESBs. For example, the maximum temperature of SRWTP discharge may not exceed the temperature of the Sacramento River by more than 20°F from May 1st through September 30th or by more than 25°F from October 1st through April 30th. Additional restrictions apply to the increase in temperature that is allowed to occur over 25% or more of the river's cross-section. If the SRWTP discharge is unable to meet these thermal requirements, Regional San must temporarily divert treated effluent to ESBs. Thermal diversions are a regular occurrence at SRWTP, particularly during cold winter months.[5]

Regional San retained Exponent to evaluate and prepare technical comments on the WaterFix project, including the WaterFix Part 2 proceedings. Specifically, Regional San asked Exponent to evaluate whether the proposed WaterFix diversions will have an impact on SRWTP operations and conditions in the Delta that might affect SRWTP operations in the future. In conducting this work, Exponent evaluated model runs performed by DWR, oversaw modeling of SRWTP ESB and diversion operations conducted by Flow Science, and reviewed DWR's assessment of WaterFix. Exponent previously submitted technical comments for Regional San on the WaterFix Final EIR/EIS, which are included in this report as Appendix B.

The primary author of this report was Susan Paulsen, Ph.D., P.E. Dr. Paulsen was assisted in this work by Aaron Mead, Ph.D., P.E., Ryan Thacher, Ph.D., P.E., and Chiyu Lin, all of Exponent. In preparing this report, Exponent relied on modeling performed by Flow Science Incorporated (Flow Science) that simulates Regional San's discharge and diversion operations.[6] Flow Science's analysis is included as Appendix A to this report.

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[5] As noted in footnote 2, Exponent did not evaluate temperature-driven impacts to SRWTP diversion operations due to a lack of available information.

[6] Flow Science. 2017. Sacramento Regional Wastewater Treatment Plant Emergency Storage Basin Analysis for California BDCP/WaterFix. Prepared for Sacramento County Regional Sanitation District, November 29. (Appendix A)

3. Methods

3.1. Delta Simulation Model (DSM2)

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. 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). Given the flows in the Delta channels simulated by HYDRO, QUAL simulates the concentrations of conservative constituents in the water (i.e., constituents that neither decay nor grow), such as electrical conductivity (EC), a measure of salinity. The model results (model output) provided by DWR as part of the WaterFix proceedings include hydrodynamic and water quality information. Output from DWR's temperature modeling (which employed the CALSIM II model) was also obtained for analysis.

Previously, Exponent obtained from DWR the modeling input and output files from the DSM2 model, which was used to simulate hydrodynamics and water quality throughout the Delta for a range of model conditions and operational scenarios. Exponent's analyses were performed for select WaterFix Project scenarios (scenarios B1, B2, H3, H4) and for the no action alternative (NAA) and the EBC2 scenario, which includes current sea levels and the Fall X2 requirement. Importantly, scenarios H3 and H4 together represent the "preferred alternative," scenario 4A. Thus, in this report "4A" will be used interchangeably with "H3 and H4" to identify the preferred alternative.

3.2. SRWTP Operations Model

A customized Matlab® model was used to simulate SRWTP discharge and ESB operations under baseline (i.e., EBC2 and NAA) and Waterfix conditions. This work was performed by Flow Science and coordinated by Exponent. The model, formulated previously, was updated to simulate as closely as possible inflow, diversion, emergency storage, and discharge operations at the SRWTP after completion of the plant upgrade currently under construction (the EchoWater project). Details of Flow Science's modeling methodology are contained in a technical report describing their work (see Appendix A).

3.3. Water year type classifications

Hydrology in the Delta varies from year to year. WYs 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 WY type by calculating a WY index number, which accounts for both the hydrology of the current year and the previous year's index.[7] By this classification system, the WYs 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
- Wet: 1982, 1983, 1984, 1986

Because there is only one Below Normal WY in the modeled record, Exponent combined results for the Below Normal year with model results for Above Normal WYs for the purposes of analyzing the WaterFix model runs; the WY type for WYs 1978–1980 is referred to from here forward as "Normal."

3.4. Salinity calculations

The EC of freshwater inflows to the Delta is lower than that of water that enters the estuary from San Francisco Bay, which typically includes seawater. The Sacramento River and east side streams are typically the freshest (i.e., have the lowest salinity), while the San Joaquin River and agricultural return flows have higher salinity. Tidal inflows to the Delta at Martinez have the highest salinity levels, as they include seawater in all but the largest flood flow conditions. For

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[7] WY classifications were obtained from the California Data Exchange Center (CDEC), accessed at http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST.

example, in 2015, average measured EC in the Sacramento River at Freeport was 168 micro-Siemens per centimeter (µS/cm) (equivalent to a total dissolved solids [TDS] of 103 milligrams per liter [mg/L][8]), while the average EC in the San Joaquin River at Vernalis was 595 µS/cm (343 mg/L TDS). In contrast, the 2015 average EC at Martinez (downstream boundary of Delta) was 26,384 µS/cm (17,882 mg/L TDS). For comparison, the salinity of seawater is approximately 50,000 µS/cm (35,000 mg/L TDS).[9,10]

3.4.1. EC to chloride conversions

The salinity of water in the Delta has historically been expressed as EC, TDS, or chloride. Many salinity measurements in the Delta are made using EC, and EC is widely used as a surrogate for salinity. Guivetchi (1986)[11] derived linear mathematical relationships between EC, TDS, and chloride 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 was converted to chloride using Guivetchi's relationships. Exponent calculated chloride concentrations at three locations in the Delta (Antioch, Brentwood, and Stockton) using conversion equations developed using data from (or near) each of these locations.[12]

3.4.2. Data averaging

The DSM2 model produces data on 15-minute intervals. The period modeled in DSM2 for most WaterFix analyses spans WY 1975 through 1991. However, WY 1975 is required for model "spin-up," and so results for that year are excluded from analyses. Thus, Exponent's analyses

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[8] EC to TDS conversions were calculated using the method of Guivetchi 1986, which presented salinity conversion factors for various locations in the Delta.

[9] Salinity (EC) data were obtained from CDEC, http://cdec.water.ca.gov/.

[10] Exponent (2016). Report on the Effects of the Proposed California WaterFix Project on Water Quality at the City of Brentwood. Exhibit Brentwood-102 of the WaterFix Change Petition Proceedings. August 30, 2016.

[11] Guivetchi, K. 1986. Salinity Unit Conversion Equations. Memorandum. California Department of Water Resources. June 24, 1986. Accessed at: http://www.water.ca.gov/suisun/facts/salin/index.cfm.

[12] Salinity impacts at these three locations are used in the discussion of salinity impacts in the Delta generally in Opinion 7 below. For the conversion equation used for Antioch, see Antioch-202 Errata at p. 7. For Brentwood, see Brentwood-102 at p. 13. The relationship used for the Delta near Stockton's intake is described in STKN-26 at p. 10.

are based on the 16-year record from WY 1976 through 1991. For this analysis, the 15-minute DSM2 data were averaged on an hourly basis.

3.5. Calculation of residence times for Delta inflow using DSM2 results

The residence time of water in the Delta was calculated for each WY between 1976 and 1991 under scenarios EBC2, NAA, B1, B2, and 4A (represented by H3 and H4) using a mass balance procedure that relied upon the total volume of water in the Delta and total Delta inflows for the given WY type and operational scenario. The monthly average residence time was estimated by dividing the total volume of water in the Delta by the total inflows for each month. Jassby and Cloern (2000)[13] 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 acre-feet). Total monthly Delta inflows were calculated as the sum of flows from the Sacramento River, San Joaquin River, east side streams, inflow from Martinez, and Yolo bypass flow minus any North Delta diversions. The monthly average inflow was determined by calculating the monthly running average inflow (i.e., sum of 30 previous daily average inflow values) using data from DWR’s DSM2 model files for the 16-year model period.

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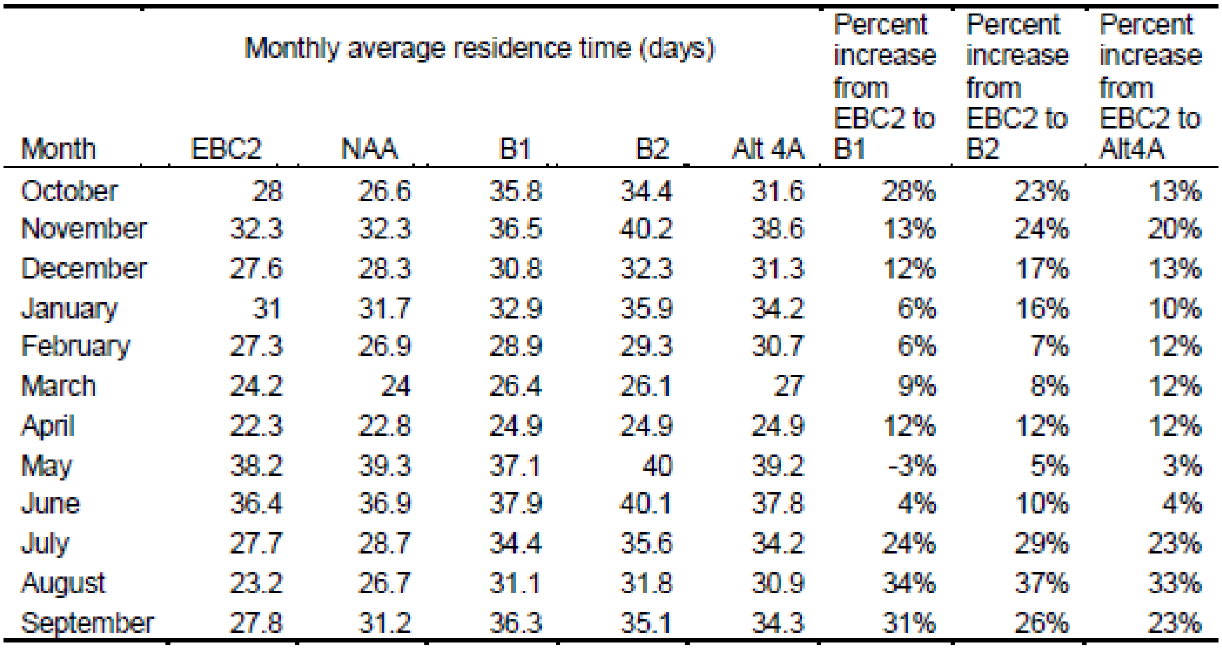
[13] Jassby, A.D., and J.E. Cloern. 2000. Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). Aquatic Conservation: Marine and Freshwater Ecosystems. 10(5):323–352. October.

4. WaterFix will increase residence time in the Delta

Exponent used DSM2 model input files obtained from DWR to evaluate residence time in the Delta for two baseline conditions—EBC2 and the NAA—and four WaterFix scenarios—H3 and H4 (together representing the preferred alternative, 4A), B1, and B2. Modeling results showed that the residence time of water entering the Delta during a dry WY will increase for scenarios B1, B2, and 4A relative to the two baseline conditions.[14] Table 1 shows calculated average monthly residence times for dry years for 4A, B1, B2, the NAA, and EBC2. Results in Table 1 show that the greatest change in residence times relative to existing conditions (EBC2) would occur from July to December—a period that includes the summer months when water temperatures are highest—and that residence times for 4A, B1, and B2 would increase markedly relative to EBC2.

Table 1. Residence times of inflows to the Delta under a dry WY



	Monthly average residence time (days)							
Month	EBC2	NAA	B1	B2	Alt 4A	Percent increase from EBC2 to B1	Percent increase from EBC2 to B2	Percent increase from EBC2 to Alt4A
October	28	26.6	35.8	34.4	31.6	28%	23%	13%
November	32.3	32.3	36.5	40.2	38.6	13%	24%	20%
December	27.6	28.3	30.8	32.3	31.3	12%	17%	13%
January	31	31.7	32.9	35.9	34.2	6%	16%	10%
February	27.3	26.9	28.9	29.3	30.7	6%	7%	12%
March	24.2	24	26.4	26.1	27	9%	8%	12%
April	22.3	22.8	24.9	24.9	24.9	12%	12%	12%
May	38.2	39.3	37.1	40	39.2	-3%	5%	3%
June	36.4	36.9	37.9	40.1	37.8	4%	10%	4%
July	27.7	28.7	34.4	35.6	34.2	24%	29%	23%
August	23.2	26.7	31.1	31.8	30.9	34%	37%	33%
September	27.8	31.2	36.3	35.1	34.3	31%	26%	23%

Source: Table 5, STKN-026, p. 40.

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[14] Exponent. 2017. Report on the Effects of the California WaterFix Project on the City of Stockton. Prepared for the City of Stockton. March 22. P. 39. (STKN-026)

For example, residence times would be 37% longer, on average, during the month of August in dry years for the B2 scenario relative to existing conditions (EBC2). Table 1 also shows that residence times would be similar for the NAA and EBC2 scenarios, demonstrating that the increase in residence times would be caused primarily by the proposed WaterFix project and not by sea level rise or climate change, which are included in the NAA. In STKN-026, Exponent's analysis further indicates that the proposed WaterFix project would result in longer Delta residence times in *all* WY types, not only in dry years.

As detailed in Sections 5 and 6, increased residence times in the Delta would likely cause the degradation of water quality in the Delta.

5. Increased *Microcystis* growth may result from WaterFix

Increased *Microcystis* accumulation may result from the WaterFix project due to increased residence times and increased water temperatures in the Delta. *Microcystis* is a genus of cyanobacteria containing species known to produce toxic chemicals called microcystins, which are a risk to humans, livestock and wildlife. Microcystins can be present outside the cells of the cyanobacteria and may not be completely removed via standard water treatment or boiling.[15]

Increased residence time in the Delta may increase the likelihood of a *Microcystis* bloom by several mechanisms.[16] The most direct effect is to decrease the loss rate of *Microcystis* from the area by flushing. As more biomass remains, there is more opportunity for *Microcystis* growth and toxin production. Indirect effects of an increase in residence time include lower mixing, which allows *Microcystis* cells to remain in the upper meter of the water column where irradiance is higher, leading to higher growth.

Additionally, water temperatures in the Delta may increase as a result of increased residence times, which may in turn increase *Microcystis* growth rates. As Exponent has previously documented,[17] DWR's analysis of temperature impacts within the Delta from WaterFix is incomplete and flawed. Flaws include the presentation of long-term monthly average simulated temperatures for DWR's 16-year DSM2 simulation period as a whole and not shorter-term (e.g., daily, monthly) simulated temperatures, which would be more relevant to *Microcystis* growth; a lack of temperature simulation results for scenarios other than the NAA and 4A (DWR did not

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[15] U.S. EPA. 2015. Health Effects Support Document for the Cyanobacterial Toxin Microcystins. EPA 820R15102. U.S. Environmental Protection Agency. Washington, DC; June 2015. Available from: http://water.epa.gov/drink/standards/hascience.cfm.

[16] Berg, M., and M. Sutula. 2015. Factors affecting the growth of cyanobacteria with special emphasis on the Sacramento-San Joaquin Delta. Southern California Coastal Water Research Project Technical Report 869 August 2015.

[17] See Exponent. 2017. Technical Comments on Petitioner's Rebuttal Testimony in the WaterFix Proceedings. Pp. 37-38. (STKN-048)

present Delta temperature analyses for scenarios EBC2, B1, B2, H3, or H4, or other modeled scenarios); and a lack of location-specific temperature modeling results for key Delta locations.

DWR's analysis of water temperature in the Delta indicates that monthly average water temperatures will increase under scenario 4A relative to the NAA, particularly in warm weather months. For example, DWR-653 states,

> Modeling shows that for the full simulation period (1922-2003), the period mean temperatures in the San Joaquin River at Prisoners Point for the CWF [California WaterFix] would be up to 0.1°C (0.18°F) higher than that modeled for the NAA for each month of the May through October period of the year … In September, the modeled maximum mean monthly temperature for the CWF would be about 0.3°C (0.6°F) higher than that modeled for the NAA.[18]

Increases in water temperature on shorter timescales and in different year types are expected to be higher than these reported monthly average increases. These projected temperature increases in the Delta are likely due, at least in part, to the projected increases in residence time because of WaterFix.

By increasing the growth rate of *Microcystis*, the higher water temperatures could not only increase the frequency and magnitude of *Microcystis* blooms during the summer months, but it could extend the season during which blooms are possible. *Microcystis* blooms in the Delta have been shown to occur when the temperature exceeds 19^{o}C, and an increase in temperature that exceeds that threshold could result in a longer blooming season.[19] Thus, despite its inadequacies, DWR's Delta temperature modeling also suggests the likelihood of increased *Microcystis* growth under WaterFix conditions.

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[18] DWR-653, p. 35.

[19] Lehman, P.W., K. Marr, G.L. Boyer, S. Acuna, and S.J. Teh. 2013. Long-Term Trends and Causal Factors Associated with *Microcystis* Abundance and Toxicity in San Francisco Estuary and Implications for Climate Change Impacts. *Hydrobiologia* 718:141–158.

6. WaterFix will cause an increase in salinity in the Delta

Salinity intrusion in the western Delta has been a concern for over a century. Historical evidence indicates that water in the Delta was predominantly fresh before the early 1900s, and water in the western Delta would have been fresh for most of the year.[20] Salinity patterns within the Delta have changed markedly over time in response to changes in the configuration of the Delta and flows to and out of the Delta, and the Delta is generally a more saline environment today than in its natural state. Because the proposed WaterFix north Delta diversion (NDD) structure is 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, which has implications for the composition and salinity of water in the Delta.

The greatest salinity impacts in the western Delta are associated with the B1 scenario. As discussed in detail in Antioch-202 Errata (Section 7.2) and Brentwood-102 Errata (Section 6b), the B1 scenario will result in changes in water composition and salinity at Antioch's intake on the San Joaquin River and at Brentwood's intake in Rock Slough. The changes in composition are broadly characterized by a lower percentage of Sacramento River water and a higher percentage of lower quality water sources, including San Joaquin River water, agricultural return flows, and saline inflow from Martinez.

DSM2 results reflect the expected changes in water quality in the western Delta under B1 operations. In previous work, Exponent calculated daily average chloride concentrations at Antioch from the DSM2 results for the modeled period (WY 1976–1991) and averaged them by month for the EBC2, NAA, and B1 scenarios, as presented in Table 2.[21] The results show that daily average chloride concentrations will increase each month under B1 compared to EBC2 and NAA scenarios.

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[20] See Antioch-202 Section 5.

[21] For more detail on DSM2 and the modeled scenarios, see Antioch-202 Errata Section 3.1.

Table 2. Daily average salinity at Antioch for EBC2, NAA, and B1 scenarios, averaged by month for the 16-year simulation period

	Daily average chloride concentration at Antioch (mg/L Cl-)				
Month	EBC2	NAA	B1	Diff. of B1 and EBC2	Diff. of B1 and NAA
January	494	573	677	183	105
February	268	269	323	55	54
March	128	117	144	16	27
April	109	126	154	45	29
May	266	266	335	69	69
June	527	540	557	30	17
July	940	987	1005	64	18
August	1160	1237	1354	194	116
September	1335	1439	1889	554	451
October	1303	1426	1973	671	548
November	1260	1433	1941	680	508
December	933	977	1304	370	326

Because the B1 and NAA scenarios include 15-cm of sea-level rise and EBC2 (the existing condition) does not, the difference between B1 and NAA isolates WaterFix-related impacts. DSM2 results show that the WaterFix project is expected to cause increases in daily average chloride concentrations at Antioch (averaged by month over the 16-year period) of more than 100 mg/L (ranging from 105 mg/L to 548 mg/L) during January and August through December.

Increased salinity in the western Delta under B1 operations will result in more frequent exceedances of the D-1641 250 mg/L chloride water quality objective for M&I beneficial uses at Contra Costa Canal, Pumping Plant #1 (PP#1).[22] Over the 16-year modeled period, EBC2, NAA, and B1 result in 210, 343, and 397 days of exceedances of the 250 mg/L chloride threshold, respectively (see Table 3). The B1 scenario would result in an average of 25 exceedances of the D-1641 250 mg/L water quality objective per year (all WY types). The simulated average annual number of days of exceedance summarized by WY type are shown in

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[22] See Antioch-202 Errata Section 3.3 Table 1 for additional detail.

Table 4. Impacts are greatest during dry and normal (above and below normal) WY types, which occur 54% of the time (based on the historical record from 1906–2016).

Table 3. Number of days of exceedance of the D-1641 250 mg/L water quality objective for M&I beneficial uses at PP#1 by WY

Water Year	Year Type	Total Days	EBC2	NAA	B1	H3	H4	B2
1976	Critical	366	26	0	0	0	0	0
1977	Critical	365	0	23	0	0	0	0
1978	Normal	365	6	78	85	55	73	0
1979	Normal	365	0	7	57	0	0	0
1980	Normal	366	45	23	18	0	0	0
1981	Dry	365	0	0	0	0	0	0
1982	Wet	365	2	2	8	0	0	0
1983	Wet	365	21	0	0	0	0	0
1984	Wet	366	0	0	0	0	0	0
1985	Dry	365	0	0	8	0	0	0
1986	Wet	365	15	21	0	0	0	0
1987	Dry	365	0	0	38	0	0	0
1988	Critical	366	0	0	0	0	0	0
1989	Dry	365	55	80	88	53	51	0
1990	Critical	365	23	18	0	0	0	0
1991	Critical	365	17	91	95	52	33	0
		sum	**210**	**343**	**397**	**160**	**157**	**0**

Table 4. Average number of days of exceedance of the D-1641 250 mg/L water quality objective for M&I beneficial uses at PP#1 by WY type

Year Type	**Days of Exceedance by Model Scenario**		
	EBC2	NAA	B1
Critical	13	26	19
Dry	14	20	34
Normal	17	36	53
Wet	10	6	2

Some of the modeled exceedances for the B1 scenario show considerably higher chloride concentrations compared to the existing condition (EBC2) and NAA scenarios; these increased concentrations persist for long periods. Figure 1 presents daily average chloride concentrations at PP#1 for WY 1978–WY 1979 from DWR's model results. The red line indicates the D-1641 250 mg/L water quality objective. During WY 1978–WY 1979, the B1 scenario is simulated to exceed the chloride threshold for over five months during two lengthy exceedance periods, and the NAA scenario is projected to exceed the threshold just over three months. These results show that compliance will likely be difficult to achieve with the projected impacts of climate change (at least during dry periods), and that compliance with water quality objectives in the western Delta will be even more challenging under B1 operations.

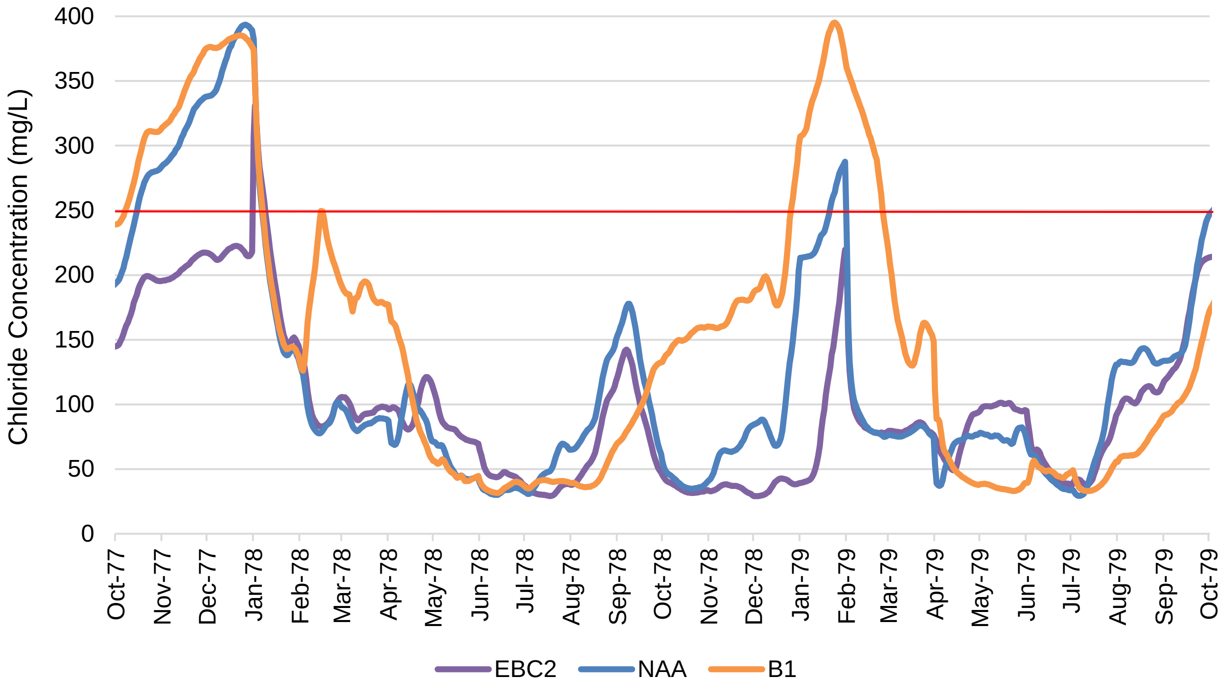

Figure 1. Simulated daily average chloride concentrations at PP#1 using DSM2 results for EBC2, NAA, and B1 scenarios. The red horizontal line represents the D-1641 250 mg/L water quality objective at PP#1.

D-1641 also requires that the daily average chloride concentration at PP#1 or Antioch be less than 150 mg/L chloride for a specified number of days per year (number of days varies by WY type).[23] DWR operates to meet this objective at PP#1 and not at Antioch because it is less costly to do so.[24]

Despite B1 water quality impacts and compliance issues associated with the D-1641 250 mg/L objective, modeling shows the B1 scenario remains compliant with the 150 mg/L water quality objective with the exception of only one year in the modeled 16-year period. Figure 2 shows salinity will increase (as indicated by fewer days of chloride concentrations less than 150 mg/L at PP#1) during WY 1976, 1978, 1980, 1984, 1986, 1987, and 1988 for the B1 scenario compared to the NAA scenario. For example, during WY 1976 there will be about 75 additional days where chloride exceeds 150 mg/L at PP#1 under B1 conditions, yet this does not trigger an exceedance of the water quality objective. Thus, even when operations comply with the 150 mg/L chloride water quality objective, salinity is shown to increase substantially under the B1 scenario.

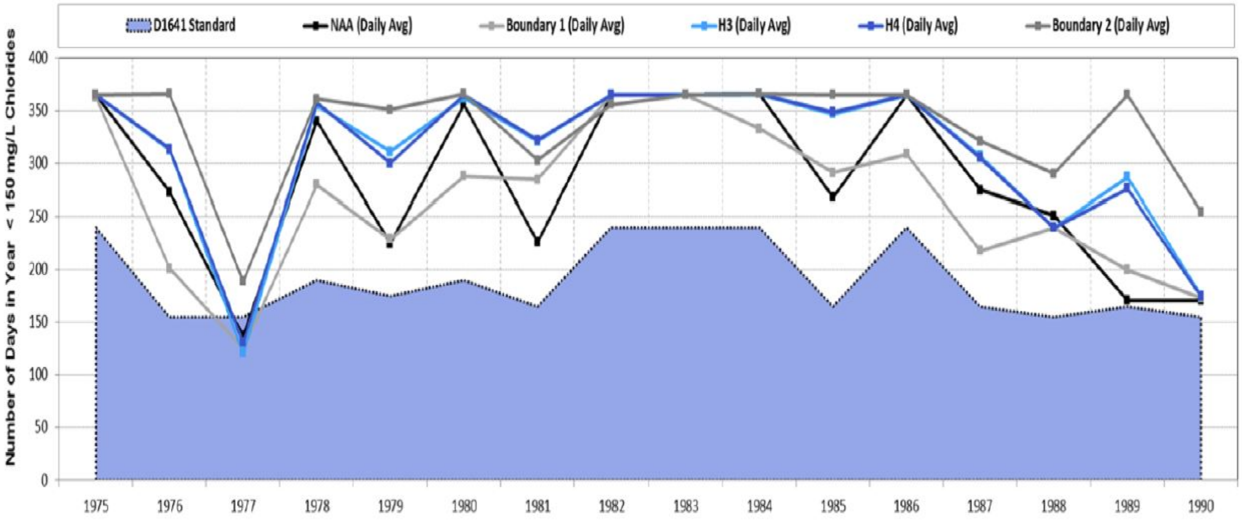

Figure 2. DWR-5 slide 72 showing the modeled compliance (and non-compliance) with the D-1641 M&I beneficial uses water quality objective at PP#1.

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[23] See Antioch-202 Errata Section 3.3 Table 1.

[24] DWR has stated that they “don’t attempt to meet it because it’s – for one, it’s not required to meet it per D-1641. The requirement is at either location [CCPP#1 or Antioch]. And typically, it would be much less costly in terms of water – water supply for the entire system if we meet it at Rock Slough” (Part 1A, Testimony Volume 11, p. 94, lines 19–24).

Exponent has also evaluated the salinity in the interior Delta, e.g., at Stockton's intake location. The City of Stockton uses an operational threshold of 110 mg/L chloride.[25] Exponent evaluated the number of days in the simulation period that this threshold would be exceeded for each of the WaterFix scenarios, as shown in Table 5. DWR's model results indicate that salinity at Stockton's intake will increase under both B1 and B2 scenarios most noticeably during dry and critical WY types. The B2 operations scenario results in the largest number of days chloride concentrations exceed 110 mg/L. DSM2 model results demonstrate that increases in salinity are also expected to occur at other locations in the interior Delta as a result of the WaterFix project.

Table 5. Number of equivalent days per year that water at Stockton's intake *exceeds* 110 mg/L chloride under various modeled scenarios for each WY between 1976 and 1991

			No. of days per year water at Stockton's intake exceeds chloride threshold of 110 mg/L			
WY	WY Type	Total Days	EBC2	NAA	B1	B2
1976	Critical	366	25	0	11	87
1977	Critical	365	9	76	56	71
1978	Normal	365	45	82	105	24
1979	Normal	365	12	29	33	31
1980	Normal	366	50	23	34	1
1981	Dry	365	12	14	5	82
1982	Wet	365	20	23	30	4
1983	Wet	365	0	0	0	0
1984	Wet	366	0	0	0	0
1985	Dry	365	7	1	7	76
1986	Wet	365	26	20	4	15
1987	Dry	365	11	6	63	81
1988	Critical	366	15	10	18	88
1989	Dry	365	93	125	109	71
1990	Critical	365	54	24	11	57
1991	Critical	365	75	139	143	72
Summary	(all)		455	572	627	759

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[25] Due to operational constraints, the City of Stockton is restricted to pumping water from the Delta when chloride is below 110 mg/L. See STKN-26 Section 4.3 for additional detail.

In sum, DWR's DSM2 results show that WaterFix scenario B1 will result in a substantial increase in salinity in the western Delta. Multiple WaterFix scenarios, including both B1 and B2 will result in significant salinity increases in the interior Delta as well, with the greatest increase expected to occur as a result of the B2 operations scenario. DWR's model results show that compliance with the D-1641 chloride objectives is expected to occur less frequently because of WaterFix and that, even when D-1641 compliance is simulated to occur, significant increases in salinity are predicted during some periods.

As detailed in the testimony of Thomas Grovhoug, P.E. (Exhibit SRCSD-16), worsening water quality in the Delta—including increased *Microcystis* growth and salinity—has the potential to result in more stringent future permit limitations on discharges to the Delta, including discharges from the SRWTP.

7. WaterFix will impact SRWTP operations by increasing the frequency and duration of diversion events relative to baseline conditions (i.e., EBC2 and NAA scenarios)

As noted in Section 3, the conditions of Regional San's NPDES permit prohibit discharge from the SRWTP to the Sacramento River when the ratio of river flow to effluent flow is below 14:1. Under these low-flow conditions, Regional San must close the valves that allow treated effluent to be discharged to the Sacramento River and divert flow to ESBs instead.

To evaluate the extent to which WaterFix would change the flow regime in the Sacramento River at Freeport and thereby affect SRWTP operations, Flow Science used DWR's DSM2 output from simulations of the EBC2 and NAA scenarios and four WaterFix scenarios (H3, H4, B1, and B2) as input to a model simulating Regional San's discharge and diversion operations.[26] Results of Flow Science's analysis are summarized in Table 6, and the detailed analysis is presented in Appendix A. These model results are a reliable basis upon which to compare the alternatives.

Results show an increase in four key parameters as a result of WaterFix: (1) the number of diversion events, (2) the percentage of time that diversion would be required, (3) the percentage of time that effluent would be stored in ESBs, and (4) the cumulative volume of water that would be pumped from ESBs over the 16-year modeling period (WY 1976–1991). Under WaterFix, these parameters would increase between 44% and 59% (depending on the parameter) relative to EBC2 and between 4% and 17% (depending on the parameter) relative to the NAA. Although climate change and sea level rise are expected to increase the number and frequency of diversion events (as indicated by the comparison of the NAA to EBC2), the WaterFix project itself is expected to increase the number and frequency of diversion events to a

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[26] Flow Science. 2017. Op. cit.

greater extent than climate change and sea level rise alone (as indicated by the comparison of the project scenarios to the NAA).

Table 6. Summary of Flow Science SRWTP operations modeling results over the 16-year simulation period (1976–1991)

Parameter	DSM2 Model Scenarios					
	EBC2	NAA	B1	B2	H3	H4
(1) Number of diversion events	2,704	3,571	3,930	3,901	3,982	4,189
Change in number of diversion events compared with EBC2 (%)	NA	+32%	+45%	+44%	+47%	+55%
Change in number of diversion events compared with NAA (%)	NA	NA	+10%	+9%	+12%	+17%
(2) Percent of time diversion required (%)	5.6	8.0	8.3	8.3	8.6	9.0
Change in total diversion time compared with EBC2 (%)	NA	41%	47%	47%	51%	59%
Change in total diversion time compared with NAA (%)	NA	NA	+4%	+4%	+8%	+13%
(3) Percent of time effluent stored in ESBs (%)	11.8%	16.4%	17.1%	17.0%	17.6%	18.4%
Change in percent time effluent stored in ESBSs compared with EBC2 (%)	NA	+39%	+45%	+44%	+49%	+56%
Change in percent time effluent stored in ESBSs compared with NAA (%)	NA	NA	+4%	+4%	+7%	+12%
(4) Cumulative volume pumped out of ESBs (million gallons [MG])	63,928	89,034	93,087	92,643	95,590	100,046
Change in cumulative volume pumped out of ESBs compared with EBC2 (%)	NA	+39%	+46%	+45%	+50%	+56%
Change in cumulative volume pumped out of ESBs compared with NAA (%)	NA	NA	+5%	+4%	+7%	+12%

Increases in (1) the number of diversion events, (2) the percentage of time that diversion would be required, and (4) the cumulative volume of water that would be pumped from ESBs over the 16-year modeling period (1976–1991) will correlate with higher operational and maintenance costs for Regional San, including added power costs for additional pumping and added costs associated with opening and closing valves more frequently and cleaning ESBs. (The testimony of Ruben Robles, P.E. [Exhibit SRCSD-28] details these costs.) Increases in (3) the percentage of time that effluent would be stored in ESBs have the potential to result in additional odor impacts due to the longer periods during which effluent would be stored in open-air ESBs. The expected increase in (1) the number of diversion events under WaterFix effectively amounts to an encroachment on Regional San's ESB capacity.

Thus, Flow Science's model results indicate that WaterFix will result in significant impacts to Regional San's operation of the SRWTP, including higher operations and maintenance costs, loss of available storage, and increased environmental impacts for Regional San relative to both EBC2 and the NAA.

Appendix A

Flow Science Incorporated Technical Report

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SACRAMENTO REGIONAL WASTEWATER TREATMENT PLANT EMERGENCY STORAGE BASIN ANALYSIS FOR CALIFORNIA WATERFIX

Prepared for

Sacramento County Regional Sanitation District

Reviewed By
E. John List, Ph.D., P.E

Prepared By
Kristen Bowman Kavanagh, P.E.
Gang Zhao, Ph.D., P.E.

FSI 164071
November 29, 2017

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1. INTRODUCTION

The Sacramento Regional County Sanitation District (Regional San) operates the Sacramento Regional Wastewater Treatment Plant (SRWTP), which discharges treated wastewater to the Sacramento River at Freeport. One of SRWTP's NPDES permit requirements is that SRWTP only discharge effluent to the Sacramento River when the ratio of river flow to effluent flow is higher than 14:1. When the river-to-effluent flow ratio is less than 14:1, SRWTP effluent is diverted to emergency storage basins (ESBs).

The California Department of Water Resources (DWR) released DSM2 modeling results for more alternatives of the California WaterFix project. The modeling results showed that there will be changes in Sacramento River flow at Freeport for the modeled alternatives. These changes will likely have impacts on SRWTP's discharge operations and the required volume of the ESBs. In addition, the ongoing EchoWater Project at SRWTP will alter the treatment process, which may change the plant's discharge flow regime.

Flow Science Incorporated (Flow Science) was retained by Regional San to work in coordination with Exponent to analyze the effect on SRWTP operations and the required ESB volumes from selected WaterFix alternatives under both current SRWTP and future EchoWater operating conditions. The six selected WaterFix alternatives are the baseline scenarios EBC2 and NAA and the project scenarios H3, H4, Boundary 1, and Boundary 2. The following bullets describe the distinctions between these alternatives:

- <u>EBC2</u>: current operations based on the USFWS (2008)[1] and NMFS (2009)[2] Biological Opinions, including management of outflows to achieve the Fall X2 salinity standards;

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[1] United States Fish and Wildlife Service (USFW), 2008. Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP). California and Nevada Region. December 2008.

[2] National Marine Fisheries Service (NMFS), 2009. Final Biological Opinion and Conference Opinion of the Proposed Long-term Operations of the Central Valley Project and State Water Project. U.S. Department of Commerce National Marine Fisheries Service. June 2009.

- NAA: includes the requirements of the USFWS (2008) and NMFS (2009) Biological Opinions, Fall X2 salinity standard, and the effects of climate change and sea level rise as of 2025;
- H3: includes the Fall X2 salinity standards but does not include enhanced spring outflow;
- H4: includes both the Fall X2 salinity standards and enhanced spring outflow;
- Boundary 1: does not include either the Fall X2 salinity standards or the enhanced spring outflow;
- Boundary 2: includes the Fall X2 salinity standards, enhanced outflow for all months, and more restrictive requirements on Old and Middle River flows.

Detailed descriptions of these alternatives can be found in Chapter 5 and Appendix 5E of the WaterFix EIR. Of the alternatives, EBC2 is the scenario with operations closest to the current conditions, whereas the NAA scenario is a hypothetical future condition. Therefore, EBC2 was selected as the baseline condition for the comparison of results of the alternatives.

Flow Science had developed a model code for analyzing SRWTP diversion operations and ESB volumes in previous ESB analysis projects. For this project, Flow Science discussed and confirmed relevant SRWTP operating parameters with Regional San, updated the model code, developed SRWTP flow data, and analyzed SRWTP operations and required ESB volumes for the selected alternatives. This memorandum presents a summary of the work completed by Flow Science.

2. BACKGROUND & QUALIFICATIONS

The primary author of this report was Kristen Bowman Kavanagh, P.E. Ms. Kavanagh is a Registered Professional Engineer in the State of California (License #C58407). Her educational background includes a Bachelor of Science in Civil Engineering from Stanford University (January 1995) and a Master of Science in Civil Engineering from Stanford University (June 1995). Her education included coursework at both undergraduate and graduate levels in fluid mechanics, hydrology, surface and groundwater flows, and aquatic chemistry.

Ms. Kavanagh is currently President and a Principal Engineer at Flow Science Incorporated (Flow Science), where she has been employed for almost 20 years (since 1998). While at Flow Science, she has been responsible for performing computational fluid dynamics (CFD) modeling, analysis and modeling of lake and reservoir water quality and hydrodynamics, and hydraulic and transient analysis. She has 22 years of experience with projects involving hydrodynamics and water quality in lakes and rivers, hydraulics, and point and non-point source discharges.

3. MODEL INPUTS AND PARAMETERS

Inputs to Flow Science's model for analyzing SRWTP diversion operations and ESB volumes include Sacramento River flow at Freeport and SRWTP flow data. DWR has conducted DSM2 modeling studies for WaterFix alternatives, and the model results include Sacramento River flow at Freeport that was used in Flow Science's ESB model. The 2016 updated DSM2 output for WaterFix alternatives H3, H4, Boundary 1, Boundary 2, and NAA were obtained from the SWRCB's ftp site[3]. The DSM2 model run for the EBC2 alternative was completed by DWR in 2013, and no changes have been made to this alternative since then. Thus, the EBC2 model results were taken from 2013 model runs previously received from DWR via hard drive. The DSM2 modeled flow data cover the period of water years 1976-1991.

Although the SRWTP's NPDES permit allows the plant to discharge a maximum average dry weather flow (ADWF) of 181 mgd, SRWTP flows in recent years have been below this permit limit of 181 mgd ADWF. However, the plant's inflow conditions could change, and flow could increase in the future. Therefore, an ADWF of 181 mgd was used in this analysis to ensure that the model results consider the maximum ESB volume required.

In previous ESB modeling over time periods longer than ten years, monthly SRWTP inflow data and hourly diurnal flow factors were used to generate hourly plant flow series. To be consistent with previous modeling, the same method was used in this analysis. For current plant operating conditions, average monthly SRWTP flows were calculated from the plant's average daily inflow data for the year 2015, and these average monthly flows were then scaled up to 181 mgd ADWF. Thus, the resulting flow patterns used in the ESB model reflect 2015 measured plant inflows, but the magnitude of the flows was increased to reflect the permit limit of 181 mgd ADWF. Flow Science and

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[3] **https://ftp.waterboards.ca.gov/#/+CalSim%20and%20DSM2%20Modeling/**

Regional San staff also discussed the possible future SRWTP effluent flow regimes after the EchoWater project is completed. The conclusions were that the plant inflow rates and patterns after the EchoWater project is completed will not be significantly different, and a new plant inflow data series was not needed for this analysis. The resulting scaled monthly flow data used in the analysis for both the existing and post-EchoWater project scenarios are summarized in **Table 1** in comparison to the 2015 measured monthly inflows. The hourly diurnal flow factors, as previously provided by Regional San and applied in the ESB model to the scaled monthly flow data in **Table 1**, are presented in **Table 2**.

Table 1 — Monthly SRWTP Influent Flows versus Modeled Monthly Flows Scaled to 181 mgd ADWF

Month	Influent Flow	Scaled to 181 mgd ADWF
	mgd	mgd
1	134	202
2	146	220
3	133	200
4	132	199
5	124	186
6	123	185
7	121	182
8	120	181
9	120	180
10	122	183
11	123	184
12	128	192

Table 2 — Hourly Diurnal Flow Factors Provided by Regional San

Hour of Day	$Q_{hourly}/Q_{monthly\ avg}$
0:00	1.13
1:00	1.1
2:00	1.05
3:00	1

Hour of Day	$Q_{hourly}/Q_{monthly\ avg}$
4:00	0.94
5:00	0.87
6:00	0.8
7:00	0.75
8:00	0.72
9:00	0.75
10:00	0.79
11:00	0.85
12:00	0.91
13:00	0.98
14:00	1.05
15:00	1.12
16:00	1.15
17:00	1.16
18:00	1.15
19:00	1.15
20:00	1.14
21:00	1.13
22:00	1.14
23:00	1.14

The temperature of the river water and SRWTP effluent can also be included as inputs to Flow Science's ESB model to simulate flow diversion for thermal compliance. However, DWR's modeling studies do not provide temperature results. Therefore it was not possible to consider flow diversion for thermal compliance in the current ESB model analysis.

ESB model parameters include the discharge capacity through the diffuser to the river, the pumping capacity from the ESB to the diffuser, the 14:1 trigger ratio of river flow to effluent flow, and a minimum river flow for diversion from the diffuser to the ESB. The minimum river flow trigger was set to 2,500 cfs as indicated by Regional San staff; however, based on the hourly flows computed from the 2015 data, the minimum river flow trigger did not come into effect. Thus, the 14:1 river-to-effluent flow ratio was the driving factor in initiating diversions in this analysis. Also note that other factors not included in this analysis, such as thermal effluent and receiving water requirements, as well as planned and unplanned maintenance, could require Regional San to initiate additional diversions and further impact ESB storage volumes. The parameter values used in the ESB model are summarized in **Table 3**.

Table 3 — Model Parameters for Existing and Post EchoWater Conditions

Parameter	Existing Value	Post EchoWater Value
Diffuser discharge capacity to river	410 mgd	410 mgd
Influent diversion capacity to ESB	400 mgd	400 mgd
Effluent diversion capacity to ESB	270 mgd[1]	330 mgd[2]
Pumping capacity from ESB	175 mgd	175 mgd
River-to-effluent flow ratio for diversion	14:1	14:1
Minimum river flow for diversion	≤ 2,500 cfs	≤ 2,500 cfs

[1] The effluent diversion capacity to the ESBs is currently limited to 270 mgd by the hydraulic capacity of the Carbonaceous Oxygenation (CO) tanks.

[2] The effluent diversion capacity to the ESBs post EchoWater project will be limited to 330 mgd by the BNR treatment process.

Note in **Table 3** that both influent to the plant and effluent from the treatment process can be diverted to ESBs in order to cease diffuser discharges to the river, when required. Thus, the total diversion capacity to ESBs is the sum of the influent and effluent diversion capacity, and this total diversion capacity not only exceeds the maximum modeled plant influent rate but also the diffuser discharge capacity.

After completion of the EchoWater project, the new biological nutrient removal (BNR) treatment process will have a maximum capacity of 330 mgd which could limit SRWTP flows. However, based upon the modeled monthly flow rates in **Table 1** and the diurnal flow factors in **Table 2**, the modeled plant flow rates never exceeded the post EchoWater project BNR capacity of 330 mgd. Similarly, the modeled plant flow rates never exceeded the existing effluent diversion capacity to the ESB of 270 mgd (due to the hydraulic capacity of the CO tanks). Thus, neither the existing hydraulic capacity of the CO tanks nor the post EchoWater BNR capacity triggered the need for diversions to the ESB in this analysis.

4. RESULTS OF ANALYSIS

Using the input flow data and model parameters described in the prior section, Flow Science ran the ESB model for the six selected WaterFix alternatives. Model outputs included hourly series of effluent flow and ESB volume data. The model results were processed to obtain the maximum required ESB volume, the probability distribution of ESB volume, a summary of diversion events, and relevant parameters of ESB storage and discharge. The modeled maximum ESB volume, the number and percent time of diversion events, the percent of time effluent is stored in the ESB, the cumulative volume of effluent pumped out of the ESB, and summary statistics of length of periods with effluent continuously stored in the ESB are presented in **Table 4**. The EBC2 alternative was found to have the smallest values for all parameters summarized in **Table 4**, except for the median length of effluent continuously stored in the ESB, for which all modeled alternatives have the same value. The EBC2 alternative is also the scenario with operating conditions most similar to current conditions. Thus, the EBC2 alternative was used as the baseline scenario with which to compare the percent differences to the other alternatives.

Table 4 — Summary of ESB Modeling Results

Parameter	WaterFix Alternatives (WYs 1976-1991)					
	EBC2	**NAA**	**Boundary 1**	**Boundary 2**	**H3**	**H4**
Maximum ESB volume required (Million Gallons)	58	61	61	61	61	61
Total number of diversion events	2704	3571	3930	3901	3982	4189
Percent of time diversion required (%)	5.6	8.0	8.3	8.3	8.6	9.0
Percent of time effluent stored in ESB (%)	11.8	16.4	17.1	17.0	17.6	18.4
Cumulative volume pumped out of ESB (million gallons)	63,928	89,034	93,087	92,643	95,590	100,046
Median length of time effluent continuously stored in ESB (hours)	6	6	6	6	6	6
Maximum length of time effluent continuously stored in ESB (hours)	23	48	48	48	48	48
Change in total number of diversion events compared with EBC2	NA	32%	45%	44%	47%	55%
Change in total diversion time compared with EBC2	NA	41%	47%	47%	51%	59%

Parameter	WaterFix Alternatives (WYs 1976-1991)					
	EBC2	NAA	Boundary 1	Boundary 2	H3	H4
Change in percent of time effluent stored in ESB	NA	39%	45%	44%	49%	56%
Change in cumulative volume pumped out of ESB	NA	39%	46%	45%	50%	56%
Change in maximum length of time effluent continuously stored in ESB	NA	109%	109%	109%	109%	109%

These results show that compared with EBC2, the other alternatives require a small (~5%) increase in the maximum ESB volume. However, the other alternatives lead to significant increases in the following parameters:

- total number of diversion events (32% to 55% more than the EBC2 alternative),
- total diversion time (41% to 59% more than the EBC2 alternative),
- percent of time effluent stored in ESB (39% to 56% more than the EBC2 alternative),
- cumulative volume of effluent pumped out of ESB (39% to 56% more than the EBC2 alternative),
- maximum length of time effluent continuously stored in ESB (109% more the the EBC2 alternative).

Plots of the probability distribution of required ESB volume for each alternative are included in **Appendix A**. Plots of the probability distribution of the length of time effluent is continuously stored in the ESB for each alternative are included in **Appendix B**.

The results presented in **Table 4** are for the entire modeled period (*i.e.*, water years 1976-1991). To better understand the impacts of different hydrologic conditions on flow diversions, the summary of diversion events was further grouped and averaged by water year types according to DWR classification (*i.e.*, wet, above normal, below normal, dry, and critically dry years). Water year types within the modeled period are presented in **Table 5**. There was only one below normal (BN) year and two above normal (AN) years within the modeled period, and therefore, model results may not be representative for these two water year types if each of these two water year types is examined individually. Therefore, results for the below normal and above normal water years were combined into one category (AN/BN) to produce more representative results for approximately normal conditions. For critical (C), dry (D) and wet (W) water year types, there are four to five years for each water year type within the modeled period. Thus, averaging model results for these water year types was helpful in gaining some insight into the effect of hydrologic conditions on diversion events. The average number of diversion events and average percent of time of diversion are presented in **Table 6** for C, D, AN/BN, and W water year types. **Table 6** also includes (in parentheses) the percent increases in these values for each alternative in comparison to the EBC2 alternative. A summary of diversion events for each water year is presented in **Appendix C**.

Table 5 — Water Year Types for the Modeled Period

Water Year	Type
1976	Critical
1977	Critical
1978	Above Normal
1979	Below Normal
1980	Above Normal
1981	Dry
1982	Wet
1983	Wet
1984	Wet
1985	Dry
1986	Wet
1987	Dry
1988	Critical
1989	Dry
1990	Critical
1991	Critical

Table 6 – Average Diversion Summary by Water Year Types

Parameter	Water Year Type	WaterFix Alternatives					
		EBC2	NAA	Boundary 1	Boundary 2	H3	H4
Average number of diversion events per year[1]	C	365	441 (21%)	453 (24%)	455 (24%)	459 (26%)	460 (26%)
	D	127	196 (55%)	203 (60%)	211 (66%)	238 (88%)	265 (109%)
	AN/BN	75	99 (32%)	163 (118%)	150 (101%)	143 (92%)	162 (117%)
	W	37	71 (95%)	91 (150%)	84 (129%)	77 (112%)	87 (137%)
Average percent of time diversion required (%)[1]	C	13%	17% (32%)	17% (30%)	17% (31%)	17% (34%)	17% (33%)
	D	3.9%	6.1% (56%)	6.2% (58%)	6.2% (58%)	7.2% (83%)	8.3% (111%)
	AN/BN	2.4%	3.5% (47%)	5.0% (111%)	5.0% (112%)	4.8% (101%)	5.2% (119%)
	W	1.0%	2.1% (109%)	2.6% (164%)	2.4% (140%)	2.2% (120%)	2.5% (156%)

[1] The values in parentheses are the computed percent increases in comparison to the EBC2 alternative.

As expected, average results for the three water year types show that the critical water years required the most diversion events and longest diversion time periods, while wet water years led to the lowest number of diversion events and the shortest duration of diversion. Using EBC2 as the base scenario, the increase in the average number of diversion events for the other alternatives ranged from 21%-26% for critical (C) water years, 55%-109% for dry (D) water years, 32%-118% for the combined above normal and below normal (AN/BN) water years, and 95%-150% for wet (W) water years. The average percent of time for diversion increased by 30%-34% for critical (C) water years, 56%-111% for dry (D) water years, 47%-119% for the combined above normal and below normal (AN/BN) water years, and 109%-164% for wet (W) water years. Therefore, the percentage changes in number of diversion events and diversion time of other alternatives, as compared to the EBC2 alternative, are most significant for the wet water year type and least significant for the critical water year type. However, it should be noted that all scenarios have the lowest absolute number of diversion events and diversion time for wet water years. The larger percentage changes between alternatives for the wet water years are due to the low base case values and should not be overemphasized.

To further examine the distribution of relevant diversion parameters within a year, parameters listed in **Table 4** are grouped by month for the 16-year modeled period. These parameters are further grouped by month and water year type to understand the effects of hydrologic and seasonal conditions on diversion operations. The detailed results are presented in **Appendix D**.

5. SUMMARY

DWR released updated DSM2 model results for several more WaterFix alternatives in 2016. Flow Science modeled the effects of these updated alternatives, as well as DWR's EBC2 alternative from 2013, which is up-to-date for EBC2, on SRWTP's diversion operations and required ESB volume. The six selected WaterFix alternatives are H3, H4, Boundary 1, and Boundary 2, and baseline condition scenarios EBC2 and NAA. Flow Science confirmed relevant model parameters with Regional San. Flow Science and Regional San staff also discussed the potential change in SRWTP flows due to the EchoWater project, and concluded that the future treatment processes would not affect the flow rates used in the ESB model analysis. Thus, the SRWTP flow rates used in the model for existing and post EchoWater operations were identical and were developed using flow data for 2015. This plant flow data set was then scaled up to 181 mgd ADWF, the maximum flow rate limitation in SRWTP's NPDES permit.

The modeled maximum ESB volume was 58 million gallons (MG) for EBC2 and 61 MG for all other alternatives. Although the increase in the maximum ESB volume was only about 5% for the other alternatives in comparison to the EBC2 alternative, other alternatives led to significant increases over EBC2 for the following ESB operation parameters:

- total number of diversion events (32% to 55% more than the EBC2 scenario),
- total diversion time (41% to 59% more than the EBC2 scenario),
- percent of time effluent stored in ESB (39% to 56% more than the EBC2 alternative),
- cumulative volume of effluent pumped out of ESB (39% to 56% more than the EBC2 alternative),
- maximum length of time effluent continuously stored in ESB (109% more the the EBC2 alternative).

Model results for diversion events were further grouped and averaged by water year types for critical, dry, combined above normal and below normal, and wet water year types. As expected, the averaged results showed that critical water years require the most diversion events and longest diversion time periods, while wet water years lead to the lowest number of diversion events and shortest duration of diversion. Using EBC2 as the baseline, the proposed alternatives resulted in the largest percentage increase in diversion events and time for wet water years, and the smallest percentage increases for critical years. However, the large percentage increases for wet water years are due to the low base case values and should not be overemphasized.

APPENDIX A

Probability Distribution of Required ESB Volume for the Selected Alternatives

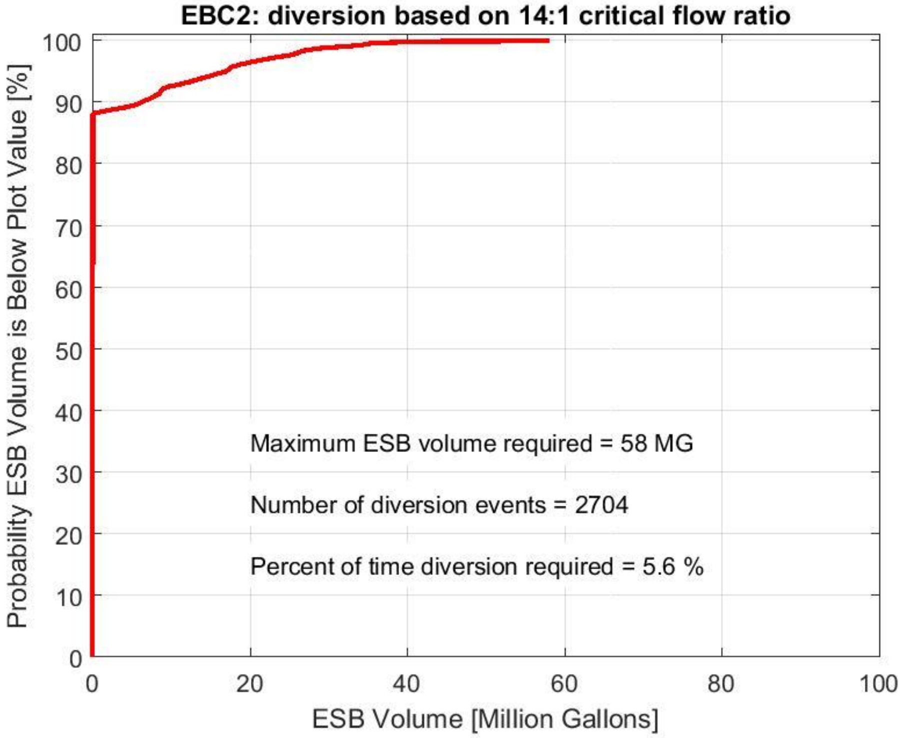

Figure A1. Probability distribution of ESB volume for the EBC2 alternative

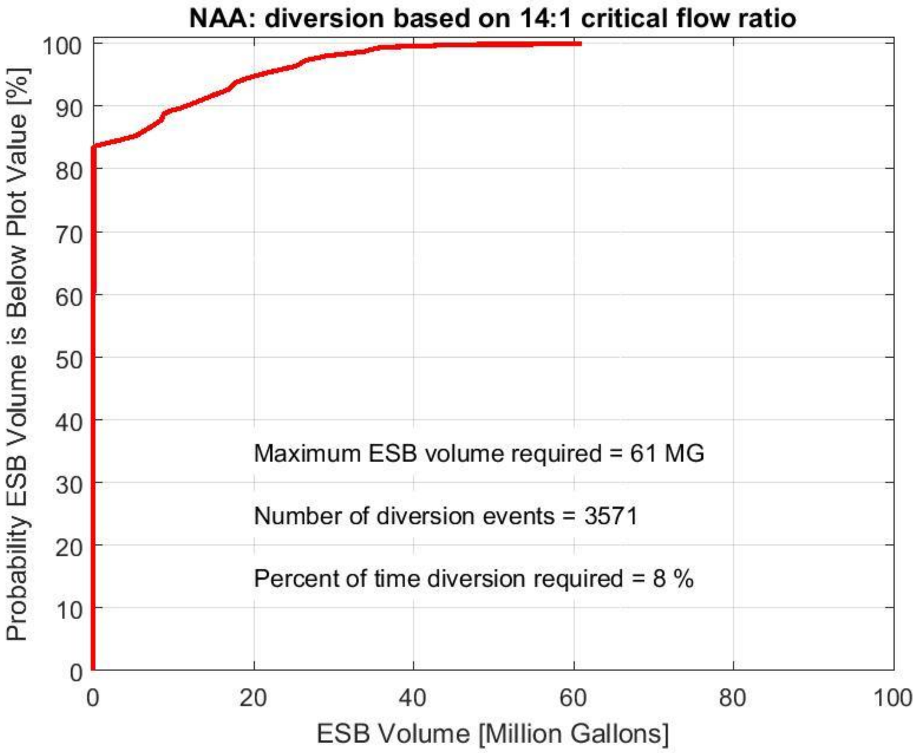

Figure A2. Probability distribution of ESB volume for the NAA alternative

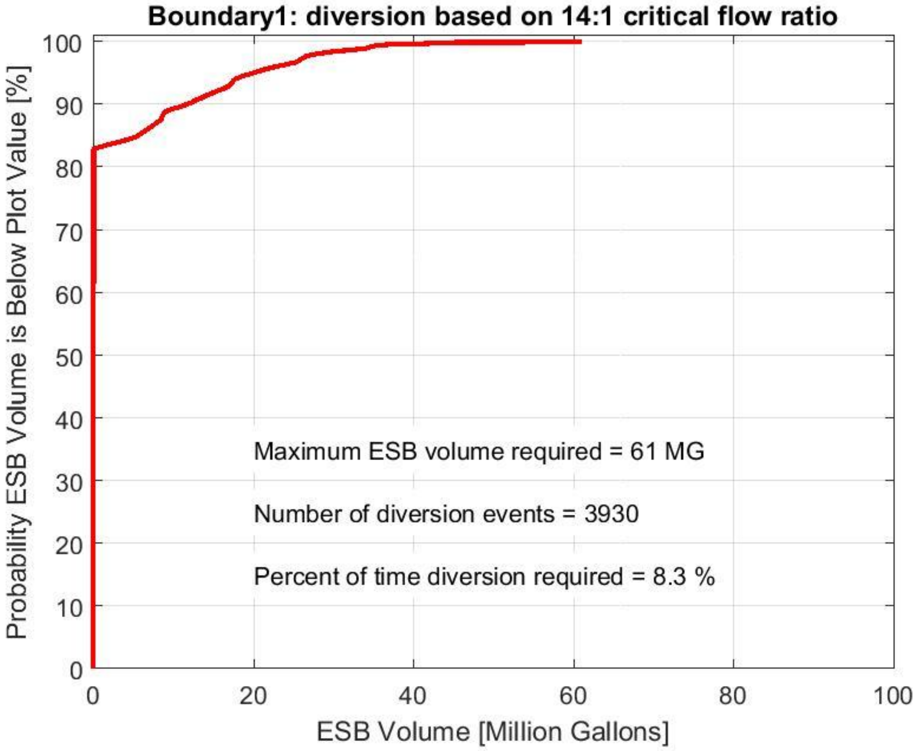

Figure A3. Probability distribution of ESB volume for the Boundary1 alternative

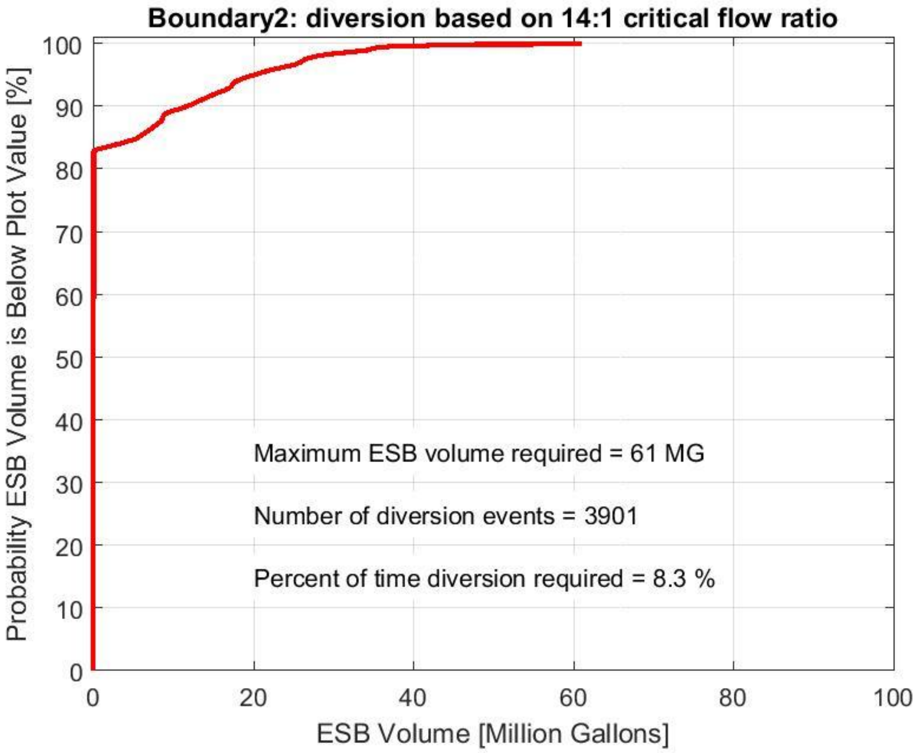

Figure A4. Probability distribution of ESB volume for the Boundary2 alternative

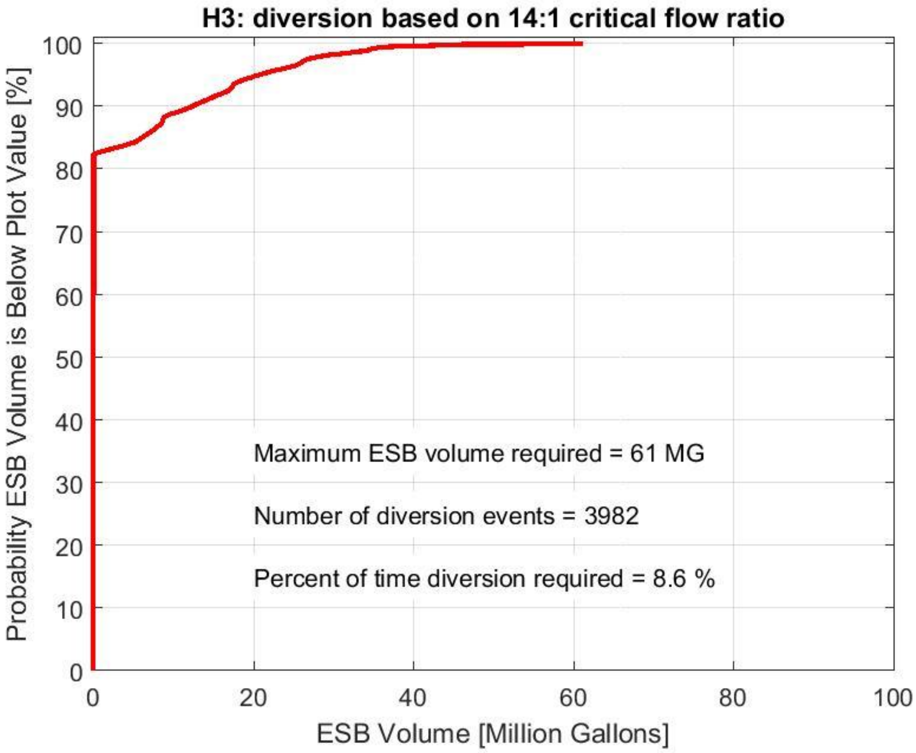

Figure A5. Probability distribution of ESB volume for the H3 alternative

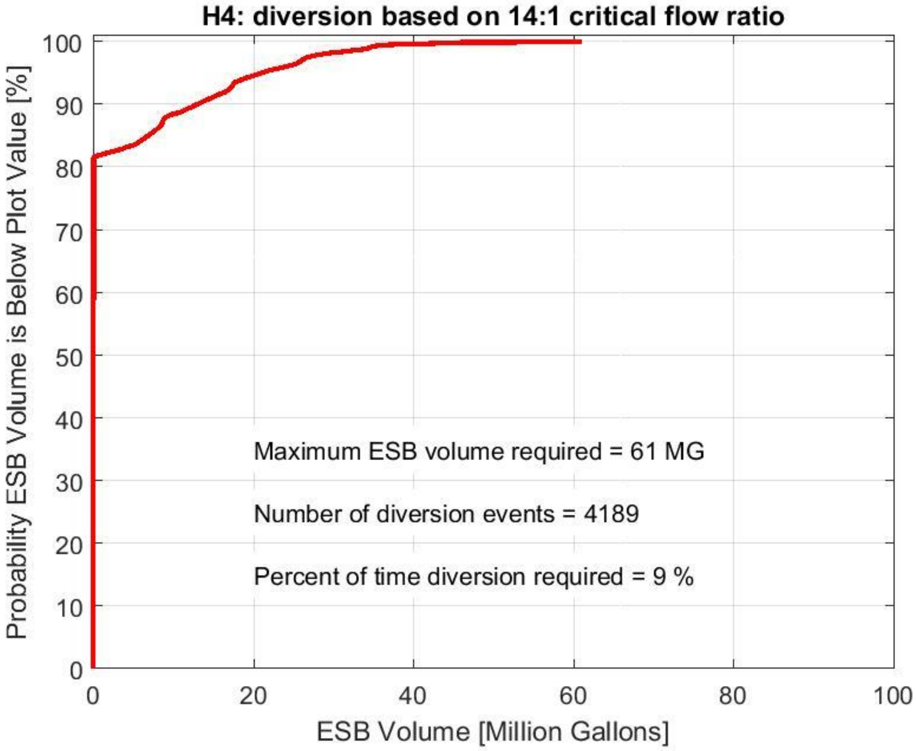

Figure A6. Probability distribution of ESB volume for the H4 alternative

APPENDIX B

Probability Distribution of Length of Time Effluent Continuously Stored in the ESB for the Selected Alternatives

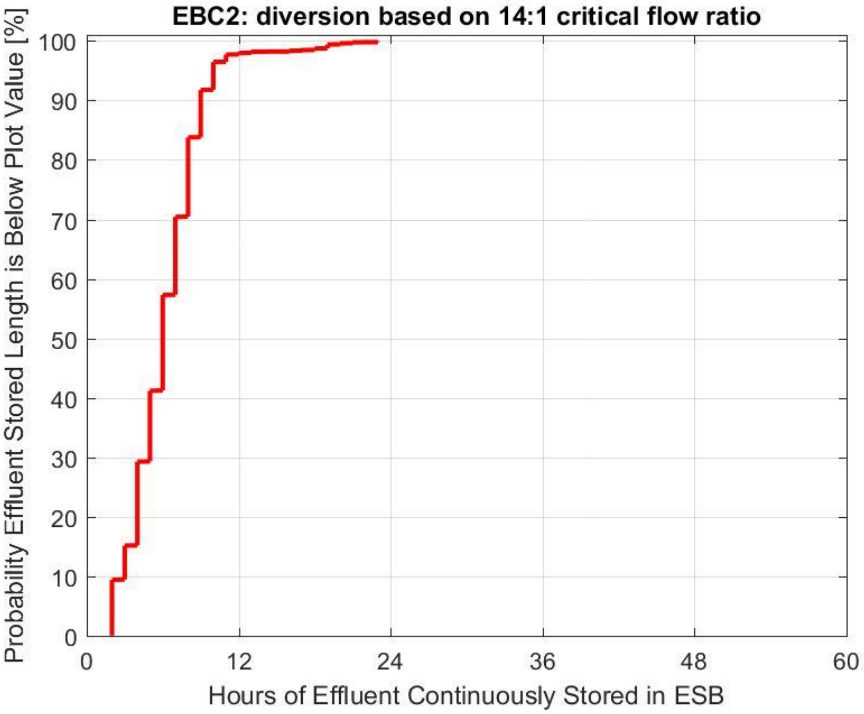

Figure B1. Probability distribution of length of time effluent continuously stored in ESB for the EBC2 alternative

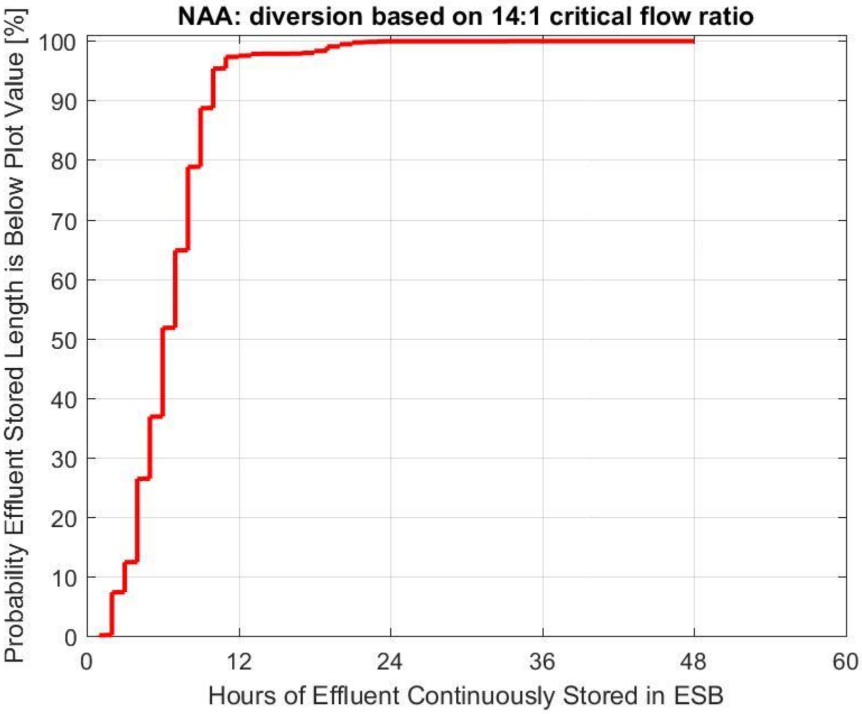

Figure B2. Probability distribution of length of time effluent continuously stored in ESB for the NAA alternative

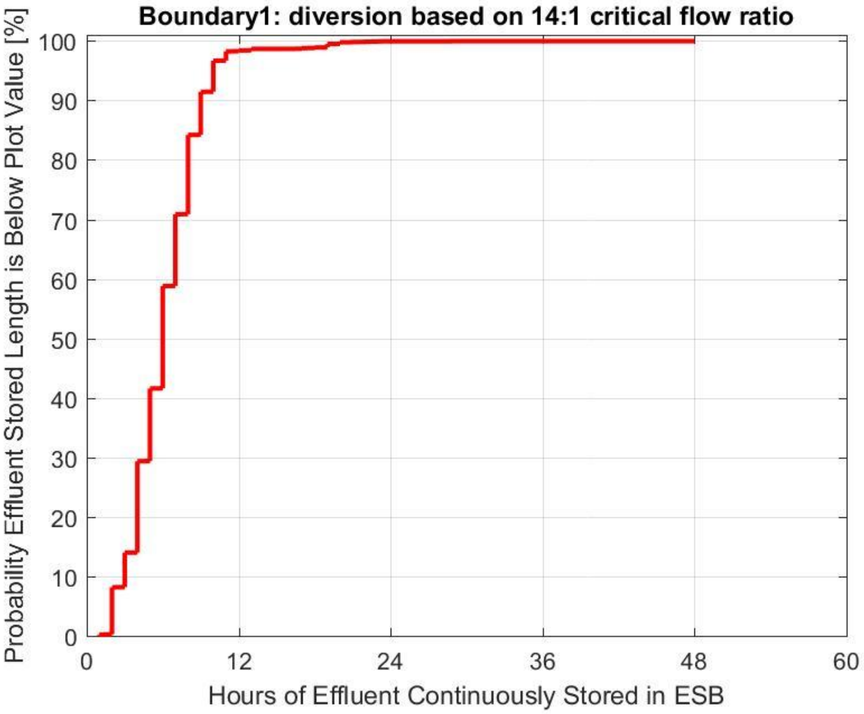

Figure B3. Probability distribution of length of time effluent continuously stored in ESB for the Boundary1 alternative

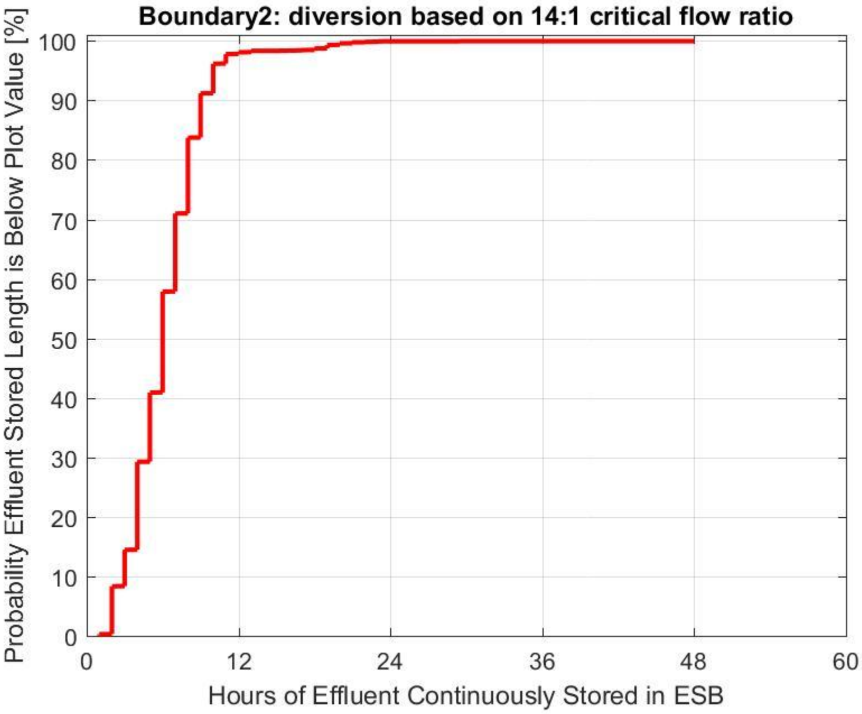

Figure B4. Probability distribution of length of time effluent continuously stored in ESB for the Boundary2 alternative

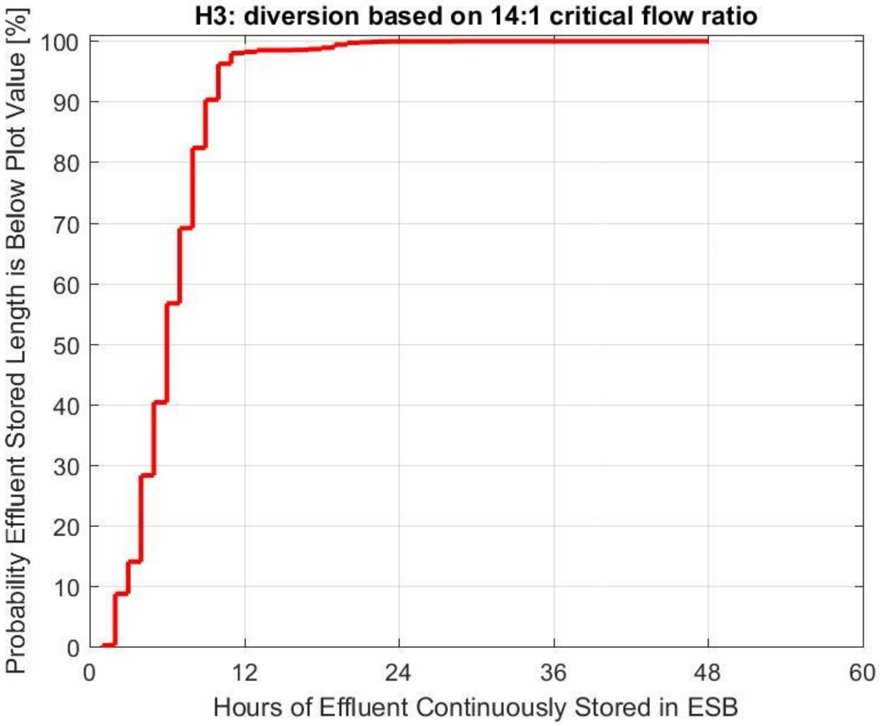

Figure B5. Probability distribution of length of time effluent continuously stored in ESB for the H3 alternative

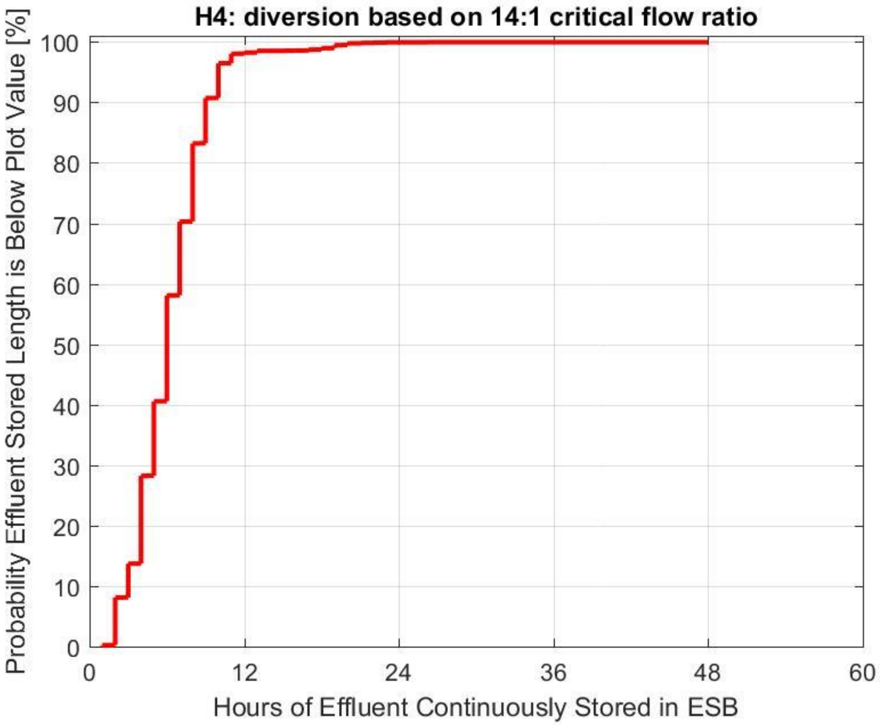

Figure B6. Probability distribution of length of time effluent continuously stored in ESB for the Boundary6 alternative

APPENDIX C

Annual Summary of Diversion Events

Table C1 – Annual Summary of Diversion Events

WY	Type[1]	EBC2		NAA		Boundary 1		Boundary 2		H3		H4	
		No. diversion events	Diversion time	No. diversion events	Diversion time	No. diversion events	Diversion time	No. diversion events	Diversion time	No. diversion events	Diversion time	No. diversion events	Diversion time
1976	C	237	7.7%	246	9.1%	229	7.2%	219	6.1%	235	7.4%	247	8.0%
1977	C	514	18.1%	641	24.1%	627	23.0%	646	24.2%	637	23.9%	636	23.6%
1978	AN	137	5.3%	166	6.9%	157	6.4%	168	7.0%	168	7.0%	169	7.0%
1979	BN	47	0.9%	42	1.1%	163	4.2%	188	5.2%	180	5.2%	179	4.8%
1980	AN	40	1.0%	88	2.5%	169	4.4%	94	2.8%	81	2.1%	137	3.8%
1981	D	76	2.2%	164	4.7%	170	4.7%	197	5.8%	231	6.6%	265	8.4%
1982	W	53	1.6%	61	1.7%	58	1.6%	65	1.9%	72	1.9%	77	2.3%
1983	W	0	0.0%	0	0.0%	1	0.0%	0	0.0%	9	0.2%	9	0.2%
1984	W	30	0.8%	50	1.2%	117	3.5%	86	2.3%	48	1.2%	49	1.5%
1985	D	63	1.4%	103	2.7%	131	3.5%	159	3.9%	169	4.4%	244	7.0%
1986	W	63	1.6%	174	5.3%	189	5.4%	183	5.3%	180	5.3%	211	6.1%
1987	D	155	4.6%	285	8.9%	231	6.9%	202	5.3%	270	7.8%	261	7.5%
1988	C	345	11.5%	399	15.0%	416	14.9%	398	14.1%	434	15.7%	443	16.0%
1989	D	213	7.5%	233	8.2%	281	9.7%	285	9.8%	281	9.8%	290	10.2%
1990	C	264	9.2%	406	15.1%	432	15.9%	448	16.6%	427	15.7%	414	14.8%
1991	C	467	17.3%	513	20.9%	559	22.0%	563	22.7%	560	22.5%	558	22.2%

[1] Per DWR classifications, "W" is a Wet Year, "AN" is an Above Normal Year, "BN" is a Below Normal year, "D" is a Dry Year, and "C" is a Critically Dry Year.

APPENDIX D

Summary of Diversion Parameters by Month

Table D1 – Summary of Diversion Parameters by Month for Alternative EBC2

Month	Max. ESB Vol. Million Gallons		Number of diversion event			Diversion hours			Percent time diversion		Vol. pumped from ESB (MGs)			Percent time ESB Vol. > 0		Hours Eff. continuously stored	
	Mean	Max	Sum	Mean	Max	Sum	Mean	Max	Mean	Max	Sum	Mean	Max	Mean	Max	Median	Max
10	30.2	52.4	436	27	59	1281	80	212	10.8%	28.5%	10456	653	1676	22.2%	57.5%	6	13
11	24.0	44.1	319	20	57	988	62	193	8.6%	26.8%	7880	492	1493	17.6%	53.9%	6	11
12	21.2	54.3	192	12	58	554	35	204	4.7%	27.4%	4509	282	1604	9.7%	55.9%	6	13
1	13.9	38.8	140	9	45	358	22	134	3.0%	18.0%	2989	187	1104	6.4%	38.4%	5	10
2	17.7	51.6	166	10	42	471	29	140	4.3%	20.8%	4245	265	1234	10.0%	47.0%	6	20
3	11.8	38.4	123	8	54	313	20	155	2.6%	20.8%	2501	156	1268	5.4%	44.0%	5	9
4	21.8	38.7	234	15	54	593	37	155	5.2%	21.5%	4753	297	1281	10.8%	46.1%	5	20
5	28.5	58.1	377	24	60	1305	82	267	11.0%	35.9%	10274	642	2089	22.8%	75.1%	7	23
6	24.6	52.7	232	15	44	664	42	155	5.8%	21.5%	5267	329	1206	11.9%	44.0%	6	19
7	5.6	34.5	9	1	4	16	1	8	0.1%	1.1%	146	9	54	0.3%	1.7%	3	6
8	9.1	43.0	135	8	51	322	20	153	2.7%	20.6%	2554	160	1208	5.6%	41.9%	5	10
9	20.4	43.1	341	21	56	1055	66	187	9.2%	26.0%	8355	522	1466	18.6%	52.6%	6	19

Table D2 – Summary of Diversion Parameters by Month for Alternative NAA

Month	Max. ESB Vol. Million Gallons		Number of diversion event			Diversion hours			Percent time diversion		Vol. pumped from ESB (MGs)			Percent time ESB Vol. > 0		Hours Eff. continuously stored	
	Mean	Max	Sum	Mean	Max	Sum	Mean	Max	Mean	Max	Sum	Mean	Max	Mean	Max	Median	Max
10	31.4	52.4	528	33	60	1747	109	257	14.7%	34.5%	13942	871	2015	30.2%	70.3%	7	20
11	25.1	48.9	375	23	58	1235	77	240	10.7%	33.3%	9738	609	1835	21.9%	66.7%	7	12
12	24.2	56.6	291	18	60	896	56	213	7.5%	28.6%	7162	448	1666	15.5%	58.3%	6	22
1	16.8	57.1	184	12	60	541	34	242	4.5%	32.5%	4460	279	1942	9.5%	66.9%	6	22
2	12.6	42.3	127	8	44	336	21	125	3.1%	18.6%	2985	187	1088	7.1%	41.7%	6	19
3	12.0	48.6	157	10	59	453	28	208	3.8%	28.0%	3661	229	1692	7.9%	59.0%	6	21
4	22.5	38.2	284	18	53	711	44	147	6.2%	20.4%	5714	357	1217	12.8%	42.8%	5	19
5	31.1	61.1	400	25	60	1303	81	277	11.0%	37.2%	10305	644	2173	22.6%	77.6%	6	48
6	29.3	55.1	343	21	54	1029	64	194	8.9%	26.9%	8129	508	1539	18.3%	55.8%	6	21
7	13.3	43.2	106	7	48	276	17	152	2.3%	20.4%	2247	140	1205	4.8%	41.4%	5	10
8	21.0	43.4	363	23	59	1146	72	216	9.6%	29.0%	8995	562	1674	19.5%	57.8%	7	20
9	23.7	51.4	413	26	58	1484	93	232	12.9%	32.2%	11696	731	1819	26.1%	65.3%	7	19

Table D3 – Summary of Diversion Parameters by Month for Alternative Boundary 1

Month	Max. ESB Vol. Million Gallons		Number of diversion event			Diversion hours			Percent time diversion		Vol. pumped from ESB (MGs)			Percent time ESB Vol. > 0		Hours Eff. continuously stored	
	Mean	Max	Sum	Mean	Max	Sum	Mean	Max	Mean	Max	Sum	Mean	Max	Mean	Max	Median	Max
10	32.8	52.4	563	35	60	1678	105	234	14.1%	31.5%	13547	847	1844	28.9%	63.2%	6	19
11	32.8	44.1	491	31	58	1557	97	222	13.5%	30.8%	12300	769	1710	27.5%	62.4%	6.5	11
12	26.6	45.9	293	18	60	852	53	211	7.2%	28.4%	6849	428	1655	14.8%	58.3%	6	11
1	16.7	57.1	168	11	60	474	30	239	4.0%	32.1%	3916	245	1919	8.3%	66.4%	6	22
2	14.6	42.3	162	10	43	460	29	120	4.2%	17.9%	4041	253	1055	9.5%	40.0%	6	10
3	11.8	38.4	139	9	54	371	23	150	3.1%	20.2%	2943	184	1197	6.3%	40.7%	5	9
4	21.3	38.2	225	14	51	544	34	108	4.7%	15.0%	4279	267	867	9.6%	31.4%	5	19
5	28.4	61.0	338	21	60	1072	67	268	9.0%	36.0%	8407	525	2104	18.3%	74.3%	6	48
6	26.0	51.3	307	19	55	932	58	185	8.1%	25.7%	7357	460	1497	16.5%	53.2%	6	20
7	13.1	43.2	180	11	51	515	32	148	4.3%	19.9%	4106	257	1172	8.9%	40.3%	6	11
8	21.0	43.2	390	24	60	1003	63	205	8.4%	27.6%	7978	499	1629	17.2%	55.1%	5	11
9	36.1	51.6	674	42	58	2211	138	255	19.2%	35.4%	17362	1085	1950	38.9%	70.8%	7	20

Table D4 – Summary of Diversion Parameters by Month for Alternative Boundary 2

Month	Max. ESB Vol. Million Gallons		Number of diversion event			Diversion hours			Percent time diversion		Vol. pumped from ESB (MGs)			Percent time ESB Vol. > 0		Hours Eff. continuously stored	
	Mean	Max	Sum	Mean	Max	Sum	Mean	Max	Mean	Max	Sum	Mean	Max	Mean	Max	Median	Max
10	36.1	52.4	647	40	60	2015	126	255	16.9%	34.3%	16024	1002	1988	34.4%	68.5%	6	20
11	30.8	44.1	501	31	58	1586	99	234	13.8%	32.5%	12486	780	1810	28.0%	65.6%	6	19
12	27.1	57.6	345	22	60	1116	70	242	9.4%	32.5%	8929	558	1883	19.4%	66.3%	7	23
1	17.3	57.1	183	11	60	542	34	244	4.6%	32.8%	4449	278	1954	9.5%	67.9%	6	22
2	14.0	52.7	151	9	43	405	25	137	3.8%	20.4%	3565	223	1215	8.4%	45.8%	6	12
3	12.5	49.7	159	10	59	465	29	221	3.9%	29.7%	3725	233	1788	8.1%	61.7%	6	21
4	22.1	38.2	265	17	52	669	42	138	5.8%	19.2%	5313	332	1133	11.9%	39.4%	5	9
5	30.5	61.0	413	26	60	1315	82	271	11.1%	36.4%	10335	646	2122	22.7%	75.3%	6	48
6	32.9	52.3	445	28	55	1298	81	190	11.3%	26.4%	10177	636	1489	23.0%	54.2%	6	20
7	16.9	43.2	143	9	49	367	23	160	3.1%	21.5%	2935	183	1265	6.2%	43.3%	5	10
8	17.7	43.0	276	17	55	715	45	166	6.0%	22.3%	5662	354	1311	12.4%	45.7%	6	10
9	21.6	43.1	373	23	58	1150	72	233	10.0%	32.4%	9042	565	1785	20.1%	64.3%	6	19

Table D5 – Summary of Diversion Parameters by Month for Alternative H3

Month	Max. ESB Vol. Million Gallons		Number of diversion event			Diversion hours			Percent time diversion		Vol. pumped from ESB (MGs)			Percent time ESB Vol. > 0		Hours Eff. continuously stored	
	Mean	Max	Sum	Mean	Max	Sum	Mean	Max	Mean	Max	Sum	Mean	Max	Mean	Max	Median	Max
10	36.2	52.4	555	35	60	1742	109	262	14.6%	35.2%	13976	873	2053	30.1%	71.4%	6	20
11	31.9	44.1	492	31	58	1552	97	222	13.5%	30.8%	12299	769	1708	27.4%	62.2%	6	11
12	26.4	56.8	328	21	60	1018	64	223	8.6%	30.0%	8140	509	1734	17.7%	60.3%	6	22
1	16.3	38.8	145	9	39	347	22	105	2.9%	14.1%	2915	182	861	6.1%	29.3%	5	9
2	15.2	51.6	177	11	44	522	33	157	4.8%	23.4%	4582	286	1377	10.7%	51.8%	6	20
3	12.2	38.4	149	9	58	405	25	163	3.4%	21.9%	3226	202	1328	7.0%	46.1%	5	10
4	22.1	38.2	273	17	51	673	42	130	5.8%	18.1%	5338	334	1066	12.0%	37.6%	5	9
5	28.5	61.2	379	24	60	1184	74	268	10.0%	36.0%	9308	582	2104	20.4%	74.3%	6	48
6	29.1	52.3	381	24	54	1126	70	187	9.8%	26.0%	8850	553	1453	19.9%	53.3%	6	20
7	16.5	43.2	203	13	49	572	36	147	4.8%	19.8%	4565	285	1163	9.9%	40.1%	6	11
8	19.9	43.2	344	22	60	917	57	205	7.7%	27.6%	7266	454	1629	15.6%	55.1%	5	11
9	26.5	52.8	556	35	58	1938	121	255	16.8%	35.4%	15126	945	1951	34.0%	70.8%	7	21

Table D6 – Summary of Diversion Parameters by Month for Alternative H4

Month	Max. ESB Vol. Million Gallons		Number of diversion event			Diversion hours			Percent time diversion		Vol. pumped from ESB (MGs)			Percent time ESB Vol. > 0		Hours Eff. continuously stored	
	Mean	Max	Sum	Mean	Max	Sum	Mean	Max	Mean	Max	Sum	Mean	Max	Mean	Max	Median	Max
10	37.8	52.4	649	41	60	2030	127	262	17.1%	35.2%	16279	1017	2053	34.9%	71.4%	6	20
11	31.2	44.1	483	30	58	1525	95	223	13.2%	31.0%	12054	753	1722	26.9%	62.2%	6	11
12	25.5	56.2	296	19	60	901	56	218	7.6%	29.3%	7208	450	1698	15.5%	59.1%	6	22
1	15.7	38.8	142	9	39	339	21	105	2.9%	14.1%	2843	178	861	5.9%	29.3%	5	9
2	16.6	51.6	182	11	44	524	33	153	4.8%	22.8%	4611	288	1343	10.8%	50.3%	6	20
3	12.4	41.3	152	10	55	406	25	177	3.4%	23.8%	3230	202	1424	7.0%	49.6%	5	20
4	20.1	38.2	255	16	51	610	38	117	5.3%	16.3%	4813	301	946	10.9%	33.9%	5	9
5	26.6	61.1	357	22	60	1173	73	267	9.9%	35.9%	9260	579	2097	20.3%	74.1%	6	48
6	30.5	52.3	408	26	54	1211	76	187	10.5%	26.0%	9544	596	1453	21.4%	53.3%	6	20
7	19.5	43.2	220	14	51	626	39	168	5.3%	22.6%	4983	311	1332	10.7%	45.7%	6	11
8	25.8	43.2	469	29	60	1171	73	202	9.8%	27.2%	9312	582	1603	20.1%	54.3%	5	11
9	28.2	52.8	576	36	59	2042	128	255	17.7%	35.4%	15909	994	1950	35.7%	70.7%	7	21

Table D7 – Summary of Diversion Parameters by Month and WY Types for Alternative EBC2

WY Type	Month	Max. ESB Vol. Million Gallons		Number of diversion event			Diversion hours			Percent time diversion		Vol. pumped from ESB (MGs)			Percent time ESB Vol. > 0		Hours Eff. continuously stored	
		Mean	Max	Sum	Mean	Max	Sum	Mean	Max	Mean	Max	Sum	Mean	Max	Mean	Max	Median	Max
C	10	31.6	43.9	186	37	59	564	113	201	15.2%	27.0%	4603	921	1594	31.3%	54.6%	6	11
	11	34.5	44.1	198	40	57	615	123	193	17.1%	26.8%	4853	971	1493	34.8%	53.9%	6	11
	12	34.1	54.3	117	23	58	350	70	204	9.4%	27.4%	2830	566	1604	19.5%	55.9%	6	13
	1	27.1	38.8	113	23	45	305	61	134	8.2%	18.0%	2536	507	1104	17.4%	38.4%	6	10
	2	37.7	51.6	111	22	42	323	65	140	9.5%	20.8%	2912	582	1234	21.6%	47.0%	7	19
	3	28.9	38.4	115	23	54	300	60	155	8.1%	20.8%	2407	481	1268	16.7%	44.0%	5	9
	4	35.2	38.7	144	29	54	387	77	155	10.8%	21.5%	3105	621	1281	22.5%	46.1%	6	20
	5	51.7	58.1	275	55	60	1041	208	267	28.0%	35.9%	8246	1649	2089	58.6%	75.1%	8	23
	6	42.1	52.7	177	35	44	548	110	155	15.2%	21.5%	4375	875	1206	31.5%	44.0%	6	19
	7	14.8	34.5	6	1	4	12	2	8	0.3%	1.1%	116	23	54	0.7%	1.7%	3	6
	8	24.1	43.0	128	26	51	314	63	153	8.4%	20.6%	2489	498	1208	17.4%	41.9%	5	10
	9	43.1	43.1	257	51	56	820	164	187	22.8%	26.0%	6479	1296	1466	46.2%	52.6%	6	19
D	10	39.5	52.4	103	26	51	300	75	182	10.1%	24.5%	2454	613	1450	21.0%	50.1%	6	13
	11	17.6	44.1	44	11	42	143	36	139	5.0%	19.3%	1159	290	1124	10.3%	40.1%	6	11
	12	24.5	45.1	39	10	29	108	27	90	3.6%	12.1%	905	226	747	7.6%	25.3%	6	11
	1	17.0	29.1	22	6	10	46	12	25	1.5%	3.4%	394	99	214	3.4%	7.5%	4	7
	2	15.9	42.3	48	12	42	133	33	122	5.0%	18.2%	1176	294	1062	11.4%	41.2%	6	20
	3	11.1	19.3	8	2	5	13	3	8	0.4%	1.1%	94	24	63	0.9%	2.2%	4	4
	4	22.4	35.5	60	15	37	138	35	82	4.8%	11.4%	1118	280	646	10.2%	23.9%	5	8
	5	31.9	36.1	87	22	32	232	58	95	7.8%	12.8%	1775	444	744	15.8%	26.5%	6	9
	6	22.7	26.0	15	4	6	29	7	12	1.0%	1.7%	233	58	96	2.1%	3.5%	4	6
	7	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	8	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	9	25.6	43.1	81	20	53	232	58	174	8.1%	24.2%	1850	463	1362	16.5%	49.3%	6	10

AN /BN	10	32.2	43.9	92	31	59	278	93	212	12.5%	28.5%	2240	747	1676	25.4%	57.5%	6	11
	11	23.5	43.9	54	18	52	170	57	167	7.9%	23.2%	1348	449	1322	16.3%	47.8%	7	11
	12	17.7	43.7	29	10	26	84	28	81	3.8%	10.9%	664	221	636	7.6%	22.0%	5	10
	1	6.1	18.3	5	2	5	7	2	7	0.3%	0.9%	58	19	58	0.6%	1.9%	2	4
	2	10.6	31.7	7	2	7	15	5	15	0.7%	2.2%	157	52	157	1.9%	5.8%	6	8
	3	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	4	10.7	32.0	10	3	10	23	8	23	1.1%	3.2%	185	62	185	2.1%	6.2%	5	8
	5	5.3	15.9	2	1	2	3	1	3	0.1%	0.4%	24	8	24	0.3%	0.8%	3	4
	6	13.4	26.3	19	6	12	35	12	26	1.6%	3.6%	268	89	204	3.2%	7.2%	4	6
	7	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	8	5.7	17.1	3	1	3	4	1	4	0.2%	0.5%	34	11	34	0.4%	1.2%	3	4
	9	2.9	8.6	3	1	3	3	1	3	0.1%	0.4%	26	9	26	0.3%	0.8%	2	2
W	10	17.6	35.2	55	14	44	139	35	114	4.7%	15.3%	1159	290	939	9.7%	31.9%	5	9
	11	17.6	35.4	23	6	17	60	15	42	2.1%	5.8%	520	130	364	4.4%	12.6%	6	8
	12	4.6	18.5	7	2	7	12	3	12	0.4%	1.6%	109	27	109	1.0%	3.8%	4	5
	1	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	2	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	3	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	4	13.0	32.0	20	5	11	45	11	31	1.6%	4.3%	345	86	261	3.2%	9.4%	4.5	8
	5	13.7	28.0	13	3	10	29	7	24	1.0%	3.2%	229	57	174	2.0%	6.2%	4	7
	6	12.9	31.5	21	5	12	52	13	37	1.8%	5.1%	391	98	286	3.7%	10.6%	5	8
	7	3.9	15.6	3	1	3	4	1	4	0.1%	0.5%	31	8	31	0.3%	1.1%	2	4
	8	2.1	8.3	4	1	4	4	1	4	0.1%	0.5%	31	8	31	0.3%	1.1%	2	2
	9	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA

Table D8 – Summary of Diversion Parameters by Month and WY Types for Alternative NAA

WY Type	Month	Max. ESB Vol. Million Gallons		Number of diversion event			Diversion hours			Percent time diversion		Vol. pumped from ESB (MGs)			Percent time ESB Vol. > 0		Hours Eff. continuously stored	
		Mean	Max	Sum	Mean	Max	Sum	Mean	Max	Mean	Max	Sum	Mean	Max	Mean	Max	Median	Max
C	10	35.6	52.4	209	42	60	727	145	257	19.5%	34.5%	5811	1162	2015	40.3%	70.3%	7	20
	11	34.5	48.9	213	43	58	728	146	240	20.2%	33.3%	5674	1135	1835	41.1%	66.7%	7	12
	12	39.6	56.6	184	37	60	604	121	213	16.2%	28.6%	4742	948	1666	33.0%	58.3%	7	22
	1	30.8	57.1	141	28	60	456	91	242	12.3%	32.5%	3730	746	1942	25.5%	66.9%	7	22
	2	25.9	42.3	77	15	41	200	40	113	6.0%	16.8%	1781	356	1000	13.4%	37.9%	6	10
	3	29.4	48.6	142	28	59	429	86	208	11.5%	28.0%	3485	697	1692	24.1%	59.0%	6	21
	4	35.3	38.2	171	34	53	447	89	147	12.4%	20.4%	3585	717	1217	25.7%	42.8%	5	19
	5	46.6	61.1	217	43	60	831	166	277	22.3%	37.2%	6631	1326	2173	46.8%	77.6%	8	48
	6	45.6	55.1	220	44	54	734	147	194	20.4%	26.9%	5834	1167	1539	42.1%	55.8%	7	21
	7	30.8	43.2	84	17	48	224	45	152	6.0%	20.4%	1818	364	1205	12.4%	41.4%	5	10
	8	41.4	43.4	259	52	59	868	174	216	23.3%	29.0%	6826	1365	1674	47.2%	57.8%	7	20
	9	44.9	51.4	288	58	58	1129	226	232	31.4%	32.2%	8798	1760	1819	63.3%	65.3%	8	19
D	10	37.3	52.4	113	28	60	372	93	241	12.5%	32.4%	2952	738	1882	25.8%	66.7%	7	20
	11	21.9	43.9	51	13	42	151	38	139	5.2%	19.3%	1241	310	1130	11.0%	40.3%	6	11
	12	27.1	36.9	68	17	33	185	46	93	6.2%	12.5%	1553	388	761	13.2%	26.5%	6	9
	1	24.0	29.1	37	9	16	76	19	34	2.6%	4.6%	654	164	289	5.5%	9.8%	4	8
	2	10.3	41.1	44	11	44	125	31	125	4.7%	18.6%	1088	272	1088	10.4%	41.7%	6	19
	3	11.1	19.3	15	4	8	24	6	14	0.8%	1.9%	176	44	107	1.6%	3.6%	3	4
	4	24.4	38.2	75	19	41	176	44	89	6.1%	12.4%	1443	361	707	12.8%	25.7%	5	9
	5	31.1	38.5	114	29	40	313	78	125	10.5%	16.8%	2428	607	988	21.2%	33.9%	5.5	10
	6	29.0	33.0	25	6	10	54	14	21	1.9%	2.9%	427	107	161	3.8%	5.8%	4	8
	7	6.5	25.9	20	5	20	49	12	49	1.7%	6.6%	396	99	396	3.4%	13.4%	5.5	7
	8	25.7	43.1	98	25	56	263	66	192	8.8%	25.8%	2066	516	1492	18.1%	51.9%	5	11
	9	32.3	43.1	125	31	58	355	89	191	12.3%	26.5%	2872	718	1519	25.3%	53.7%	6	10

AN /BN	10	32.2	43.9	108	36	60	377	126	254	16.9%	34.1%	2972	991	1979	34.2%	68.7%	7	11
	11	23.5	44.1	71	24	58	261	87	231	12.1%	32.1%	2040	680	1781	24.4%	64.6%	8	11
	12	17.7	43.7	29	10	26	85	28	82	3.8%	11.0%	671	224	643	7.7%	22.3%	5.5	10
	1	6.1	18.3	6	2	6	9	3	9	0.4%	1.2%	76	25	76	0.8%	2.4%	3	4
	2	10.6	31.7	6	2	6	11	4	11	0.6%	1.6%	116	39	116	1.4%	4.2%	5	7
	3	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	4	10.7	32.0	12	4	12	26	9	26	1.2%	3.6%	208	69	208	2.4%	7.1%	4	8
	5	28.2	33.2	22	7	9	51	17	27	2.3%	3.6%	405	135	215	4.6%	7.4%	4	9
	6	17.4	34.8	35	12	22	80	27	57	3.7%	7.9%	612	204	433	7.4%	16.0%	4	9
	7	2.7	8.0	1	0	1	1	0	1	0.0%	0.1%	8	3	8	0.1%	0.3%	2	2
	8	8.6	25.7	6	2	6	15	5	15	0.7%	2.0%	103	34	103	1.3%	3.9%	5	7
	9	8.6	25.7	0	0	0	0	0	0	0.0%	0.0%	26	9	26	0.1%	0.4%	4	4
W	10	19.7	43.9	98	25	55	271	68	163	9.1%	21.9%	2207	552	1314	18.9%	45.2%	6	11
	11	17.6	35.4	40	10	26	95	24	62	3.3%	8.6%	783	196	516	6.9%	18.2%	4	8
	12	6.9	27.7	10	3	10	22	6	22	0.7%	3.0%	196	49	196	1.6%	6.3%	5	6
	1	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	2	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	3	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	4	13.4	32.0	26	7	15	62	16	38	2.2%	5.3%	479	120	319	4.4%	11.4%	4.5	8
	5	13.7	28.0	47	12	24	108	27	58	3.6%	7.8%	841	210	463	7.4%	16.0%	4.5	7
	6	18.0	43.2	63	16	48	161	40	138	5.6%	19.2%	1256	314	1087	11.5%	39.6%	5	19
	7	6.3	16.9	1	0	1	2	1	1	0.1%	0.1%	25	6	17	0.2%	0.4%	3.5	4
	8	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	9	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA

Table D9 – Summary of Diversion Parameters by Month and WY Types for Alternative Boundary 1

WY Type	Month	Max. ESB Vol. Million Gallons		Number of diversion event			Diversion hours			Percent time diversion		Vol. pumped from ESB (MGs)			Percent time ESB Vol. > 0		Hours Eff. continuously stored	
		Mean	Max	Sum	Mean	Max	Sum	Mean	Max	Mean	Max	Sum	Mean	Max	Mean	Max	Median	Max
C	10	33.2	43.9	208	42	59	679	136	230	18.3%	30.9%	5451	1090	1806	37.5%	62.5%	7	19
	11	40.5	44.1	232	46	58	778	156	222	21.6%	30.8%	6037	1207	1708	43.6%	62.1%	7	11
	12	40.9	45.9	173	35	60	554	111	211	14.9%	28.4%	4387	877	1655	30.6%	58.3%	6	11
	1	30.4	57.1	126	25	60	390	78	239	10.5%	32.1%	3199	640	1919	21.9%	66.4%	6	22
	2	32.3	42.3	115	23	43	334	67	120	9.8%	17.9%	2937	587	1055	21.9%	40.0%	6	10
	3	28.9	38.4	124	25	54	345	69	150	9.3%	20.2%	2754	551	1197	18.8%	40.7%	5	9
	4	35.3	38.2	150	30	51	367	73	108	10.2%	15.0%	2896	579	867	20.9%	31.4%	5	19
	5	44.8	61.0	208	42	60	782	156	268	21.0%	36.0%	6213	1243	2104	43.4%	74.3%	8	48
	6	43.4	51.3	220	44	55	734	147	185	20.4%	25.7%	5816	1163	1497	41.7%	53.2%	7	20
	7	37.2	43.2	178	36	51	512	102	148	13.8%	19.9%	4082	816	1172	28.3%	40.3%	6	11
	8	34.6	43.2	240	48	60	678	136	205	18.2%	27.6%	5398	1080	1629	37.0%	55.1%	6	11
	9	46.5	51.6	289	58	58	1124	225	255	31.2%	35.4%	8707	1741	1950	62.7%	70.8%	8	20
D	10	39.5	52.4	156	39	59	455	114	222	15.3%	29.8%	3664	916	1753	31.6%	61.3%	6	14
	11	32.5	43.9	115	29	43	334	84	150	11.6%	20.8%	2720	680	1196	23.9%	42.8%	6	11
	12	25.9	41.7	63	16	37	157	39	105	5.3%	14.1%	1297	324	844	11.1%	29.2%	5	10
	1	24.0	29.1	36	9	16	74	19	34	2.5%	4.6%	632	158	287	5.3%	9.9%	4	8
	2	10.3	41.1	43	11	43	118	30	118	4.4%	17.6%	1020	255	1020	9.7%	38.7%	6	10
	3	11.1	19.3	15	4	9	26	7	17	0.9%	2.3%	190	47	130	1.7%	4.3%	4	5
	4	19.8	29.9	36	9	16	79	20	37	2.7%	5.1%	628	157	305	5.6%	11.1%	4	8
	5	22.7	31.7	53	13	21	119	30	55	4.0%	7.4%	884	221	428	7.8%	15.2%	4	8
	6	27.0	33.0	53	13	23	116	29	49	4.0%	6.8%	896	224	373	8.1%	13.3%	4	8
	7	3.9	15.6	1	0	1	2	1	2	0.1%	0.3%	16	4	16	0.1%	0.5%	4	4
	8	17.2	34.4	57	14	34	141	35	79	4.7%	10.6%	1111	278	607	9.5%	21.1%	5	8
	9	38.8	43.1	185	46	57	546	137	210	19.0%	29.2%	4348	1087	1644	38.6%	58.8%	6	10

AN /BN	10	38.0	43.9	127	42	60	382	127	234	17.1%	31.5%	3078	1026	1844	34.8%	63.2%	6	11
	11	38.1	43.9	97	32	58	320	107	222	14.8%	30.8%	2534	845	1710	30.1%	62.4%	7	11
	12	29.8	43.7	47	16	26	119	40	84	5.3%	11.3%	970	323	655	11.2%	23.0%	5	10
	1	6.5	19.4	6	2	6	10	3	10	0.5%	1.3%	85	28	85	0.9%	2.7%	4	4
	2	10.6	31.7	4	1	4	8	3	8	0.4%	1.2%	85	28	85	1.0%	3.0%	5	7
	3	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	4	10.7	32.0	13	4	13	34	11	34	1.6%	4.7%	264	88	264	3.0%	9.0%	5	8
	5	28.2	33.2	27	9	9	54	18	23	2.4%	3.1%	413	138	179	4.6%	5.9%	4	8
	6	14.3	26.3	14	5	13	29	10	27	1.3%	3.8%	222	74	206	2.7%	7.4%	4	6
	7	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	8	17.3	26.0	54	18	40	113	38	85	5.1%	11.4%	885	295	673	10.6%	23.8%	4	7
	9	28.7	34.6	100	33	49	243	81	124	11.3%	17.2%	1977	659	996	23.4%	35.7%	5	8
W	10	21.9	35.2	72	18	35	162	41	80	5.4%	10.8%	1354	339	663	11.3%	21.9%	4	9
	11	19.6	43.2	47	12	28	125	31	72	4.3%	10.0%	1009	252	591	9.1%	21.2%	6	10
	12	6.9	27.7	10	3	10	22	6	22	0.7%	3.0%	196	49	196	1.6%	6.5%	5	6
	1	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	2	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	3	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	4	13.4	32.0	26	7	15	64	16	40	2.2%	5.6%	491	123	331	4.6%	11.7%	5	8
	5	13.7	28.0	50	13	26	117	29	62	3.9%	8.3%	898	224	488	7.9%	16.8%	5	7
	6	12.0	34.1	20	5	19	53	13	51	1.8%	7.1%	422	106	408	3.8%	14.4%	5.5	8
	7	2.2	8.6	1	0	1	1	0	1	0.0%	0.1%	9	2	9	0.1%	0.3%	2	2
	8	10.8	25.8	39	10	25	71	18	51	2.4%	6.9%	584	146	418	5.1%	14.2%	4	6
	9	25.8	43.1	100	25	56	298	75	177	10.4%	24.6%	2330	583	1372	20.9%	49.9%	6	10

Table D10 – Summary of Diversion Parameters by Month and WY Types for Alternative Boundary 2

WY Type	Month	Max. ESB Vol. Million Gallons		Number of diversion event			Diversion hours			Percent time diversion		Vol. pumped from ESB (MGs)			Percent time ESB Vol. > 0		Hours Eff. continuously stored	
		Mean	Max	Sum	Mean	Max	Sum	Mean	Max	Mean	Max	Sum	Mean	Max	Mean	Max	Median	Max
C	10	40	52	214	43	59	699	140	250	18.8%	33.6%	5557	1111	1958	38.1%	67.9%	7	13
	11	39	44	231	46	58	802	160	224	22.3%	31.1%	6209	1242	1718	44.9%	62.4%	7	11
	12	43	58	198	40	60	711	142	242	19.1%	32.5%	5576	1115	1883	39.2%	66.3%	7	23
	1	31	57	141	28	60	456	91	244	12.3%	32.8%	3716	743	1954	25.5%	67.9%	7	22
	2	30	53	104	21	43	286	57	137	8.5%	20.4%	2520	504	1215	19.0%	45.8%	6	12
	3	31	50	144	29	59	438	88	221	11.8%	29.7%	3529	706	1788	24.4%	61.7%	6	21
	4	35	38	167	33	52	435	87	138	12.1%	19.2%	3461	692	1133	24.7%	39.4%	5	9
	5	45	61	221	44	60	839	168	271	22.6%	36.4%	6679	1336	2122	46.9%	75.3%	8	48
	6	45	52	227	45	55	766	153	190	21.3%	26.4%	6073	1215	1489	43.8%	54.2%	7	20
	7	34	43	133	27	49	352	70	160	9.5%	21.5%	2810	562	1265	19.0%	43.3%	5	10
	8	35	43	231	46	55	627	125	166	16.9%	22.3%	4974	995	1311	34.7%	45.7%	6	10
	9	41	43	263	53	58	915	183	233	25.4%	32.4%	7115	1423	1785	50.9%	64.3%	7	19
D	10	42	52	173	43	60	525	131	235	17.6%	31.6%	4160	1040	1831	36.1%	64.8%	6	20
	11	31	44	120	30	50	322	81	152	11.2%	21.1%	2599	650	1213	23.0%	43.5%	5	11
	12	27	37	80	20	37	214	54	105	7.2%	14.1%	1777	444	841	15.2%	29.3%	6	9
	1	26	36	36	9	16	76	19	35	2.6%	4.7%	647	162	295	5.5%	10.2%	4.5	8
	2	10	41	43	11	43	111	28	111	4.1%	16.5%	960	240	960	9.2%	36.8%	6	10
	3	11	19	15	4	9	27	7	17	0.9%	2.3%	196	49	130	1.8%	4.3%	4	5
	4	23	38	59	15	29	139	35	75	4.8%	10.4%	1118	280	629	10.1%	22.1%	5	9
	5	31	38	113	28	43	297	74	116	10.0%	15.6%	2284	571	912	20.2%	31.9%	5	10
	6	33	43	75	19	29	185	46	84	6.4%	11.7%	1421	355	661	12.8%	23.5%	5	10
	7	15	24	7	2	2	11	3	4	0.4%	0.5%	84	21	33	0.7%	1.1%	3	6
	8	17	26	35	9	20	70	18	46	2.4%	6.2%	565	141	376	5.0%	12.8%	4	7
	9	28	35	87	22	40	193	48	95	6.7%	13.2%	1572	393	762	13.7%	27.1%	4.5	8

AN /BN	10	38	44	154	51	60	517	172	255	23.2%	34.3%	4076	1359	1988	46.5%	68.5%	7	11
	11	35	44	110	37	58	360	120	234	16.7%	32.5%	2842	947	1810	33.9%	65.6%	7	19
	12	27	44	57	19	31	171	57	87	7.7%	11.7%	1396	465	741	15.8%	24.7%	6	10
	1	6	19	6	2	6	10	3	10	0.5%	1.3%	86	29	86	0.9%	2.8%	4	5
	2	11	32	4	1	4	8	3	8	0.4%	1.2%	85	28	85	1.0%	3.0%	5	7
	3	0	0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	4	11	32	12	4	12	30	10	30	1.4%	4.2%	236	79	236	2.7%	8.2%	5	8
	5	28	33	27	9	10	58	19	29	2.6%	3.9%	449	150	227	5.1%	7.8%	4	9
	6	25	35	51	17	23	108	36	60	5.0%	8.3%	812	271	451	10.0%	16.7%	4	8
	7	3	8	1	0	1	1	0	1	0.0%	0.1%	8	3	8	0.1%	0.3%	2	2
	8	9	26	5	2	5	12	4	12	0.5%	1.6%	77	26	77	1.0%	3.0%	4	6
	9	9	26	23	8	23	42	14	42	1.9%	5.8%	355	118	355	4.2%	12.5%	4	6
W	10	24	44	106	27	50	274	69	134	9.2%	18.0%	2230	558	1090	18.8%	36.7%	5	11
	11	18	35	40	10	31	102	26	79	3.5%	11.0%	835	209	641	7.4%	22.9%	6	8
	12	7	28	10	3	10	20	5	20	0.7%	2.7%	179	45	179	1.4%	5.6%	4	6
	1	0	0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	2	0	0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	3	0	0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	4	13	32	27	7	16	65	16	41	2.3%	5.7%	498	124	338	4.5%	11.8%	5	8
	5	14	28	52	13	28	121	30	66	4.1%	8.9%	924	231	514	8.1%	17.7%	4	7
	6	24	43	92	23	49	239	60	140	8.3%	19.4%	1871	468	1100	17.0%	39.6%	5	19
	7	8	17	2	1	1	3	1	1	0.1%	0.1%	32	8	17	0.3%	0.4%	3	4
	8	4	16	5	1	5	6	2	6	0.2%	0.8%	46	11	46	0.4%	1.6%	2	4
	9	0	0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA

Table D11 – Summary of Diversion Parameters by Month and WY Types for Alternative H3

WY Type	Month	Max. ESB Vol. Million Gallons		Number of diversion event			Diversion hours			Percent time diversion		Vol. pumped from ESB (MGs)			Percent time ESB Vol. > 0		Hours Eff. continuously stored	
		Mean	Max	Sum	Mean	Max	Sum	Mean	Max	Mean	Max	Sum	Mean	Max	Mean	Max	Median	Max
C	10	38.9	52.4	203	41	59	693	139	257	18.6%	34.5%	5554	1111	2015	38.3%	70.4%	7	20
	11	38.8	44.1	233	47	58	793	159	222	22.0%	30.8%	6166	1233	1708	44.6%	62.2%	7	11
	12	41.3	56.8	190	38	60	662	132	223	17.8%	30.0%	5180	1036	1734	36.3%	60.3%	7	22
	1	27.1	38.8	98	20	39	250	50	105	6.7%	14.1%	2081	416	861	14.0%	29.3%	5	9
	2	34.2	51.6	130	26	44	396	79	157	11.7%	23.4%	3477	695	1377	25.9%	51.8%	7	20
	3	28.9	38.4	134	27	58	377	75	163	10.1%	21.9%	3024	605	1328	20.8%	46.1%	6	10
	4	35.3	38.2	162	32	51	415	83	130	11.5%	18.1%	3294	659	1066	23.7%	37.6%	5	9
	5	44.9	61.2	214	43	60	818	164	268	22.0%	36.0%	6525	1305	2104	45.7%	74.3%	8	48
	6	45.0	52.3	221	44	54	741	148	187	20.6%	26.0%	5874	1175	1453	42.2%	53.3%	7	20
	7	36.1	43.2	175	35	49	509	102	147	13.7%	19.8%	4051	810	1163	28.0%	40.1%	6	11
	8	36.3	43.2	244	49	60	697	139	205	18.7%	27.6%	5541	1108	1629	38.1%	55.1%	6	11
	9	46.8	52.8	289	58	58	1126	225	255	31.3%	35.4%	8723	1745	1951	63.1%	70.8%	8	21
D	10	39.5	52.4	141	35	60	438	110	243	14.7%	32.7%	3474	869	1899	30.3%	67.2%	6	20
	11	32.8	43.9	99	25	43	277	69	150	9.6%	20.8%	2294	574	1204	19.9%	42.9%	6	11
	12	24.7	36.9	69	17	37	165	41	100	5.5%	13.4%	1375	344	808	11.9%	28.2%	5	9
	1	26.6	29.1	40	10	16	85	21	35	2.9%	4.7%	731	183	297	6.2%	10.1%	4.5	8
	2	10.3	41.1	43	11	43	118	30	118	4.4%	17.6%	1021	255	1021	9.7%	38.8%	6	10
	3	12.7	19.3	15	4	9	28	7	17	0.9%	2.3%	202	50	130	1.8%	4.3%	4	5
	4	22.9	38.2	71	18	32	159	40	75	5.5%	10.4%	1282	320	629	11.5%	22.1%	5	9
	5	22.9	31.7	85	21	36	185	46	77	6.2%	10.4%	1398	349	598	12.4%	21.1%	4	8
	6	27.0	33.0	67	17	26	150	38	63	5.2%	8.8%	1155	289	489	10.4%	17.4%	4	8
	7	10.4	25.9	25	6	24	59	15	57	2.0%	7.7%	472	118	456	4.1%	15.9%	5	7
	8	27.9	34.4	87	22	32	193	48	73	6.5%	9.8%	1521	380	559	13.1%	19.8%	4	8
	9	38.8	43.1	209	52	58	652	163	217	22.6%	30.1%	5132	1283	1696	45.9%	61.0%	6	10

AN /BN	10	37.7	51.7	102	34	60	350	117	262	15.7%	35.2%	2812	937	2053	32.1%	71.4%	7	13
	11	38.1	43.9	106	35	57	342	114	219	15.8%	30.4%	2721	907	1699	32.2%	61.5%	7	11
	12	30.0	43.7	59	20	30	171	57	85	7.7%	11.4%	1406	469	715	15.9%	23.7%	6	10
	1	6.5	19.4	7	2	7	12	4	12	0.5%	1.6%	103	34	103	1.1%	3.4%	4	5
	2	10.6	31.7	4	1	4	8	3	8	0.4%	1.2%	85	28	85	1.0%	3.0%	5	7
	3	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	4	10.7	32.0	13	4	13	34	11	34	1.6%	4.7%	264	88	264	3.0%	9.0%	5	8
	5	28.2	33.2	28	9	10	60	20	29	2.7%	3.9%	461	154	227	5.3%	7.8%	4	9
	6	17.4	34.8	38	13	23	85	28	60	3.9%	8.3%	645	215	451	8.0%	16.7%	4	8
	7	2.7	8.0	1	0	1	1	0	1	0.0%	0.1%	8	3	8	0.1%	0.3%	2	2
	8	8.6	25.8	13	4	13	27	9	27	1.2%	3.6%	204	68	204	2.5%	7.5%	4	7
	9	11.5	34.6	58	19	58	160	53	160	7.4%	22.2%	1270	423	1270	15.0%	45.0%	6	9
W	10	28.6	35.2	109	27	48	261	65	118	8.8%	15.9%	2136	534	961	18.2%	33.1%	4	9
	11	17.6	35.4	54	14	36	140	35	95	4.9%	13.2%	1118	279	758	9.9%	26.9%	6	8
	12	6.9	27.7	10	3	10	20	5	20	0.7%	2.7%	179	45	179	1.5%	5.8%	4.5	6
	1	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	2	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	3	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	4	13.4	32.0	27	7	16	65	16	40	2.3%	5.6%	499	125	332	4.6%	11.7%	5	8
	5	13.7	28.0	52	13	28	121	30	66	4.1%	8.9%	924	231	514	8.2%	17.9%	5	7
	6	20.1	43.2	55	14	49	150	38	141	5.2%	19.6%	1175	294	1107	10.6%	40.0%	5	19
	7	8.5	16.9	2	1	1	3	1	1	0.1%	0.1%	34	8	17	0.3%	0.4%	3	4
	8	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	9	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA

Table D12 – Summary of Diversion Parameters by Month and WY Types for Alternative H4

WY Type	Month	Max. ESB Vol. Million Gallons		Number of diversion event			Diversion hours			Percent time diversion		Vol. pumped from ESB (MGs)			Percent time ESB Vol. > 0		Hours Eff. continuously stored	
		Mean	Max	Sum	Mean	Max	Sum	Mean	Max	Mean	Max	Sum	Mean	Max	Mean	Max	Median	Max
C	10	40.6	52.4	229	46	59	744	149	249	20.0%	33.5%	5979	1196	1953	41.0%	67.6%	7	20
	11	38.8	44.1	232	46	58	786	157	223	21.8%	31.0%	6092	1218	1711	44.0%	62.2%	7	11
	12	41.9	56.2	183	37	60	616	123	218	16.6%	29.3%	4852	970	1698	33.7%	59.1%	7	22
	1	27.1	38.8	97	19	39	248	50	105	6.7%	14.1%	2066	413	861	13.8%	29.3%	5	9
	2	34.2	51.6	130	26	44	391	78	153	11.5%	22.8%	3434	687	1343	25.6%	50.3%	7	20
	3	29.4	41.3	137	27	55	378	76	177	10.2%	23.8%	3029	606	1424	20.9%	49.6%	5	20
	4	35.3	38.2	161	32	51	397	79	117	11.0%	16.3%	3135	627	946	22.7%	33.9%	5	9
	5	45.1	61.1	216	43	60	824	165	267	22.2%	35.9%	6576	1315	2097	46.2%	74.1%	8	48
	6	45.0	52.3	220	44	54	733	147	187	20.4%	26.0%	5810	1162	1453	41.7%	53.3%	7	20
	7	36.5	43.2	176	35	51	528	106	168	14.2%	22.6%	4200	840	1332	29.0%	45.7%	6	11
	8	36.3	43.2	227	45	60	621	124	202	16.7%	27.2%	4949	990	1603	33.9%	54.3%	6	11
	9	46.8	52.8	290	58	59	1149	230	255	31.9%	35.4%	8880	1776	1950	64.0%	70.7%	8	21
D	10	41.6	52.4	178	45	60	560	140	235	18.8%	31.6%	4458	1115	1840	38.7%	65.1%	6	20
	11	32.3	43.9	103	26	43	284	71	150	9.9%	20.8%	2343	586	1197	20.5%	42.8%	6	11
	12	24.7	36.9	58	15	37	142	36	100	4.8%	13.4%	1174	294	808	10.0%	28.2%	5	9
	1	24.2	29.1	39	10	16	81	20	34	2.7%	4.6%	692	173	287	5.8%	9.9%	4	8
	2	15.6	41.1	48	12	43	125	31	118	4.7%	17.6%	1093	273	1020	10.4%	38.7%	6	10
	3	12.7	19.3	15	4	9	28	7	17	0.9%	2.3%	202	50	130	1.8%	4.3%	4	5
	4	22.9	38.2	71	18	32	159	40	75	5.5%	10.4%	1282	320	629	11.5%	22.1%	5	9
	5	28.4	38.5	94	24	42	237	59	101	8.0%	13.6%	1813	453	779	16.1%	28.1%	5	10
	6	28.8	33.0	59	15	26	138	35	62	4.8%	8.6%	1083	271	480	9.7%	17.2%	5	8
	7	18.7	33.5	40	10	23	92	23	53	3.1%	7.1%	728	182	428	6.2%	14.5%	5	8
	8	34.3	34.4	140	35	47	339	85	121	11.4%	16.3%	2691	673	970	23.4%	34.1%	5	9
	9	38.8	43.1	215	54	58	709	177	214	24.6%	29.7%	5557	1389	1671	49.9%	60.3%	7	10

AN /BN	10	37.8	51.7	123	41	60	416	139	262	18.6%	35.2%	3323	1108	2053	37.9%	71.4%	7	13
	11	35.2	43.9	95	32	58	314	105	223	14.5%	31.0%	2492	831	1722	29.6%	62.2%	7	11
	12	23.8	43.7	45	15	26	121	40	84	5.4%	11.3%	987	329	654	11.3%	23.0%	5	10
	1	6.5	19.4	6	2	6	10	3	10	0.5%	1.3%	85	28	85	0.9%	2.7%	4	4
	2	10.6	31.7	4	1	4	8	3	8	0.4%	1.2%	85	28	85	1.0%	3.0%	5	7
	3	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	4	10.7	32.0	12	4	12	30	10	30	1.4%	4.2%	236	79	236	2.7%	8.2%	5	8
	5	19.8	33.2	19	6	10	46	15	29	2.1%	3.9%	356	119	227	4.1%	7.8%	4	9
	6	17.4	34.8	36	12	21	81	27	56	3.8%	7.8%	615	205	421	7.6%	15.7%	4	9
	7	2.7	8.0	1	0	1	1	0	1	0.0%	0.1%	8	3	8	0.1%	0.3%	2	2
	8	20.1	34.5	73	24	45	154	51	104	6.9%	14.0%	1205	402	815	14.0%	28.4%	4	8
	9	20.5	34.6	71	24	58	184	61	162	8.5%	22.5%	1472	491	1282	17.3%	45.7%	6	9
W	10	30.5	42.9	119	30	55	310	78	158	10.4%	21.2%	2519	630	1271	21.3%	43.0%	5	10
	11	17.6	35.4	53	13	37	141	35	101	4.9%	14.0%	1127	282	806	10.1%	28.9%	6	9
	12	6.9	27.7	10	3	10	22	6	22	0.7%	3.0%	196	49	196	1.6%	6.5%	5	6
	1	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	2	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	3	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA
	4	5.4	21.6	11	3	11	24	6	24	0.8%	3.3%	160	40	160	1.6%	6.5%	5	6
	5	6.7	26.7	28	7	28	66	17	66	2.2%	8.9%	514	129	514	4.5%	17.9%	5	7
	6	23.8	43.2	93	23	49	259	65	141	9.0%	19.6%	2035	509	1107	18.2%	40.0%	6	19
	7	11.6	16.9	3	1	1	5	1	2	0.2%	0.3%	47	12	17	0.4%	0.4%	3	4
	8	8.6	25.8	29	7	27	57	14	55	1.9%	7.4%	467	117	450	4.0%	15.3%	4	6
	9	0.0	0.0	0	0	0	0	0	0	0.0%	0.0%	0	0	0	0.0%	0.0%	NA	NA

Appendix B

Exponent Comments on the Bay Delta Conservation Plan/California WaterFix Final EIR/EIS, on Behalf of Regional San

Exponent®

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January 27, 2017

Sacramento Regional County Sanitation District
10060 Goethe Road
Sacramento, CA 95827

Attention: Terrie Mitchell, Manager, Legislative & Regulatory Affairs

Subject: Comments on the Bay Delta Conservation Plan/California WaterFix Final Environmental Impact Report/Environmental Impact Statement

Dear Terrie,

We have reviewed the recently issued "Bay Delta Conservation Plan/California WaterFix Final Environmental Impact Report/Environmental Impact Statement" (FEIR/EIS)[1] and have prepared the following technical comments on the document pertaining to Sacramento Regional County Sanitation District's (Regional San) interests.[2] Our evaluation and comments are as follows:

1. The FEIR/EIS modeling of Sacramento River flow impacts at Freeport is inadequate.

Original Regional San Comment: Regional San previously submitted comments on the Draft EIR/EIS (DEIR/EIS) and Recirculated Draft EIR/EIS (RDEIR/SDEIS).[3] Regional San's comments included a discussion of the Department of Water Resources' (DWR) modeling of Sacramento River flow at Freeport. Regional San believes DWR's modeling was insufficient to characterize potential impacts to operation of the Sacramento Regional Wastewater Treatment Plant, which discharges treated effluent to the Sacramento River from an outfall at Freeport, upstream of the proposed WaterFix diversion points.

Regional San commented that the proposed WaterFix project involves the operation of the State Water Project/Central Valley Project (SWP/CVP) system such that Sacramento River flow rates

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[1] California Department of Water Resources and U.S. Bureau of Reclamation. 2016. Final Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan/California WaterFix. December. (DOE/EIS-0515.) (ICF 00139.14.) Prepared by ICF International, Sacramento, CA.

Exponent has undertaken a diligent effort to identify the components of the FEIR/EIS that are relevant to Regional San's comments, and we have thoroughly reviewed the FEIR/EIS response to comments and sections/references cited in the response to Regional San's comments. However, given the size of the FEIR/EIS and the very limited time available for review, we have not reviewed the entire FEIR/EIS.

[2] Each author's curriculum vitae is attached to this letter as Exhibit A.

[3] Regional San. 2014. Regional San Comments on Draft BDCP and Associated Draft EIR/EIS. July 29. Comments submitted to Ryan Wulff, National Marine Fisheries Service, via email: BDCP.comments@noaa.gov; Regional San. 2015. Regional San Comments on BDCP/CA WaterFix's Recirculated Draft EIR/Supplemental Draft EIS. October 30. Comments submitted to the California Department of Water Resources and U.S. Bureau of Reclamation, via email: BDCPComments@icfi.com.

near Regional San's outfall at Freeport could change under project conditions. Regional San is concerned the project could increase the number and duration of low-flow and reverse-flow periods in the river. During low-flow and reverse-flow conditions and as specified in Regional San's NPDES permit, Regional San would not be permitted to discharge.

Regional San also commented that the analysis presented in the RDEIR/SDEIS included only monthly average river flow rates at Freeport; these documents did not include or describe the tidally-influenced hourly or sub-hourly flow rates. Regional San's operations depend upon river flow rates that are measured on an hourly or sub-hourly basis, and these flow rates determine whether or not Regional San is permitted to discharge. If the proposed project increases the frequency or duration of low flow rates in the river at Freeport, Regional San could be required to divert greater volumes of treated effluent to emergency storage basins (ESBs), which could in turn necessitate the construction of additional ESB volume at significant cost and with associated environmental impacts. But, because the environmental documents did not present relevant modeling results, a proper determination of impacts to Regional San's operations, and potential related impacts associated with construction of additional storage facilities, could not be made (Letter 321, Comment 1; Letter 2579, Comments 1, 12, 13, 14, 15, 16, 20, 21, 57, 63).

FEIR/EIS Response 1: The FEIR/EIS responses to this comment make several points. First, the response to Letter 321, Comment 1, states that Figure 4.3.2-4 of the RDEIR (presented below as Figure 1) shows that flows at Freeport will not change significantly under project conditions, and thus that Regional San's operations would not be significantly impacted by the project. Responses to Letter 2579, Comments 13, 14, 15, 16, 20, 21, 57, and 63 also make this point.

> Exponent Reply 1: Figure 4.3.2-4 does not present results that can be used to evaluate impacts to Regional San's operations. Figure 4.3.2-4 presents a plot of monthly average Sacramento River flow rates at Freeport over the 16-year modeling period (1976–1991), which seems to have been generated by first calculating an average flow rate for each month from 15-minute DSM2 output, then by averaging those average flow rates over the 16-year period.[4] The information shown in Figure 4.3.2-4 contains the type of data that Regional San's comments noted would be inadequate to understand impacts on its operations. Tidal impacts on river flows at Freeport are well understood and can be readily modeled; thus, there appears to be no reason to present monthly average flow rates instead of hourly data that would show tidal influences.

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[4] The exact calculation methodology could not be identified in the RDEIR/SDEIS documents.

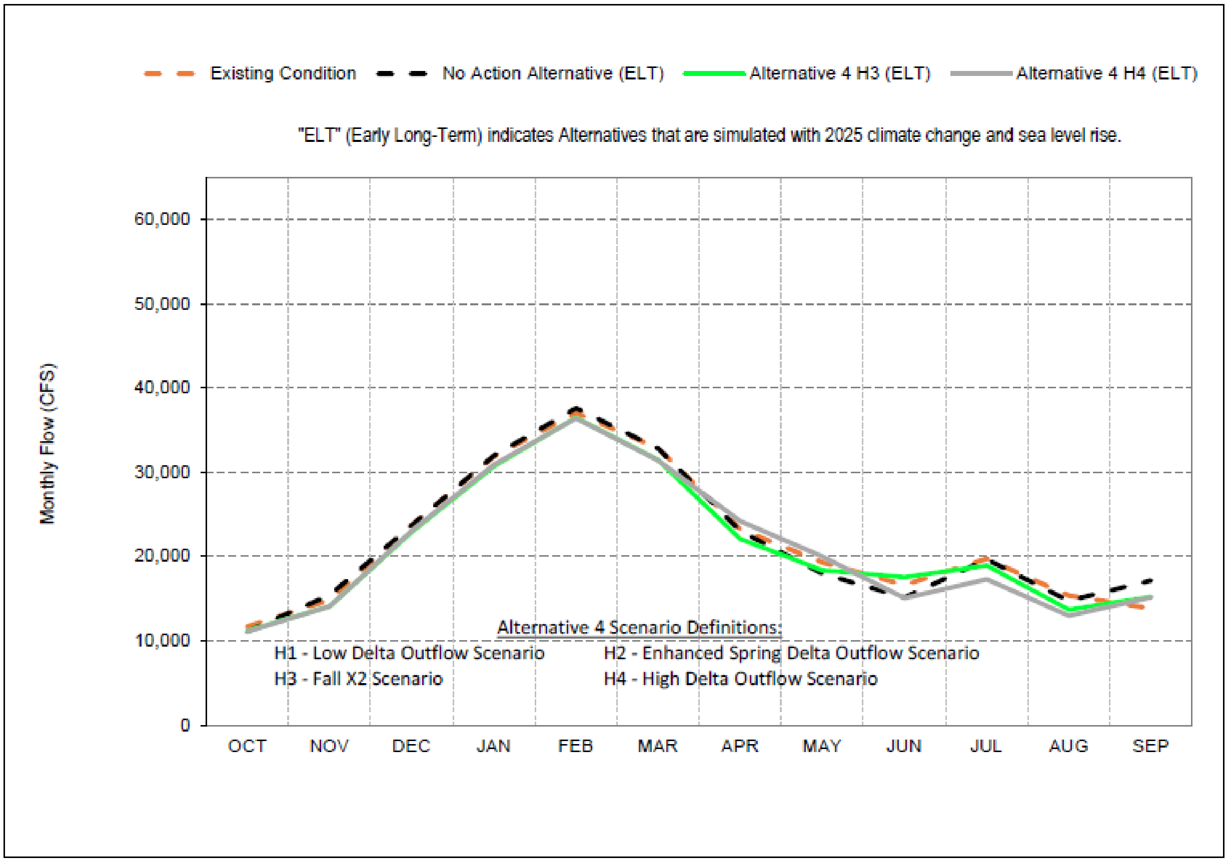

Figure 4.3.2-4
Sacramento River Flow at Freeport for Alternative 4A, Long-Term Average

Figure 1. Figure 4.3.2-4 from the Recirculated Draft Environmental Impact Report.

Source: California Department of Water Resources (2015). U.S. Bureau of Reclamation, Bay Delta Conservation Plan/California WaterFix Partially Recirculated Draft Environmental Impact Report/Supplemental Draft Environmental Impact Statement (RDEIR/SDEIS). July 10. Accessed 1/24/2017 at http://baydeltaconservationplan.com/RDEIRS/Recirc_Figures/Fig_4.3.2.4_Sac%20Freeport%20LT_Alt4A.pdf

Prior work performed by Flow Science Incorporated[5] evaluated the ability of DSM2 to simulate hourly and sub-hourly flow rates at Freeport accurately. At lower river flow rates (i.e., the flow rates at which reverse flow events will occur over the course of a tidal cycle), the DSM2 accurately simulated reverse flow events. Thus, DSM2 is a suitable tool for exactly this purpose. Aggregating flows to monthly averages, as the Lead Agencies have done in the FEIR/EIS, obscures the impact of short-term flow variations that result in low and reverse flows. Figure A-6 of the FEIR/EIS (p. 5A-A18,

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[5] Sacramento Regional County Sanitation District. 2014. Draft Environmental Impact Report for the Sacramento Regional County Sanitation District EchoWater Project (Control Number 2012-70044, State Clearinghouse #2012052017). March 4. Appendix D1, Water Quality Modeling Approach, pp. 6-17.

presented below as Figure 2) illustrates this phenomenon for the Sacramento River at Freeport.

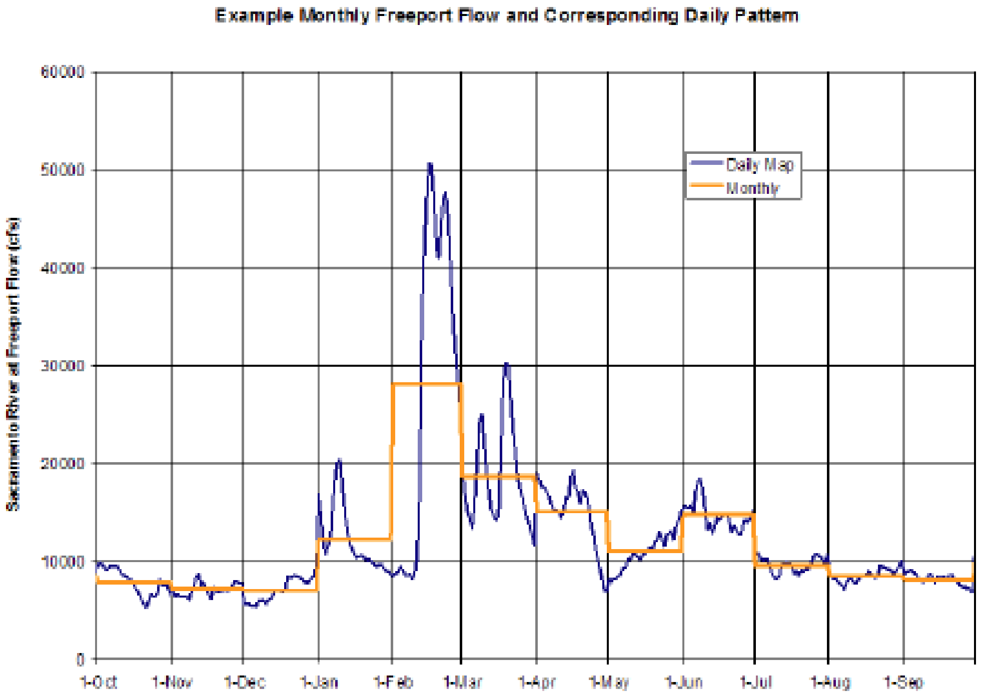
Example Monthly Freeport Flow and Corresponding Daily Pattern

Figure A-6: Example monthly-averaged and daily-averaged flow for Sacramento River at Freeport

Figure 2. Figure A-6 from the Final Environmental Impact Report/Environmental Impact Statement

Source: California Department of Water Resources and U.S. Bureau of Reclamation. 2016. Final Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan/California WaterFix. December. (DOE/EIS-0515.) (ICF 00139.14.) Prepared by ICF International, Sacramento, CA. Appendix 5A, “Modeling Technical Appendix – Section A,” p. 5A-A18. Accessed 1/24/2017 at http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Final_EIR-EIS_Appendix_5A_-_BDCP-California_WaterFix_FEIR-FEIS_Modeling_Technical_Appendix_-_Section_A.sflb.ashx

In Figure A-6, the daily average flow rate on May 1 is approximately 7,500 cubic feet per second (cfs) while the monthly average flow rate—calculated from the plotted daily average flow rates—is significantly higher at approximately 11,000 cfs. The monthly average value thus obscures how low the daily-simulated average flow rate actually becomes. Thus, FEIR/EIS statements that *monthly average* flow rates at Freeport do not change significantly under project conditions are not responsive to the question of variability between years within the 16-year model period, or whether there will be additional low-flow events at Freeport, and thus whether Regional San’s operations will be impacted. DWR’s response to these comments is thereby inadequate.

FEIR/EIS Response 2: The FEIR/EIS further responds to Regional San's original comment by asserting (a) that the Lead Agencies did, in fact, use DSM2 to assess changes in sub-daily Freeport flow rates under project conditions ("Disaggregated data was [sic] calculated during preparation of the EIR/EIS using the DSM2 model to indicate changes during tidal cycles" [responses to Letter 2579, Comment 13 and other comments]) and (b) that the FEIR/EIS includes a commitment to operate the proposed project in a way that does not require additional ESB storage at Regional San. Specifically, the FEIR/EIS states, "As part of preparing the Final EIR/EIS, the DSM2 model was used by the project proponent to model the change in frequency of reverse flow events at Freeport and potential effects on operations of the Freeport Water Project and SRWTP. An additional environmental commitment will be added to the Final EIR/EIS to develop an operational rule curve for use of the North Delta diversion facilities such that these facilities can be operated in a manner that would not result in reverse flow conditions that would exceed the SRWTP's ability to accommodate such events based on its storage basin capacity" (Response to Letter 2579, Comment 12). In Appendix 3B, Section 3.6, the FEIR/EIS's "environmental commitment" is stated as follows: "DWR, in consultation with Regional San, will develop a rule curve and/or operating protocols for the North Delta Intake diversions…to ensure that Regional San operations will remain consistent with facility storage capabilities and thus not adversely impact Sacramento Regional Wastewater Treatment Plant operations" (p. 3B-81).

> Exponent Reply 2: The FEIR/EIS response to Regional San's original comment is problematic for several reasons. As an initial matter, although the FEIR/EIS refers to DSM2 modeling that was "used by the project proponent to model the change in frequency of reverse flow events at Freeport and potential effects on operations of the Freeport Water Project and SRWTP" (Response to Letter 2579, Comment 12), the results of this modeling, and the details of any analysis based on this modeling, are not presented in the FEIR/EIS except in a passing comment on p. 1-39 of Master Response 15 (see also below). As a result, it is not possible to determine from the FEIR/EIS whether the proposed project would have an adverse impact on flow rates at Freeport or on Regional San's operations. Because the data were available, the Lead Agencies should have presented these modeling data and an analysis of the results in the FEIR/EIS to address Regional San's comments.
>
> The FEIR/EIS also makes inconsistent statements about the effect of the proposed project on Sacramento River reverse flows at Freeport. The FEIR/EIS states that the project would not have a significant impact on the Sacramento River flow regime at Freeport. For example, as noted above, in response to Letter 321, Comment 1, the FEIR/EIS states, "As shown in Figure 4.3.2-4 of the RDEIR/SDEIS, lower Sacramento River flow at Freeport would change minimally between Alternative 4A and Existing Conditions and the No-Action Alternative (NAA)." This response implies that reverse-flow and low-flow conditions would not change significantly under project conditions.

> However, Master Response 15 from the FEIR/EIS states, “Modeling shows that Alternative 4A may increase reverse flows in the lower Sacramento River at Freeport, relative to the NAA…” (p. 1-39). The fact that the FEIR/EIS makes an “environmental commitment” to develop “a rule curve and/or operating protocol for the North Delta Intake diversions…to ensure that Regional San operations will remain consistent with facility storage capabilities” (Appendix 3B, Section 3.6, p. 3B-81) implies that the project-driven increase in reverse flow events revealed by the Lead Agencies’ DSM2 modeling is in fact significant. Thus, not only does the FEIR/EIS fail to present relevant DSM2 modeling results in any detail, but FEIR/EIS statements about the Sacramento River modeling results are inconsistent.
>
> Finally, it is not clear from the FEIR/EIS whether the proposed “rule curve and/or operational protocol for the North Delta Intake (NDI) diversions” is feasible or whether changes in NDI diversions could have a sufficient impact on flow rates at Freeport to eliminate any impacts to Regional San’s operations. The SWP/CVP system is operated as an integrated system, and flow rates at Freeport are largely a result of reservoir releases and operations upstream of Freeport. Because the NDI diversions are downstream of Freeport, it is not clear that changes to NDI diversion patterns would have a material effect on flow rates at Freeport. In any case, the effect of changes to NDI diversions on flow rates at Freeport has not been demonstrated by the FEIR/EIS. To demonstrate the feasibility of this “environmental commitment,” the FEIR/EIS should have presented (at least conceptually) the proposed rule curve and/or operational protocol, along with an explanation and supporting evidence demonstrating how this protocol would affect flow rates in the Sacramento River at Freeport and Regional San operations. In fact, the FEIR/EIS presented no concrete information about the proposed rule curve/protocol or its impact on Regional San operations, apart from an unsubstantiated assurance that Regional San’s operations would not be significantly impacted.

2. FEIR/EIS fails to consider impacts resulting from Boundary 1 and Boundary 2 scenarios, which represent the operational range of the proposed project.

The FEIR/EIS presents the potential impacts of the preferred project alternative (Alternative 4A). However, the FEIR/EIS also states that two additional scenarios not presented in the DEIR/EIS or RDEIR/SDEIS—Boundary 1 (B1) and Boundary 2 (B2)—represent the full range of possible operations of the proposed project under adaptive management. For example, p. 5-167 of the FEIR/EIS states, “Future conveyance facilities operational changes may also be made as a result of adaptive management to respond to advances in science and understanding of how operations affect species. Conveyance facilities would be operated under an adaptive management range represented by Boundary 1 and Boundary 2.” Thus, the B1 and B2 scenarios represent the range of possible operations of the proposed project. Consistent with this idea, Jennifer Pierre of DWR stated in her oral testimony before the State Water Resources Control

Board in the associated WaterFix water rights change petition proceedings, on July 29, 2016, that the B1 model scenario can be used as a basis for assessment of harm since it represents possible project operations (See Exhibit B [Excerpt of July 29, 2016 transcript, State Water Resources Control Board, Hearing in the matter of California Department of Water Resources and United States Bureau of Reclamation Request for a Change in Point of Diversion for California Water Fix (WaterFix Water Rights Hearing)]).

The B1 and B2 scenarios represent a significantly different range of operations than the preferred alternative identified in the RDEIR/EIS (Alternative 4A). Despite the fact that B1 and B2 represent possible operating scenarios of the proposed project, the FEIR/EIS does not present the potential impacts of these scenarios. The Lead Agencies' rationale for not presenting the impacts of B1 and B2 seems to be that "[i]mpacts as a result of operations within this range [spanning B1 and B2] would be consistent with the impacts discussed for the alternatives considered in this EIR/EIS" (p. 5-167).

However, the only evidence presented in the FEIR/EIS that the impacts of B1 and B2 on Sacramento River flow rates at Freeport would be consistent with the impacts of the preferred alternative (Alternative 4A) appears to be Figure 5E-8 (Appendix 5E, p. 5E-18, presented below as Figure 3), which shows monthly average Sacramento River flow rates at Freeport aggregated over a 16-year period under both B1 and B2, along with several other scenarios including the future no-action alternative (NAA). While monthly average flow rates presented in Figure 5E-8 for the various scenarios are similar, as noted in comments above, river flow rates as influenced by the tides (i.e., hourly or sub-hourly flow rates) determine Regional San's ability to discharge treated effluent to the river. The FEIR/EIS has not provided information about hourly river flow rates at Freeport for Scenarios 4A, B1, or B2, but it is well known that export flow rates differ markedly for each of these scenarios. According to DWR testimony, B1 would represent an *increase* in total average annual exports of approximately 1.2 million acre-feet (MAF) relative to the NAA, and B2 would represent a *reduction* in total average annual exports of approximately 1.1 MAF relative to NAA, representing a differential spread of approximately 2.3 MAF/year on average.[6] Alternative 4A exports would fall between the B1 and B2 numbers. The potential project impacts to Regional San's operations cannot be understood without a distinct evaluation of the impacts of B1 and B2 separately from those of Alternative 4A; because it does not include this analysis, the FEIR/EIS does not disclose the full range of impacts of the project, including both the full likely operating range and hourly flow rates, on Regional San.

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[6] Exhibit C, WaterFix Water Rights Hearing, Written Testimony of Armin Munevar. May 31, 2016. P. 18, lines 16–23.

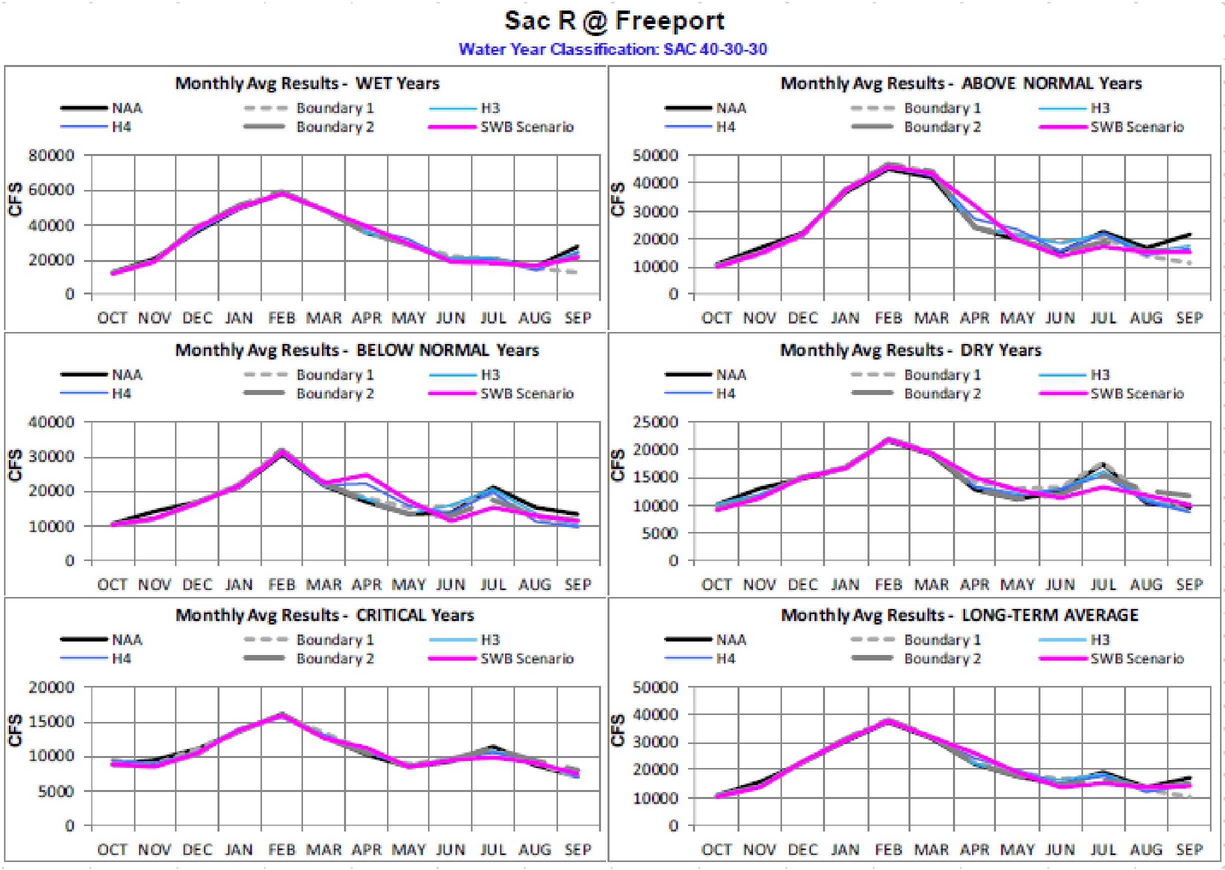

Figure 5E-8: Monthly Average Sacramento River at Freeport Flow

Figure 3. Figure 5E-8 from the Final Environmental Impact Report/Environmental Impact Statement

Source: California Department of Water Resources and U.S. Bureau of Reclamation. 2016. Final Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan/California WaterFix. December. (DOE/EIS-0515.) (ICF 00139.14.) Prepared by ICF International, Sacramento, CA. Appendix 5E, “Supplemental Modeling Related to the SWRCB,” p. 5E-18. Accessed 1/24/2017 at http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Final_EIR-EIS_Appendix_5E_-_Supplemental_Modeling_Related_to_the_SWRCB.sflb.ashx

3. The FEIR/EIS evaluation of Sacramento River temperature impacts at Freeport is inadequate.

<u>Original Regional San Comment</u>: Regional San has certain thermal requirements in its NPDES permit that constrain the discharge of treated effluent to the Sacramento River. Regional San previously commented on the DEIR/EIS and RDEIR/EIS documents that the proposed project could alter the water temperature in the Sacramento River at Freeport and thereby reduce the times when Regional San is permitted to discharge and/or cause permit non-compliance. Because the proposed project involves new operating scenarios for upstream reservoirs, which

influence the temperature of the Sacramento River at Freeport, potential impacts to river temperature need to be evaluated in the FEIR/EIS.

FEIR/EIS Response: The Lead Agencies' response to this comment asserts that changes in river temperature at Freeport will be insignificant since river temperatures at Freeport are generally in equilibrium with air temperature and since river flow rates are not expected to change as a result of the project. The response concludes, "Although minor changes in flows and river temperature would occur under Alternative 4A, relative to the NAA, they would not be of sufficient magnitude and duration to change Regional San's overall thermal compliance record relative to compliance under the NAA. Also, minor changes in river flow and temperatures that may occur under Alternative 4A, relative to conditions under the NAA, would not cause the Regional Water Quality Control Board to modify the thermal limitations in the NPDES permit or cause Regional San to build cooling towers to cool its effluent when such modifications would not be required under the NAA" (response to Letter 321, Comment 1).

> Exponent Reply: There are several problems with the FEIR/EIS response to Regional San's original comment. First, as noted in previous comments, Sacramento River flow rates may well change significantly under proposed project scenario 4A, and other operating scenarios, including B1 and B2, are simulated to have different reservoir releases, river flow rates, and export volumes. The response does not provide relevant evidence or analysis to support the conclusion that river flow rates at Freeport will not change significantly under the range of operating conditions proposed for the project.
>
> Second, the temperature of the river will be a function of a range of factors, including the temperature of the water released from upstream reservoirs, the river flow rate and travel time to Freeport (a function of flow rate), air temperature, humidity, and wind speed. The response to comments appears to assert that river flow rate is the main factor influencing river temperature at Freeport, and that since river flow rates will not change appreciably, river temperatures will not change appreciably. However, DWR provides no data or analysis to support this assertion, and we believe it to be an oversimplification of the processes that affect river temperature.
>
> Even if river temperature were a function primarily of river flow rate, the Lead Agencies have not demonstrated that river temperatures at Freeport will remain the same under project conditions, since project flows would be different from baseline flows, which could affect travel times between upstream reservoirs and Freeport. Thus, the air-water temperature equilibrium and river temperatures at Freeport could be different under project conditions than under baseline conditions because project flows would be different from baseline flows. As a result, the FEIR/EIS's response to Regional San's comment about river temperatures is unsubstantiated in this respect.

> To adequately address the concern raised in Regional San's comment, the FEIR/EIS should have made a thorough scientific investigation of the impacts of the proposed project on temperatures in the Sacramento River at Freeport (e.g., a modeling analysis), rather than relying on unsupported inferences from the flow regime and air-water thermal equilibrium.

4. FEIR/EIS employs the incorrect "existing condition" baseline scenario.

The FEIR/EIS employs both an existing condition (EBC1) and the NAA as baseline conditions. However, the existing condition scenario (EBC1) does not include the Fall X2 requirement,[7] despite the fact that the 2008 USFWS biological opinion (BiOp) that governs operations of the CVP/SWP requires it. The FEIR/EIS states the reason for excluding Fall X2 from the existing condition scenario as follows: "As of spring 2011, when a lead agency technical team began a new set of complex computer model runs in support of this EIR/EIS, DWR determined that full implementation of the Fall X2 salinity standard as described in the 2008 USFWS BiOp was not certain to occur within a reasonable near-term timeframe because of a recent court decision and reasonably foreseeable near-term hydrological conditions. As of that date, the United States District Court has not yet ruled in litigation filed by various water users over the issue of whether the delta smelt BiOp had failed to sufficiently explain the basis for the specific location requirements of the Fall X2 action, and its implementation was uncertain in the foreseeable future" (p. 4-6).[8]

However, after the U.S. District Court's ruling in March 2011 that the BiOp insufficiently explained the basis for Fall X2 location requirements, in March 2014—almost three years before the issuing of the FEIR/EIS—the Ninth Circuit U.S. Court of Appeals overturned the District Court's ruling on this point, finding that the BiOp *did* sufficiently explain the basis of the specific Fall X2 location requirements (*San Luis vs. Jewell*, Case No. 11-15871). Thus, the pending litigation referred to in the FEIR/EIS has long since been resolved, and the Fall X2 requirement should have been included in the existing condition baseline scenario, together with the other 2008 BiOp requirements that were included in the baseline existing condition. In fact, a second existing condition baseline model run that includes the Fall X2 requirements (EBC2) was conducted in connection with the Administrative Draft BDCP EIR/EIS and released to the public in 2013. This baseline model run (EBC2) was thus available to DWR at the time the RDEIR/SDEIS and FEIR/EIS were prepared. This EBC2 baseline condition should have been

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[7] The Fall X2 requirement is a requirement that the 2 parts per thousand (ppt) salinity contour ("isohaline") be located west of certain compliance locations in the Sacramento-San Joaquin River Delta (Delta) during the fall season to accommodate the habitat requirements of delta smelt. "X2" is the location of the 2 ppt isohaline typically given in kilometers from the Golden Gate. Fall X2 generally requires more freshwater Delta outflow than would otherwise be the case, in order to maintain the 2 ppt isohaline at the relevant locations.

[8] The FEIR/EIS makes similar remarks in "Master Response 1: Environmental Baselines." See FEIR/EIS Volume II, Part 1, p. 1-9.

used to evaluate the impacts of Alternative 4A. Thus, the EBC1 existing condition scenario employed as a baseline in the FEIR/EIS is insufficient since it lacks the Fall X2 requirement and does not accurately reflect existing conditions.

Excluding the Fall X2 requirement from the existing condition baseline scenario tends to bias impact assessments toward lower impacts on Regional San's operations than would be reflected if Fall X2 were included in the baseline scenario. Exclusion of the Fall X2 requirement generally yields a baseline condition with lower flow rates in the Sacramento River during the fall than would be the case with the requirement, since Fall X2 generally entails augmented Delta outflow. Thus, any reductions in Sacramento River flow rate attributable to the WaterFix project during the fall would look less significant next to a baseline condition lacking Fall X2 than next to a baseline with Fall X2, since the baseline lacking Fall X2 would already exhibit lower flow rates than the baseline with Fall X2. In effect, excluding the Fall X2 requirement from the existing condition baseline scenario is likely to understate the impacts to Regional San operations.

Thank you for the opportunity to assist you with these comments. Please let us know if you have any questions or would like to discuss the comments with us.

Sincerely,

Aaron Mead

Aaron Mead, Ph.D., P.E.
Managing Engineer

Susan C. Paulsen

Susan C. Paulsen, Ph.D., P.E.
Principal Scientist, Director of Environmental & Earth Sciences Practice